

Microsoft Windows NT Server

TCP/IP

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ftp

hostname

ipconfig

lpq

lpr

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ping

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route

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Overview of Microsoft TCP/IP for Windows NT

Transmission Control Protocol/Internet Protocol (TCP/IP) is a networking protocol that provides communication across interconnected networks made up of computers with diverse hardware architectures and various operating systems. TCP/IP can be used to communicate with Windows NT systems, with devices that use other Microsoft networking products, and with non-Microsoft systems, such as UNIX.

This chapter introduces Microsoft TCP/IP for Windows NT. The topics in this chapter include the following:

- What is TCP/IP for Windows NT?
- What does Microsoft TCP/IP include?
- Windows NT solutions in TCP/IP internetworks

For more detailed information on TCP/IP and its integration with Microsoft Windows NT and other networking products, see Chapter 3, "Networking Concepts for TCP/IP."

What Is TCP/IP for Windows NT?

The TCP/IP protocol family is a standard set of networking protocols, or rules, that govern how data is passed between computers on a network. TCP/IP is used to connect the Internet, the worldwide internetwork connecting over two million universities, research labs, U.S. defense installations, and corporations. (By convention, "Internet" is capitalized when referring to the worldwide internetwork.) These same protocols can be used in private internetworks that connect several local area networks.

Microsoft TCP/IP for Windows NT enables enterprise networking and connectivity on Windows NT computers. Adding TCP/IP to a Windows NT configuration offers the following advantages:

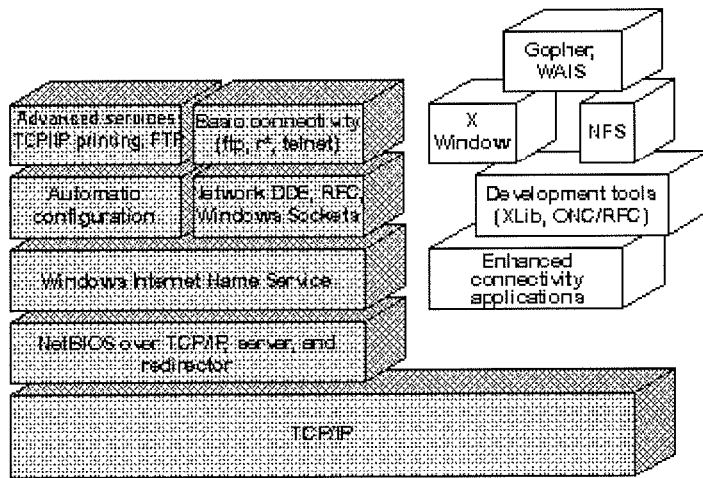
- A standard, routable enterprise networking protocol that is the most complete and accepted protocol available. All modern operating systems offer TCP/IP support, and most large networks rely on TCP/IP for much of their network traffic.
- A technology for connecting dissimilar systems. Many standard connectivity utilities are available to access and transfer data between dissimilar systems, including File Transfer Protocol (FTP) and Terminal Emulation Protocol (Telnet). Several of these standard utilities are included with Windows NT.
- A robust, scalable, cross-platform client-server framework. Microsoft TCP/IP supports the Windows Sockets 1.1 interface, which is ideal for developing client-server applications that can run with Windows Sockets-compliant stacks from other vendors. Many public-domain Internet tools are also written to the Windows Sockets standard. Windows Sockets applications can also take advantage of other networking protocols such as Microsoft NWLink, the Microsoft implementation of the IPX/SPX protocols used in Novell® NetWare® networks.
- The enabling technology necessary to connect Windows NT to the global Internet. TCP/IP, Point to Point Protocol (PPP), and Windows Sockets 1.1 provide the foundation needed to connect and use Internet services.

What Does Microsoft TCP/IP Include?

Microsoft TCP/IP provides all the elements necessary to implement these protocols for networking. **Microsoft TCP/IP includes the following:**

- Core TCP/IP protocols, including the Transmission Control Protocol (TCP), Internet Protocol (IP), User Datagram Protocol (UDP), Address Resolution Protocol (ARP), and Internet Control Message Protocol (ICMP). This suite of Internet protocols provides a set of standards for how computers communicate and how networks are interconnected. Support is also provided for PPP and Serial-Line IP (SLIP), which are protocols used for dial-up access to TCP/IP networks, including the Internet.
- Support for application interfaces, including Windows Sockets 1.1 for network programming, remote procedure call (RPC) for communicating between systems, **NetBIOS for establishing logical names and sessions on the network**, and network dynamic data exchange (Network DDE) for sharing information embedded in documents across the network.
- Basic TCP/IP connectivity utilities, including **finger, ftp, lpr, rcp, rexec, rsh, telnet, and tftp**. These utilities allow Windows NT users to interact with and use resources on non-Microsoft hosts, such as UNIX workstations.
- TCP/IP diagnostic tools, including **arp, hostname, ipconfig, lpq, nbtstat, netstat, ping, route, and tracert**. These utilities can be used to detect and resolve TCP/IP networking problems.
- **Services and related administrative tools, including the FTP Server service for transferring files between remote computers, Windows Internet Name Service (WINS) for dynamically registering and querying computer names on an internetwork, Dynamic Host Configuration Protocol (DHCP) service for automatically configuring TCP/IP on Windows NT computers, and TCP/IP printing for accessing printers connected to a UNIX computer or connected directly to the network via TCP/IP.**
- Simple Network Management Protocol (SNMP) agent. This component allows a Windows NT computer to be administered remotely using management tools such as Sun® Net Manager or HP® Open View. SNMP can also be use to monitor and manage DHCP servers and WINS servers.
- The client software for simple network protocols, including Character Generator, Daytime, Discard, Echo, and Quote of the Day. These protocols allow a Windows NT computer to respond to requests from other systems that support these protocols. When these protocols are installed, a sample QUOTES files is also installed in the `\systemroot\SYSTEM32\DRIVERS\ETC` directory.
- Path MTU Discovery, which provides the ability to determine the datagram size for all routers between Windows NT computers and any other systems on the WAN. Microsoft TCP/IP also supports the Internet Gateway Multicast Protocol (IGMP), which is used by new workgroup software products.

The following diagram shows the elements of Microsoft TCP/IP alongside the variety of additional applications and connectivity utilities provided by Microsoft and other developers.



- Integrated with Windows NT
- Developed by third parties or the research community

Microsoft TCP/IP: Core Technology and Third-Party Add-ons

TCP/IP standards are defined in *Requests for Comments* (RFCs), which are published by the Internet Engineering Task Force (IETF) and other working groups. The relevant RFCs supported in this version of Microsoft TCP/IP (and for Microsoft Remote Access Service) are described in the following table.

Requests for Comments (RFCs) Supported by Microsoft TCP/IP

RFC	Title
768	User Datagram Protocol (UDP)
783	Trivial File Transfer Protocol (TFTP)
791	Internet Protocol (IP)
792	Internet Control Message Protocol (ICMP)
793	Transmission Control Protocol (TCP)
826	Address Resolution Protocol (ARP)
854	Telnet Protocol (TELNET)
862	Echo Protocol (ECHO)
863	Discard Protocol (DISCARD)
864	Character Generator Protocol (CHARGEN)
865	Quote of the Day Protocol (QUOTE)
867	Daytime Protocol (DAYTIME)
894	IP over Ethernet
919, 922	IP Broadcast Datagrams (broadcasting with subnets)
959	File Transfer Protocol (FTP)

1001, 1002	NetBIOS Service Protocols
1034, 1035	Domain Name System (DOMAIN)
1042	IP over Token Ring
1055	Transmission of IP over Serial Lines (IP-SLIP)
1112	Internet Gateway Multicast Protocol (IGMP)
1122, 1123	Host Requirements (communications and applications)
1134	Point to Point Protocol (PPP)
1144	Compressing TCP/IP Headers for Low-Speed Serial Links
1157	Simple Network Management Protocol (SNMP)
1179	Line Printer Daemon Protocol
1188	IP over FDDI
1191	Path MTU Discovery
1201	IP over ARCNET
1231	IEEE 802.5 Token Ring MIB (MIB-II)
1332	PPP Internet Protocol Control Protocol (IPCP)
1334	PPP Authentication Protocols
1533	DHCP Options and BOOTP Vendor Extensions
1534	Interoperation Between DHCP and BOOTP
1541	Dynamic Host Configuration Protocol (DHCP)
1542	Clarifications and Extensions for the Bootstrap Protocol
1547	Requirements for Point to Point Protocol (PPP)
1548	Point to Point Protocol (PPP)
1549	PPP in High-level Data Link Control (HDLC) Framing
1552	PPP Internetwork Packet Exchange Control Protocol (IPXCP)
1553	IPX Header Compression
1570	Link Control Protocol (LCP) Extensions
Draft RFCs	NetBIOS Frame Control Protocol (NBFCP); PPP over ISDN; PPP over X.25; Compression Control Protocol

All RFCs can be found on the Internet via ds.internic.net.

In this version of Windows NT, Microsoft TCP/IP does not include a complete suite of TCP/IP connectivity utilities, Network File System (NFS) support, or some TCP/IP server services (daemons) such as **routed** and **telnetd**. Many such applications and utilities that are available in the public domain or from third-party vendors work with Microsoft TCP/IP.

Tip

For Windows for Workgroups computers and MS-DOSbased computers on a Microsoft network, you can install the new version of Microsoft TCP/IP-32 for Windows for Workgroups and the Microsoft Network Client version 2.0 for MS-DOS from the Windows NT Server 3.5 compact disc. This software includes the DHCP and WINS clients and other elements of the new Microsoft TCP/IP software. For information about installing these clients, see Chapter 9, "Network Client Administrator," in the *Windows NT Server Installation Guide*.

Windows NT Solutions in TCP/IP Internetworks

When TCP/IP is used as a transport protocol with Windows NT, Windows NT computers can communicate with other kinds of systems without additional networking software. Microsoft TCP/IP in combination with other parts of Windows NT provides a scalable solution for enterprise networks that include a mix of system types and software on many platforms.

This section summarizes how TCP/IP works with Windows NT to provide enterprise networking solutions. For information about how the elements discussed in this section fit within the networking architecture, see "TCP/IP and Windows NT Networking" in Chapter 3, "Networking Concepts for TCP/IP."

Windows NT Solutions in TCP/IP Internetworks

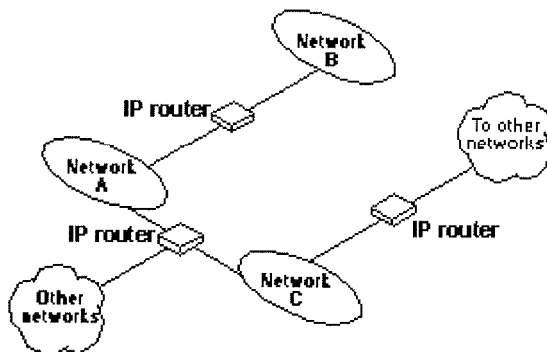
Using TCP/IP for Scalability in Windows Networks

TCP/IP delivers a scalable internetworking technology widely supported by hardware and software vendors.

When TCP/IP is used as the enterprise networking protocol, the Windows networking solutions from Microsoft can be used on an existing internetwork to provide client and server support for TCP/IP and connectivity utilities. These solutions include:

- Microsoft Windows NT Workstation 3.5, with enhancements to support wide area networks (WAN), TCP/IP printing, extended LMHOSTS, Windows Sockets 1.1, FTP Server service software, and DHCP and WINS client software.
- Microsoft Windows NT Server 3.5, with the same enhancements as Windows NT, plus DHCP server and WINS server software to support the implementation of these new protocols.
- Microsoft TCP/IP-32 for Windows for Workgroups 3.11, with Windows Sockets support, can be used to provide access for Windows for Workgroups computers to Windows NT, LAN Manager, and other TCP/IP systems. Microsoft TCP/IP-32 includes DHCP and WINS client software.
- Microsoft LAN Manager, including both client and server support for Windows Sockets, and MS-DOS®based connectivity utilities. The Microsoft Network Client 2.0 software on the Windows NT Server compact disc includes new Microsoft TCP/IP support with DHCP and WINS clients.

The current version of TCP/IP for Windows NT also supports IP routing in systems with multiple network adapters attached to separate physical networks (multihomed systems).



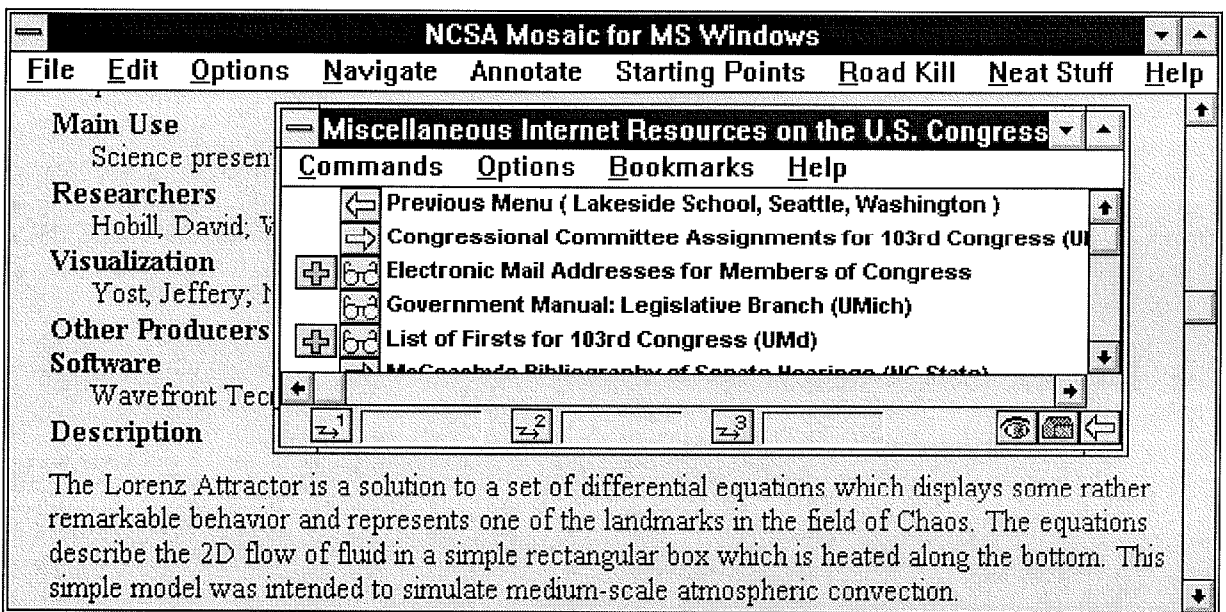
Windows NT Solutions in TCP/IP Internetworks

Using TCP/IP for Connectivity to the Internet

Microsoft TCP/IP provides Windows networking with a set of internetworking protocols based on open standards.

Microsoft TCP/IP for Windows NT includes many common connectivity applications such as **ftp**, **rsh**, and **telnet** that support file transfer, remote process execution, and terminal emulation for communication on the Internet and between non-Microsoft network systems.

TCP/IP applications created by researchers and other users, such as Gopher and NCSA Mosaic, are in the public domain or are available through other vendors as both 16-bit and 32-bit Windows-based applications. Any of these applications that follow the Windows Sockets 1.1 standard are compatible with Windows NT. Such applications allow a Windows NT computer to act as a powerful Internet client using the extensive internetworking components with public-domain viewers and applications to access Internet resources.



Tip

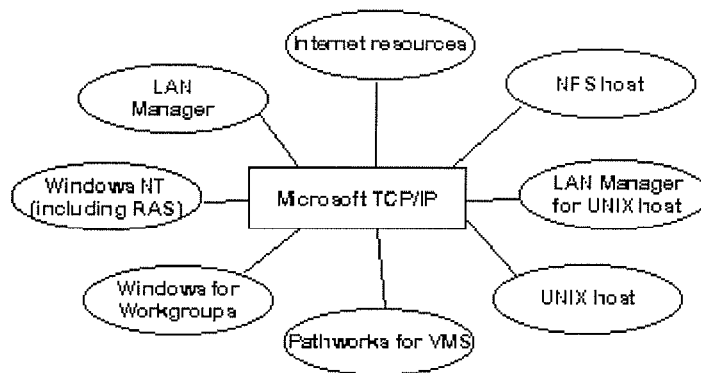
Public-domain Windows-based utilities such as LPR and Gopher can be obtained on the Internet via ftp.cica.indiana.edu in the /pub/win3/nt or /pub/win3/winsock directory, or via the same directories on ftp.cdrom.com.

Windows NT Solutions in TCP/IP Internetworks

TCP/IP for Heterogeneous Networking

Because most modern operating systems (in addition to Windows NT) support TCP/IP protocols, an internetwork with mixed system types can share information using simple networking applications and utilities. With TCP/IP as a connectivity protocol, Windows NT can communicate with many non-Microsoft systems, including:

- Internet hosts
- Apple® Macintosh® systems
- IBM® mainframes
- UNIX systems
- Open VMS® systems
- Printers with network adapters connected directly to the network



Microsoft TCP/IP Connectivity

Microsoft TCP/IP provides a framework for interoperable heterogeneous networking. The modular architecture of Windows NT networking with its transport-independent services contributes to the strength of this framework. For example, Windows NT supports these transport protocols, among many others:

- IPX/SPX for use in NetWare environments, using the Microsoft NWLink transport. Besides providing interoperability with NetWare networks, IPX/SPX is a fast LAN transport for Windows networking as well.
- TCP/IP for internetworks based on IP technologies. TCP/IP is the preferred transport for internetworks and provides interoperability with UNIX and other TCP/IP-based networks.
- NetBEUI as the protocol for local area networking on smaller networks and compatibility with existing LAN Manager and Lan Server networks.
- AppleTalk® for connecting to and sharing resources with Macintosh systems.

Other transport protocols provided by third-party vendors, such as DECnet™ and OSI, can also be used by Windows NT networking services.

Windows NT provides standard network programming interfaces through the Windows Sockets, RPC, and NetBIOS interfaces. Developers can take advantage of this heterogeneous client-server platform to create custom applications that will run on any system in the

enterprise. An example of such a service is Microsoft SQL Server, which uses Windows Sockets 1.1 to provide access to NetWare, MS-DOSbased, Windows NT, and UNIX clients.

Windows NT Solutions in TCP/IP Internetworks

Using TCP/IP with Third-Party Software

TCP/IP is a common denominator for heterogeneous networking, and Windows Sockets is a standard used by application developers. Together they provide a framework for cross-platform client-server development. TCP/IP-aware applications from vendors that comply with the Windows Sockets standards can run over virtually any TCP/IP implementation.

The Windows Sockets standard ensures compatibility with Windows-based TCP/IP utilities developed by more than 30 vendors. This includes third-party applications for the X Window System, sophisticated terminal emulation software, NFS, electronic mail packages, and more. Because Windows NT offers compatibility with 16-bit Windows Sockets, applications created for Windows 3.x Windows Sockets will run over Windows NT without modification or recompilation.

For example, third-party applications for X Window provide strong connectivity solutions by means of X Window servers, database servers, and terminal emulation. With such applications, a Windows NT computer can work as an X Window server platform while retaining compatibility with applications created for Windows NT, Windows 3.1, and MS-DOS on the same system. Other third-party software includes X Window client libraries for Windows NT, which allow developers to write X Window client applications on Windows NT that can be run and displayed remotely on X Window server systems.

The Windows Sockets API is a networking API used by programmers creating applications for both the Microsoft Windows NT and Windows operating systems. Windows Sockets is an open standard that is part of the Microsoft Windows Open System Architecture (WOSA) initiative. It is a public specification based on Berkeley UNIX sockets, which means that UNIX applications can be quickly ported to Microsoft Windows and Windows NT. Windows Sockets provides a single standard programming interface supported by all the major vendors implementing TCP/IP for Windows systems.

The Windows NT TCP/IP utilities use Windows Sockets, as do 32-bit TCP/IP applications developed by third parties. Windows NT also uses the Windows Sockets interface to support Services for Macintosh and IPX/SPX in NWLink. Under Windows NT, 16-bit Windows-based applications created under the Windows Sockets standard will run without modification or recompilation. Most TCP/IP users will use programs that comply with the Windows Sockets standard, such as **ftp** or **telnet** or third-party applications.

The Windows Sockets standard allows a developer to create an application with a single common interface and a single executable that can run over many of the TCP/IP implementations provided by vendors. The goals for Windows Sockets are the following:

- Provide a familiar networking API to programmers using Windows NT, Windows for Workgroups, or UNIX
- Offer binary compatibility between vendors for heterogeneous Windows-based TCP/IP stacks and utilities
- Support both connection-oriented and connectionless protocols

Typical Windows Sockets applications include graphic connectivity utilities, terminal emulation software, Simple Mail Transfer Protocol (SMTP) and electronic mail clients, network printing utilities, SQL client applications, and corporate client-server applications.

If you are interested in developing a Windows Sockets application, specifications for Windows Sockets are available on the Internet from ftp.microsoft.com, on CompuServe® in the MSL

library, and in the Microsoft Win32® Software Developers Kit.

▶ **To get a copy of the Windows Sockets specification via anonymous FTP**

1. Make sure you have write permission in your current working directory.
2. Start **ftp** and connect to **ftp.microsoft.com** (or **198.105.232.1**).
3. Log on as **anonymous**.
4. Type your electronic mail address for the *password*.
5. Type **cd ladvsys\winsock\spec11** and press ENTER.
6. Use the **dir** command to see the list of available file types. If you want binary data such as in the Microsoft Word version, type **bin** and press ENTER.
7. Determine the file with the format you want [for example, ASCII (.TXT), PostScript® (.PS), or Microsoft Word (.DOC)], and then type **get winsock.ext** where *ext* is the format that you want, such as **winsock.doc** for the Microsoft Word version.

▶ **To get a copy of the Windows Sockets specification from CompuServe**

1. Type **go msl** and press ENTER.
2. Browse using the keywords **windows sockets**.
3. Choose the file with the format you want [ASCII (.TXT), PostScript (.PS), or Microsoft Word for Windows (.DOC)], and then type **get winsock.ext**.

There is also an electronic mailing list designed for discussion of Windows Sockets programming.

▶ **To subscribe to the Windows Sockets mailing list**

- Send electronic mail to listserv@sunsite.unc.edu with a message body that contains **subscribe winsock** *user's-email-address*.

You can use the same procedure to subscribe to two mailing lists called **winsock-hackers** and **winsock-users**.

Installing and Configuring Microsoft TCP/IP and SNMP

This chapter explains how to install TCP/IP and the SNMP service for Windows NT and how to configure the protocols on your computer.

The TCP/IP protocol family can be installed as part of Custom Setup when you install Windows NT, following the steps described in this chapter. Also, if you upgrade to a new version of Windows NT, Setup automatically installs the new TCP/IP protocol and preserves your previous TCP/IP settings. This chapter assumes that Windows NT has been successfully installed on your computer but TCP/IP has not been installed.

The following topics appear in this chapter:

- Before installing Microsoft TCP/IP
- Installing TCP/IP
- Configuring TCP/IP
- Configuring TCP/IP to use DNS
- Configuring advanced TCP/IP options
- Configuring SNMP
- Removing TCP/IP components
- Configuring Remote Access Service (RAS) for use with TCP/IP



You must be logged on as a member of the Administrators group to install and configure all elements of TCP/IP.

Before Installing Microsoft TCP/IP

Important

The values that you will use for manually configuring TCP/IP and SNMP must be supplied by the network administrator.

Check with your network administrator to find out the following information before you install Microsoft TCP/IP on a Windows NT computer:

- Whether you can use Dynamic Host Configuration Protocol (DHCP) to configure TCP/IP. You can choose this option if a DHCP server is installed on your internetwork. You cannot choose this option if this computer will be a DHCP server. For information, see "Using Dynamic Host Configuration Protocol" later in this chapter.
- Whether this computer will be a DHCP server. This option is available only for Windows NT Server. For information, see Chapter 4, "Installing and Configuring DHCP Servers."
- Whether this computer will be a Windows Internet Name Service (WINS) server. This option is available only for Windows NT Server. For information, see Chapter 5, "Installing and Configuring WINS Servers."
- Whether this computer will be a WINS proxy agent. For information, see "Windows Internet Name Service and Broadcast Name Resolution" in Chapter 3, "Networking Concepts for TCP/IP."

If you cannot use DHCP for automatic configuration, you need to obtain these values from the network administrator so you can configure TCP/IP manually:

- The IP address and subnet mask for each network adapter card installed on the computer. For information, see "IP Addressing" in Chapter 3.
- The IP address for the default local gateways (IP routers).
- Whether your computer will use Domain Name System (DNS) and, if so, the IP addresses and DNS domain name of the DNS servers on the internetwork. For information, see "Domain Name System Addressing" in Chapter 3.
- The IP addresses for WINS servers, if WINS servers are available on your network.

You need to know the following information before you install the Simple Network Management Protocol (SNMP) service on your computer, as described in "Configuring SNMP" later in this chapter:

- Community names in your network
- Trap destination for each community
- IP addresses or computer names for SNMP management hosts

Installing TCP/IP



You must be logged on as a member of the Administrators group for the local computer to install and configure TCP/IP.

► To install Microsoft TCP/IP on a Windows NT computer

1. Start the Network option in Control Panel.
2. In the Network Settings dialog box, choose the Add Software button.
3. In the Add Network Software dialog box, select TCP/IP Protocol And Related Components from the Network Software list, and then choose the Continue button.
4. In the Windows NT TCP/IP Installation Options dialog box, check the options for the TCP/IP components you want to install, as described in the table that follows this procedure, and then choose the Continue button.

If any TCP/IP elements have been installed previously, these are dimmed and not available in the Windows NT TCP/IP Installation Options dialog box.

You can read the hint bar at the bottom of each TCP/IP dialog box for information about a selected item, or choose the Help button to get detailed online information while you are installing or configuring TCP/IP.

5. Windows NT Setup displays a message asking for the full path to the Windows NT distribution files. Provide the appropriate location, and choose the Continue button.

You can specify a drive letter for floppy disks, a CD-ROM drive, or a shared network directory, or you can specify the Universal Naming Convention (UNC) path name for a network resource, such as \\NTSETUP\MASTER.

All necessary files are copied to your hard disk.

Note

If you are installing from floppy disks, Windows NT Setup may request disks more than once. This is normal and is not an error condition.

6. If you selected the options for installing the SNMP and FTP Server services, you are automatically asked to configure these services. Follow the directions provided in the online Help for these dialog boxes. For additional details, see "Configuring SNMP" later in this chapter, and see also Chapter 7, "Using the Microsoft FTP Server Service."
7. In the Network Settings dialog box, choose OK.

If you checked the Enable Automatic DHCP Configuration option and a DHCP server is available on your network, all configuration settings for TCP/IP are completed automatically, as described in "Using Dynamic Host Configuration Protocol" later in this chapter.

If you did not check the Enable Automatic DHCP Configuration option, continue with the

configuration procedures described in "Configuring TCP/IP Manually" later in this chapter. TCP/IP must be configured in order to operate.

If you checked the DHCP Server Service or WINS Server Service options, you must complete the configuration steps described in Chapters 4 and 5.

Windows NT TCP/IP Installation Options

Option	Usage
TCP/IP Internetworking	Includes the TCP/IP protocol, NetBIOS over TCP/IP and Windows Sockets interfaces, and the TCP/IP diagnostic utilities. These elements are installed automatically.
Connectivity Utilities	Installs the TCP/IP utilities. Select this option to install the connectivity utilities described in Chapter 11, "Utilities Reference."
SNMP Service	Installs the SNMP service. Select this option to allow this computer to be administered remotely using management tools such as Sun Net Manager or HP Open View. This option also allows you to monitor statistics for the TCP/IP services and WINS servers using Performance Monitor, as described in Chapter 8, "Using Performance Monitor with TCP/IP Services."
TCP/IP Network Printing Support	Allows this computer to print directly over the network using TCP/IP. Select this option if you want to print to UNIX print queues or TCP/IP printers that are connected directly to the network, as described in Chapter 9, "Internetwork Printing with TCP/IP." This option must be installed if you want to use the Lpdsvr service so that UNIX computers can print to Windows NT printers.
FTP Server Service	Allows files on this computer to be shared over the network with remote computers that support FTP and TCP/IP (especially non-Microsoft network computers). Select this option if you want to use TCP/IP to share files with other computers, as described in Chapter 7, "Using the Microsoft FTP Server Service."
Simple TCP/IP Services	Provides the client software for the Character Generator, Daytime, Discard, Echo, and Quote of the Day services. Select this option to allow this computer to respond to requests from other systems that support these protocols.
DHCP Server Service	Installs the server software to support automatic configuration and addressing for computers using TCP/IP on your internetwork. This option is available only for Windows NT Server. Select this option if this computer is to be a DHCP Server, as described in Chapter 4, "Installing and Configuring DHCP Servers." If you select this option, you must manually configure the IP address, subnet mask, and default gateway for this computer.
WINS Server Service	Installs the server software to support WINS, a dynamic name resolution service for computers on a Windows internetwork. This option is available only for Windows NT Server. Select this option if this computer is to be installed as a primary or secondary WINS server, as described in Chapter 5, "Installing and Configuring WINS Servers." Do not select this option if this computer will be a WINS proxy agent.
Enable Automatic DHCP Configuration	Turns on automatic configuration of TCP/IP parameters for this computer. Select this option if there is a DHCP server on your internetwork to support dynamic host configuration. This is the preferred method for configuring TCP/IP on most Windows NT computers. This option is not available if the DHCP Server Service or WINS Server Service option is selected.

If you have trouble installing Microsoft TCP/IP on your computer, follow the suggestions in the error messages. You can also use diagnostic utilities such as **ping** to isolate network hardware problems and incompatible configurations. For information, see Chapter 10, "Troubleshooting TCP/IP."

After TCP/IP is installed, the `\systemroot\SYSTEM32\DRIVERS\ETC` directory contains several files, including default HOSTS, NETWORKS, PROTOCOLS, QUOTES, and SERVICES files plus a sample LMHOSTS.SAM file that describes the format for this file.

Configuring TCP/IP

For TCP/IP to work on your computer, it must be configured with the IP addresses, subnet mask, and default gateway for each network adapter on the computer. Microsoft TCP/IP can be configured using two different methods:

- If there is a DHCP server on your internetwork, it can automatically configure TCP/IP for your computer using DHCP.
- If there is no DHCP server, or if you are configuring a Windows NT Server computer to be a DHCP server, you must manually configure all TCP/IP settings.

These options are described in this section.

Configuring TCP/IP

Using DHCP

The best method for ensuring easy and accurate installation of TCP/IP is to use automatic DHCP configuration, which uses DHCP to configure your local computer with the correct IP address, subnet mask, and default gateway.

You can take advantage of this method for configuring TCP/IP if there is a DHCP server installed on your network. The network administrator can tell you if this option is available. You cannot use DHCP configuration for a server that you are installing as a DHCP server. You must configure TCP/IP settings manually for DHCP servers, as described in "Configuring TCP/IP Manually" later in this chapter.

▶ To configure TCP/IP using DHCP

1. Make sure the Enable Automatic DHCP Configuration option is checked in either the Windows NT TCP/IP Installation Options dialog box or the TCP/IP Configuration dialog box.
2. When you restart the computer after completing TCP/IP installation, the DHCP server automatically provides the correct configuration information for your computer.

If you subsequently attempt to configure TCP/IP in the Network Settings dialog box, the system will warn you that any manual settings will override the automatic settings provided by DHCP. As a general rule, you should not change the automatic settings unless you specifically want to override a setting provided by DHCP. For detailed information about DHCP, see "Dynamic Host Configuration Protocol" in Chapter 3, "Networking Concepts for TCP/IP."

Configuring TCP/IP

Configuring TCP/IP Manually

After the Microsoft TCP/IP protocol software is installed on your computer, you must manually provide valid addressing information if you are installing TCP/IP on a DHCP server or if you cannot use automatic DHCP configuration.



You must be logged on as a member of the Administrators group for the local computer to configure TCP/IP.

Caution

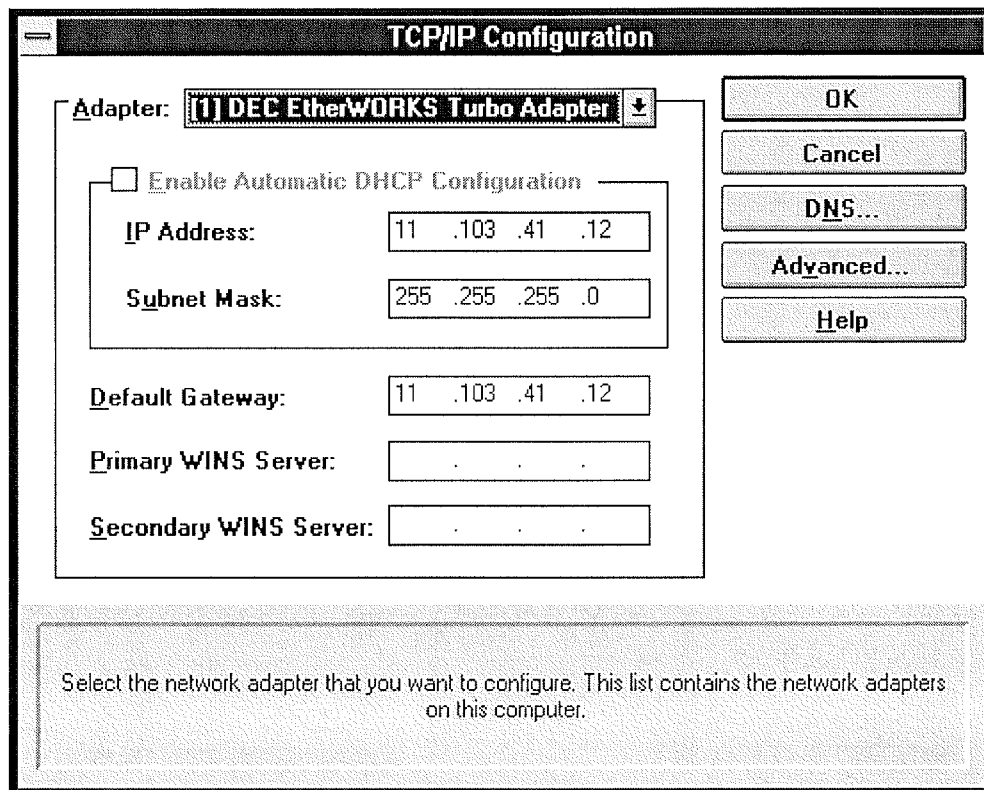
Be sure to use the values for IP addresses and subnet masks that are supplied by your network administrator to avoid duplicate addresses. If duplicate addresses do occur, this can cause some computers on the network to function unpredictably. For more information, see "IP Addressing" in Chapter 3, "Networking Concepts for TCP/IP."

▶ To manually configure the TCP/IP protocol

1. When you are installing TCP/IP, the Microsoft TCP/IP Configuration dialog box appears automatically when you choose the OK button in the Network Settings dialog box after completing all options in the Windows NT TCP/IP Installation Options dialog box.

Or

If you are reconfiguring TCP/IP, start the Network option in Control Panel to display the Network Settings dialog box. In the Installed Network Software list box, select TCP/IP Protocol, and choose the Configure button.



2. In the Adapter list of the TCP/IP Configuration dialog box, select the network adapter for which you want to set IP addresses.

The Adapter list contains all network adapters to which IP is bound on this computer. This list includes all adapters installed on this computer.

You must set specific IP addressing information for each bound adapter with correct values provided by the network administrator. The bindings for a network adapter

determine how network protocols and other layers of network software work together.

3. For each bound network adapter, type values in the IP Address and Subnet Mask boxes.
 - The value in the IP Address box identifies the IP address for your local computer or, if more than one network card is installed in the computer, for the network adapter card selected in the Adapter box.
 - The value in the Subnet Mask box identifies the network membership for the selected network adapter and its host ID. This allows the computer to separate the IP address into host and network IDs. The subnet mask defaults to an appropriate value, as shown in the following list:

κ DNS:name resolution:search order κ TCP/IP:configuring:name resolution search order κ
Name resolution:search order

Address class	Range of first octet in IP address	Subnet mask
Class A	1126	255.0.0.0
Class B	128191	255.255.0.0
Class C	192223	255.255.255.0

4. For each network adapter on the computer, type the correct IP address value in the Default Gateway box, as provided by the network administrator.

This value specifies the IP address of the default gateway (or IP router) used to forward packets to other networks or subnets. This value should be the IP address of your local gateway.

This parameter is required only for systems on internetworks. If this parameter is not provided, IP functionality will be limited to the local subnet unless a route is specified with the TCP/IP **route** utility, as described in Chapter 11, "Utilities Reference."

If your computer has multiple network cards, additional default gateways can be added using the Advanced Microsoft TCP/IP Configuration dialog box, as described later in this chapter.

5. If there are WINS servers installed on your network and you want to use WINS in combination with broadcast name queries to resolve computer names, type IP addresses in the boxes for the primary and, optionally, the secondary WINS servers. The network administrator should provide the correct values for these parameters. These are global values for the computer, not just individual adapters.

If an address for a WINS server is not specified, this computer will use name query broadcasts (the b-node mode for NetBIOS over TCP/IP) plus the local LMHOSTS file to resolve computer names to IP addresses. Broadcast resolution is limited to the local network.

Note

WINS name resolution is enabled and configured automatically for a computer that is configured with DHCP.

On a WINS server, NetBIOS over TCP/IP (NETBT.SYS) uses WINS on the local computer as the primary name server, regardless of how name resolution may be configured. Also, NetBIOS over TCP/IP binds to the first IP address on a network adapter and ignores any additional addresses.

For overview information about name resolution options, see "Name Resolution for Windows Networking" in Chapter 3. For detailed information about installing and configuring WINS servers, see Chapter 5.

6. If you want to configure the advanced TCP/IP options for multiple gateways and other items, choose the Advanced button, and continue with the configuration procedure, as described in "Configuring Advanced TCP/IP Options" later in this chapter.
7. If you want to use DNS for host name resolution, choose the DNS button, and continue with the configuration procedure, as described in the next section.
8. If you do not want to configure DNS or advanced options, or if you have completed the other configuration procedures, choose the OK button. When the Network Settings dialog box reappears, choose the OK button.

Microsoft TCP/IP has been configured. If you are installing TCP/IP for the first time, you

must restart the computer for the configuration to take effect. If you are changing your existing configuration, you do not have to restart your computer.

After TCP/IP is installed, the `\systemroot\SYSTEM32\DRIVERS\ETC` directory contains a default HOSTS file and a sample LMHOSTS.SAM file. The network administrator may require that replacement HOSTS and LMHOSTS files be used instead of these default files.

Configuring TCP/IP to Use DNS

Although TCP/IP uses IP addresses to identify and reach computers, users typically prefer to use computer names. DNS is a naming service generally used in the UNIX networking community to provide standard naming conventions for IP workstations. Windows Sockets applications and TCP/IP utilities, such as **ftp** and **telnet**, can also use DNS in addition to the HOSTS file to find systems when connecting to foreign hosts or systems on your network.

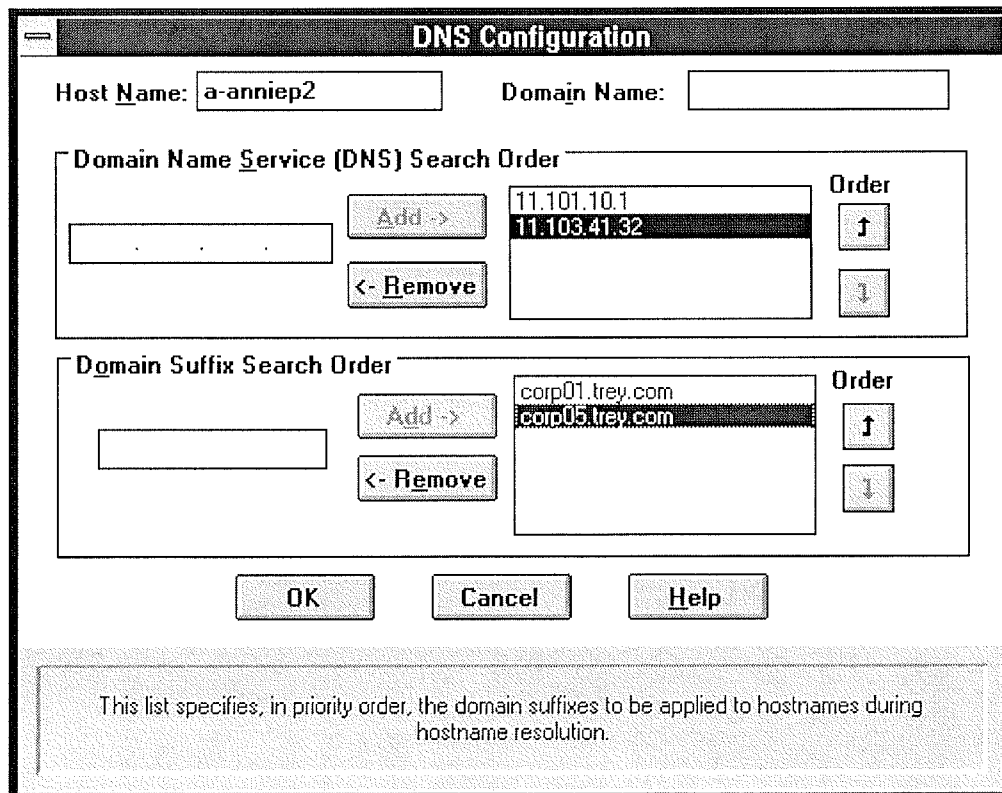
Contact the network administrator to find out whether you should configure your computer to use DNS. Usually you will use DNS if you are using TCP/IP to communicate over the Internet or if your private internetwork uses DNS to distribute host information. For information, see "Domain Name System Addressing" in Chapter 3.

Microsoft TCP/IP includes DNS client software for resolving Internet or UNIX system names. Microsoft Windows networking provides dynamic name resolution for NetBIOS computer names via WINS servers and NetBIOS over TCP/IP.

DNS configuration is global for all network adapters installed on a computer.

► **To configure TCP/IP DNS connectivity**

1. Start the Network option in Control Panel to display the Network Settings dialog box. In the Installed Network Software list box, select TCP/IP Protocol, and then choose the Configure button.
2. In the TCP/IP Configuration dialog box, choose the DNS button.



3. In the DNS Configuration dialog box, you can, optionally, type a name in the Host Name box (usually your computer name).

The name can be any combination of AZ letters, 09 numerals, and the hyphen (-) plus the period (.) character used as a separator. By default, this value is the Windows NT computer name, but the network administrator can assign another host name without affecting the computer name.

Note

Some characters that can be used in Windows NT computer names, particularly the underscore, cannot be used in host names.

The host name is used to identify the local computer by name for authentication by some utilities. Other TCP/IP-based utilities, such as **rexec**, can use this value to learn the name of the local computer. Host names are stored on DNS servers in a table that maps names to IP addresses for use by DNS.

4. Optionally, type a name in the Domain Name box. This is usually an organization name followed by a period and an extension that indicates the type of organization, such as microsoft.com.

The name can be any combination of AZ letters, 09 numerals, and the hyphen (-) plus the period (.) character used as a separator.

This DNS Domain Name is used with the host name to create a fully qualified domain name (FQDN) for the computer. The FQDN is the host name followed by a period (.) followed by the domain name. For example, this could be **corp01.research.trey.com**, where **corp01** is the host name and **research.trey.com** is the domain name. During DNS queries, the local domain name is appended to short names.

Note

A DNS domain is not the same as a Windows NT or LAN Manager domain.

5. In the Domain Name System (DNS) Search Order box, type the IP address of the DNS server that will provide name resolution. Then choose the Add button to move the IP address to the list on the right. The network administrator should provide the correct values for this parameter.

You can add up to three IP addresses for DNS servers. The servers running DNS will be queried in the order listed. To change the order of the IP addresses, select an IP address to move, and then use the up- and down-arrow buttons. To remove an IP address, select it and choose the Remove button.

6. In the Domain Suffix Search Order box, type the domain suffixes to add to your domain suffix search list, and then choose the Add button.

This list specifies the DNS domain suffixes to be appended to host names during name resolution. You can add up to six domain suffixes. To change the search order of the domain suffixes, select a domain name to move, and use the up- and down-arrow buttons. To remove a domain name, select it and choose the Remove button.

7. When you are done setting DNS options, choose the OK button.
8. When the TCP/IP Configuration dialog box reappears, choose the OK button. When the Network Settings dialog box reappears, choose the OK button.

The settings take effect after you restart the computer.

Configuring Advanced TCP/IP Options

If your computer has multiple network adapters connected to different networks using TCP/IP, you can choose the Advanced button in the TCP/IP Configuration dialog box to configure options for the adapters or to configure alternate default gateways.

► To configure or reconfigure advanced TCP/IP options

1. Start the Network option in Control Panel to display the Network Settings dialog box. In the Installed Network Software list box, select TCP/IP Protocol and choose the Configure button.
2. In the TCP/IP Configuration dialog box, choose the Advanced button.

The screenshot shows the 'TCP/IP Configuration' dialog box with the 'Advanced' tab selected. The 'Adapter' dropdown is set to '[1] DEC EtherWORKS Turbo Adapter'. The 'IP Address' and 'SubnetMask' fields are empty. The 'Default Gateway' field is empty. The 'IP Addresses' table contains two entries: 11.103.41.12 with Subnet Mask 255.255.255.0, and 11.101.0.1 with Subnet Mask 255.255.255.0. The 'Default Gateway' list contains 11.103.41.12. The 'Windows Networking Parameters' section has 'Enable DNS for Windows Name Resolution' unchecked, 'Enable LMHOSTS Lookup' checked, and 'Scope ID' empty. 'Enable IP Routing' and 'Enable WINS Proxy Agent' are also unchecked. The 'Import LMHOSTS...' button is visible. At the bottom, there are 'OK', 'Cancel', and 'Help' buttons. A footer note reads: 'Type additional IP addresses for the selected network adapter.'

IP Addresses	Subnet Masks
11.103.41.12	255.255.255.0
11.101.0.1	255.255.255.0

Windows Networking Parameters

Enable DNS for Windows Name Resolution

Enable LMHOSTS Lookup

Scope ID:

Enable IP Routing

Enable WINS Proxy Agent

Type additional IP addresses for the selected network adapter.

3. In the Adapter box of the Advanced Microsoft TCP/IP Configuration dialog box, select the network adapter for which you want to specify advanced configuration values. The IP address and default gateway settings in this dialog box are defined only for the selected network adapter.

4. In the IP Address and SubnetMask boxes, type an additional IP address and subnet mask for the selected adapter. Then choose the Add button to move the IP address to the list on the right. The network administrator should provide the correct values for this parameter.

Optionally, if your network card uses multiple IP addresses, repeat this process for each additional IP address. You can specify up to five additional IP addresses and subnet masks for identifying the selected network adapter. This can be useful for a computer connected to one physical network that contains multiple logical IP networks.

5. In the Default Gateway box, type the IP address for an additional gateway that the selected adapter can use. Then choose the Add button to move the IP address to the list on the right. Repeat this process for each additional gateway. The network administrator should provide the correct values for this parameter.

This list specifies up to five additional default gateways for the selected network adapter.

To change the priority order for the gateways, select an address to move and use the up- or down-arrow buttons. To remove a gateway, select it and choose the Remove button.

6. If you want to use DNS for DNS name resolution on Windows networks, check the Enable DNS For Windows Name Resolution option.

If this option is checked, the system finds the DNS server by using the IP address specified in the DNS Configuration dialog box, as described earlier in this chapter. Checking this option enables DNS name resolution for use by Windows networking applications.

7. If you want to use the LMHOSTS file for NetBIOS name resolution on Windows networks, check the Enable LMHOSTS Lookup option. If you already have a configured LMHOSTS file, choose the Import LMHOSTS button and specify the directory path for the LMHOSTS file you want to use. By default, Windows NT uses the LMHOSTS file found in `\systemroot\SYSTEM32\DRIVERS\ETC`.

For any method of name resolution used in a Windows NT network, the LMHOSTS file is consulted last after querying WINS or using broadcasts, but before DNS is consulted.

8. In the Scope ID box, type the computer's scope identifier, if required on an internetwork that uses NetBIOS over TCP/IP.

To communicate with each other, all computers on a TCP/IP internetwork must have the same scope ID. Usually this value is left blank. A scope ID may be assigned to a group of computers that will communicate only with each other and no other systems. Such computers can find each other if their scope IDs are identical. Scope IDs are used only for communication based on NetBIOS over TCP/IP.

The network administrator should provide the correct value, if required.

9. To turn on static IP routing, check the Enable IP Routing option.

This option allows this computer to participate with other static routers on a network. You should check this option if you have two or more network cards and your network uses static routing, which also requires the addition of static routing tables. For information about creating static routing tables, see the **route** utility in Chapter 11, "Utilities Reference."

This option is not available if your computer has only one network adapter and one IP address. Also, this option does not support routers running the Routing Information Protocol (RIP).

10. If you want this computer to be used to resolve names based on the WINS database,

check the Enable WINS Proxy Agent option.

This option allows the computer to answer name queries for remote computers, so other computers configured for broadcast name resolution can benefit from the name resolution services provided by a WINS server.

This option is available only if you entered a value for a primary WINS server in the TCP/IP Configuration dialog box, as described in "Configuring TCP/IP" earlier in this chapter. However, the proxy agent cannot be run on a computer that is also a WINS server.

Consult with the network administrator to determine whether your computer should be configured as a WINS proxy agent, as only a few computers on each subnetwork should be configured for this feature.

11. When you are done setting advanced options, choose the OK button. When the TCP/IP Configuration dialog box reappears, choose the OK button. When the Network Settings dialog box reappears, choose the OK button to complete advanced TCP/IP configuration.

You must restart the computer for the changes to take effect.

Configuring SNMP

The SNMP service is installed when you check the SNMP Service option in the Windows NT TCP/IP Installation Options dialog box. After the SNMP service software is installed on your computer, you must configure it with valid information for SNMP to operate.



You must be logged on as a member of the Administrators group for the local computer to configure SNMP.

The SNMP configuration information identifies communities and trap destinations.

- A *community* is a group of hosts to which a Windows NT computer running the SNMP service belongs. You can specify one or more communities to which the Windows NT computer using SNMP will send traps. The community name is placed in the SNMP packet when the trap is sent.

When the SNMP service receives a request for information that does not contain the correct community name and does not match an accepted host name for the service, the SNMP service can send a trap to the trap destination(s), indicating that the request failed authentication.

- *Trap destinations* are the names or IP addresses of hosts to which you want the SNMP service to send traps with the selected community name.

You might want to use SNMP for statistics, but may not care about identifying communities or traps. In this case, you can specify the "public" community name when you configure the SNMP service.

► To configure the SNMP service

1. Start the Network option in Control Panel to display the Network Settings dialog box. In the Installed Network Software list box, select SNMP Service, and choose the Configure button. The SNMP Service Configuration dialog box appears.

The screenshot shows the 'SNMP Service Configuration' dialog box. It is divided into two main sections. The top section, titled 'Send Trap with Community Names', features a list box containing 'public' and 'engineering' (which is selected). To the right of this list are '< Add' and 'Remove ->' buttons, and a text field labeled 'Community Names'. The bottom section, titled 'Trap Destination for engineering', features a list box containing '102.54.0.3' (which is selected). To the right of this list are '< Add' and 'Remove ->' buttons, and a text field labeled 'IP Host/Address or IPX Address'. On the right side of the dialog, there are five buttons: 'OK', 'Cancel', 'Security...', 'Agent...', and 'Help'.

2. To identify each community to which you want this computer to send traps, type the name in the Community Names box. After typing each name, choose the Add button to move the name to the Send Traps With Community Names list on the left.

Typically, all hosts belong to public, which is the standard name for the common community of all hosts. To delete an entry in the list, select it and choose the Remove button.

Note

Community names are case sensitive.

3. To specify hosts for each community you send traps to, after you have added the community and while it is still highlighted, type the hosts in the IP Host/Address Or IPX Address box. Then choose the Add button to move the host name or IP address to the Trap Destination for the *selected community* list on the left.

You can enter a host name, its IP address, or its IPX address.

To delete an entry in the list, select it and choose the Remove button.

4. To enable additional security for the SNMP service, choose the Security button. Continue with the configuration procedure, as described in the next section, "Configuring SNMP Security."
5. To specify Agent information (comments about the user, location, and services), choose the Agent button. Continue with the configuration procedure, as described in "Configuring SNMP Agent Information" later in this chapter.
6. When you have completed all procedures, choose the OK button. When the Network Settings dialog box reappears, choose the OK button.

The Microsoft SNMP service has been configured and is ready to start. It is not necessary to reboot the computer.

2

Configuring SNMP

Configuring SNMP Security

SNMP security allows you to specify the communities and hosts a computer will accept requests from, and to specify whether to send an authentication trap when an unauthorized community or host requests information.

► **To configure SNMP security**

1. Start the Network option in Control Panel to display the Network Settings dialog box. In the Installed Network Software list box, select SNMP Service and choose the Configure button.
2. In the SNMP Service Configuration dialog box, choose the Security button.

SNMP Security Configuration

Send Authentication Trap

Accepted Community Names

public
engineering

<- Add Community Name

Remove -> []

Accept SNMP Packets from Any Host

Only Accept SNMP Packets from These Hosts:

[]

<- Add IP Host/Address or IPX Address:

Remove -> 11.101.41.12

OK
Cancel
Help

3. If you want to send a trap for failed authentications, select the Send Authentication Trap check box in the SNMP Security Configuration dialog box.
4. In the Community Name box, type the community names you will accept requests from. Choose the Add button after typing each name to move the name to the Accepted Community Names list on the left.

A host must belong to a community that appears on this list for the SNMP service to accept requests from that host. Typically, all hosts belong to public, which is the standard name for the common community of all hosts. To delete an entry in the list, select it and choose the Remove button.

5. Select an option to specify whether to accept SNMP packets from any host or from only specified hosts.
 - If the Accept SNMP Packets From Any Host option is selected, no SNMP packets are rejected on the basis of source host ID. The list of hosts under Only Accept SNMP Packets From These Hosts has no effect.
 - If the Only Accept SNMP Packets From These Hosts option is selected, SNMP packets will be accepted only from the hosts listed. In the IP Host/Address Or IPX Address box, type the host names, IP addresses, or IPX addresses of the hosts from which you will accept requests. Then choose the Add button to move the host name or IP address to the list box on the left. To delete an entry in the list, select it and choose the Remove button.
6. Choose the OK button. The SNMP Service Configuration dialog box reappears.

To specify Agent information (comments about the user, location, and services), choose the Agent button. Continue with the configuration procedure, as described in the next section.
7. After you complete all procedures, choose the OK button. When the Network Settings dialog box reappears, choose the OK button.

The Microsoft SNMP service and SNMP security have been configured and are ready to start. You do not need to reboot the computer.

Configuring SNMP

Configuring SNMP Agent Information

SNMP agent information allows you to specify comments about the user and the physical location of the computer and to indicate the types of service to report. The types of service that can be reported are based on the computer's configuration.

► To configure SNMP agent information

1. Start the Network option in Control Panel to display the Network Settings dialog box. In the Installed Network Software list box, select SNMP Service and choose the Configure button.
2. In the SNMP Service Configuration dialog box, choose the Agent button.

3. In the SNMP Agent dialog box, type the computer user's name in the Contact box and the computer's physical location in the Location box. These are comments that will be used as text and cannot include embedded control characters.
4. Select the services to report in the Service box. Check all boxes that indicate network capabilities provided by your Windows NT computer. SNMP must have this information to manage the enabled services.

If you have installed additional TCP/IP services, such as a bridge or router, you should consult RFC 1213 for additional information.

Option	Meaning
Physical	Select this option if this Windows NT computer manages any physical TCP/IP device, such as a repeater.
Datalink/Subnetwork	Select this option if this Windows NT computer manages a TCP/IP subnetwork or datalink, such as a bridge.
Internet	Select this option if this Windows NT computer acts as an IP gateway.
End-to-End	Select this option if this Windows NT computer acts as an IP host. This option should be selected for all Windows NT installations.

Applications

Select this option if this Windows NT computer includes any applications that use TCP/IP, such as electronic mail. This option should be selected for all Windows NT installations.

5. Choose the OK button.
6. When the SNMP Service Configuration dialog box reappears, choose the OK button. When the Network Settings dialog box reappears, choose the OK button.

SNMP is now ready to operate without rebooting the computer.

Removing TCP/IP Components

If you want to remove the TCP/IP protocols or any of the services installed on a computer, use the Network option in Control Panel to remove it.

When you remove any network software, Windows NT warns you that the action permanently removes that component. You cannot reinstall a component that has been removed until after you restart the computer.

▶ **To remove any TCP/IP component**

1. In Control Panel, choose the Network option.
2. In the Installed Network Software list in the Network Settings dialog box, select the component that you want to remove.
3. Choose the Remove button.

Configuring RAS for Use with TCP/IP

Windows NT users who install Remote Access Service (RAS) for remote networking maintain all the benefits of TCP/IP networking, including access to the WINS and DNS capabilities of Microsoft TCP/IP. RAS clients can be configured to use Point to Point Protocol (PPP) or Serial Line Internet Protocol (SLIP) to allow TCP/IP dial-up support for existing TCP/IP internetworks and the Internet. When PPP is configured on a Windows NT Remote Access server, it can function as a router for RAS clients. SLIP client software is provided to support older implementations; it does not support multiple protocols.

As with all network services, you install RAS by using the Network option in Control Panel. During RAS installation and configuration, you can specify the network protocol settings to use for RAS connections, which also allows you to specify TCP/IP configuration settings. When the network administrator installs a Microsoft RAS server, IP addresses are reserved for use by RAS clients.

Users with RAS client computers can use the Remote Access program to enter and maintain names and telephone numbers of remote networks. RAS clients can connect to and disconnect from these networks through the Remote Access program. You can also use the Remote Access Phone Book application to select the network protocols to use for a specific Phone Book entry. If TCP/IP is installed, the Phone Book automatically selects TCP/IP over PPP as the protocol.

If a RAS client computer has a serial COM port, you can use the Remote Access Phone Book application to configure SLIP for use with a selected Phone Book entry. If you configure a RAS client computer to use the SLIP option, when you dial in for a connection to the selected Phone Book entry, the Terminal screen appears, and you can begin an interactive session with a SLIP server. When you use SLIP, Remote Access Phone Book bypasses user authentication. You will not be asked for a username and password.

For complete information about setting up RAS servers and clients and using RAS with Windows NT, see *Windows NT Server Remote Access Service*.

Networking Concepts for TCP/IP

This chapter describes how TCP/IP fits in the Windows NT network architecture and explains the various components of the Internet Protocol suite and IP addressing. As part of the discussion on name resolution in Windows networking, this chapter also describes NetBIOS over TCP/IP and Domain Name System (DNS). For additional information about these topics, see the books listed in "Finding More Information" in "Welcome."

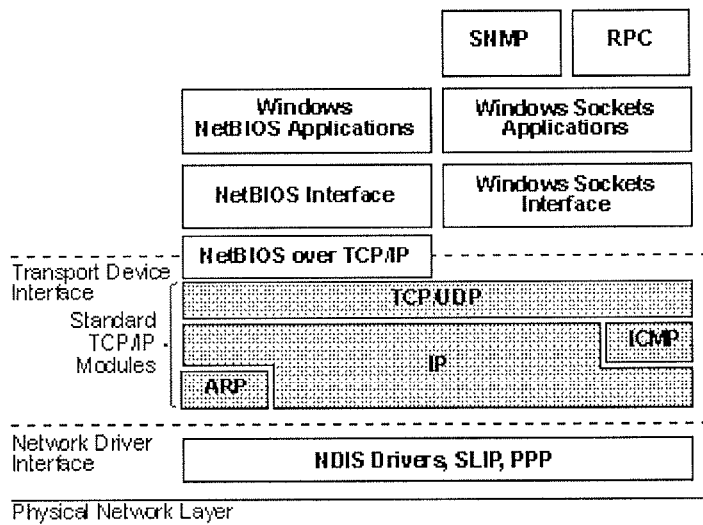
This chapter also provides conceptual information about two key features for Microsoft TCP/IP: Dynamic Host Configuration Protocol (DHCP) and Windows Internet Name Service (WINS).

The following topics appear in this chapter:

- TCP/IP and Windows NT networking
- Internet protocol suite
- IP addressing
- Name resolution for Windows networking
- SNMP

TCP/IP and Windows NT Networking

The architecture of the Microsoft Windows NT operating system with integrated networking is protocol-independent. This architecture, illustrated in the following figure, provides Windows NT file, print, and other services over any network protocol that uses exports from the TDI interface. The protocols package network requests for applications in their respective formats and send the requests to the appropriate network adapter via the *network device interface specification* (NDIS) interface. The NDIS specification allows multiple network protocols to reside over a wide variety of network adapters and media types.



Architectural Model of Windows NT with TCP/IP

Under the Windows NT transport-independent architecture, TCP/IP is a protocol family that can be used to offer Windows networking capabilities. The TCP/IP protocol gives Windows NT, Windows for Workgroups, and LAN Manager computers transparent access to each other and allows communication with non-Microsoft systems in the enterprise network.

Internet Protocol Suite

TCP/IP refers to the Internet suite of protocols. It includes a set of standards that specify how computers communicate and gives conventions for connecting networks and routing traffic through the connections.

The Internet protocols are a result of a Defense Advanced Research Projects Agency (DARPA) research project on network interconnection in the late 1970s. It was mandated on all United States defense long-haul networks in 1983 but was not widely accepted until it was integrated with 4.2 Berkeley Software Distribution (BSD) UNIX. The popularity of TCP/IP is based on:

- Robust client-server framework. TCP/IP is an excellent client-server application platform, especially in wide-area network (WAN) environments.
- Information sharing. Thousands of academic, military, scientific, and commercial organizations share data, electronic mail, and services on the Internet using TCP/IP.
- General availability. Implementations of TCP/IP are available on nearly every popular computer operating system. Source code is widely available for many implementations. Vendors for bridges, routers, and network analyzers all offer support for the TCP/IP protocol suite within their products.

The following discussion introduces the components of the IP protocol suite. Some knowledge of the architecture and interaction between TCP/IP components is useful for both administrators and users, but most of the details discussed here are transparent when you are actually using TCP/IP.

Internet Protocol Suite

Transmission Control Protocol and Internet Protocol

Transmission Control Protocol (TCP) and Internet Protocol (IP) are only two members of the IP protocol suite. IP is a protocol that provides packet delivery for all other protocols within the TCP/IP family. IP provides a best-effort, connectionless delivery system for computer data. That is, IP packets are not guaranteed to arrive at their destination, nor are they guaranteed to be received in the sequence in which they were sent. The protocol's checksum feature confirms only the IP header's integrity. Thus, responsibility for the data contained within the IP packet (and the sequencing) is assured only by using higher-level protocols.

Perhaps the most common higher-level IP protocol is TCP. TCP supplies a reliable, connection-based protocol over (or encapsulated within) IP. TCP guarantees the delivery of packets, ensures proper sequencing of the data, and provides a checksum feature that validates both the packet header and its data for accuracy. In the event that the network either corrupts or loses a TCP/IP packet during transmission, TCP is responsible for retransmitting the faulty packet. This reliability makes TCP/IP the protocol of choice for session-based data transmission, client-server applications, and critical services such as electronic mail.

This reliability has a price. TCP headers require the use of additional bits to provide proper sequencing of information, as well as a mandatory checksum to ensure reliability of both the TCP header and the packet data. To guarantee successful data delivery, the protocol also requires the recipient to acknowledge successful receipt of data.

Such acknowledgments (or ACKs) generate additional network traffic, diminishing the level of data throughput in favor of reliability. To reduce the impact on performance, most hosts send an acknowledgment for every other segment or when an ACK timeout expires.

Internet Protocol Suite

User Datagram Protocol

If reliability is not essential, User Datagram Protocol (UDP), a TCP complement, offers a connectionless datagram service that guarantees neither delivery nor correct sequencing of delivered packets (much like IP). Higher-level protocols or applications may provide reliability mechanisms in addition to UDP/IP. UDP data checksums are optional, providing a way to exchange data over highly reliable networks without unnecessarily consuming network resources or processing time. When UDP checksums are used, they validate both header and data. ACKs are also not enforced by the UDP protocol; this is left to higher-level protocols.

UDP also offers one-to-many service capabilities, because it can be either broadcast or multicast.

Internet Protocol Suite

Address Resolution Protocol and Internet Control Message Protocol

Two other protocols in the IP suite perform important functions, although these are not directly related to the transport of data: Address Resolution Protocol (ARP) and Internet Control Message Protocol (ICMP). ARP and ICMP are maintenance protocols that support the IP framework and are usually invisible to users and applications.

IP packets contain both source and destination IP addresses, but the hardware address of the destination computer system must also be known. IP acquires a system's hardware address by broadcasting a special inquiry packet (an ARP *request packet*) containing the IP address of the system with which it is attempting to communicate. All of the ARP-enabled nodes on the local IP network detect these broadcasts, and the system that owns the IP address in question replies by sending its hardware address to the requesting computer system in an ARP reply packet. The hardware/IP address mapping is then stored in the requesting system's ARP cache for subsequent use. Because the ARP reply can also be broadcast to the network, it is likely that other nodes on the network can use this information to update their own ARP caches. (You can use the **arp** utility to view the ARP tables.)

ICMP allows two nodes on an IP network to share IP status and error information. This information can be used by higher-level protocols to recover from transmission problems or by network administrators to detect network trouble. Although ICMP packets are encapsulated within IP packets, they are not considered to be a higher-level protocol (ICMP is required in every TCP/IP implementation). The **ping** utility makes use of the ICMP *echo request* and *echo reply* packets to determine whether a particular IP node (computer system) on a network is functional. This is useful for diagnosing IP network or gateway failures.

IP Addressing

A host is any device attached to the network that uses TCP/IP. To receive and deliver packets successfully between hosts, TCP/IP relies on three pieces of information that the user provides: IP address, subnet mask, and default gateway.

The network administrator provides each of these pieces of information for configuring TCP/IP on a computer. Windows NT users on networks with DHCP servers can take advantage of automatic system configuration and do not need to manually configure TCP/IP parameters. This section provides details about IP addresses, subnet masks, and IP gateways.

IP Addressing

IP Addresses

Every host interface, or node, on a TCP/IP network is identified by a unique IP address. This address is used to identify a host on a network; it also specifies routing information in an internetwork. The *IP address* identifies a computer as a 32-bit address that is unique across a TCP/IP network. An address is usually represented in dotted decimal notation, which depicts each octet (eight bits, or one byte) of an IP address as its decimal value and separates each octet with a period. An IP address looks like this:

102.54.94.97

Important

Because IP addresses identify nodes on an interconnected network, each host on the internetwork must be assigned a unique IP address, valid for its particular network.

Network ID and Host ID

Although an IP address is a single value, it contains two pieces of information: the network ID and the host (or system) ID for your computer.

- The *network ID* identifies a group of computers and other devices that are all located on the same logical network, which are separated or interconnected by routers. In internetworks (networks formed by a collection of local area networks), there is a unique network ID for each network.
- The *host ID* identifies your computer within a particular network ID. (A host is any device that is attached to the network and uses TCP/IP.)

Networks that connect to the public Internet must obtain an official network ID from the InterNIC to guarantee IP network ID uniqueness. The InterNIC can be contacted via electronic mail at info@internic.net (for the United States, 18004444345 or, for Canada and overseas, 6194554600). Internet registration requests can be sent to hostmaster@internic.net. You can also use FTP to connect to is.internic.net, then log in as **anonymous**, and change to the /INFOSOURCE/FAQ directory.

After receiving a network ID, the local network administrator must assign unique host IDs for computers within the local network. Although private networks not connected to the Internet can choose to use their own network identifier, obtaining a valid network ID from InterNIC allows a private network to connect to the Internet in the future without reassigning addresses.

The Internet community has defined address *classes* to accommodate networks of varying sizes. Each network class can be discerned from the first octet of its IP address. The following table summarizes the relationship between the first octet of a given address and its network ID and host ID fields. It also identifies the total number of network IDs and host IDs for each address class that participates in the Internet addressing scheme. This sample uses w.x.y.z to designate the bytes of the IP address.

IP Address Classes

Class	w values ^{1,2}	Network ID	Host ID	Available networks	Available hosts per net
A	1126	w	x.y.z	126	16,777,214

B	128191	w.x	y.z	16,384	65,534
C	192223	w.x.y	z	2,097,151	254

- 1 Inclusive range for the first octet in the IP address.
- 2 The address 127 is reserved for loopback testing and interprocess communication on the local computer; it is not a valid network address. Addresses 224 and above are reserved for special protocols (IGMP multicast and others), and cannot be used as host addresses.

A network host uses the network ID and host ID to determine which packets it should receive or ignore and to determine the scope of its transmissions (only nodes with the same network ID accept each other's IP-level broadcasts).

Because the sender's IP address is included in every outgoing IP packet, it is useful for the receiving computer system to derive the originating network ID and host ID from the IP address field. This is done by using subnet masks, as described in the following section.

Subnet Masks

Subnet masks are 32-bit values that allow the recipient of IP packets to distinguish the network ID portion of the IP address from the host ID. Like an IP address, the value of a subnet mask is frequently represented in dotted decimal notation. Subnet masks are determined by assigning 1's to bits that belong to the network ID and 0's to the bits that belong to the host ID. Once the bits are in place, the 32-bit value is converted to dotted decimal notation, as shown in the following table.

Default Subnet Masks for Standard IP Address Classes

Address class	Bits for subnet mask	Subnet mask
Class A	11111111 00000000 00000000 00000000	255.0.0.0
Class B	11111111 11111111 00000000 00000000	255.255.0.0
Class C	11111111 11111111 11111111 00000000	255.255.255.0

The result allows TCP/IP to determine the host and network IDs of the local computer. For example, when the IP address is 102.54.94.97 and the subnet mask is 255.255.0.0, the network ID is 102.54 and the host ID is 94.97.

Although configuring a host with a subnet mask might seem redundant after examining the previous tables (since the class of a host is easily determined), subnet masks are also used to further segment an assigned network ID among several local networks.

For example, suppose a network is assigned the Class-B network address 144.100. This is one of over 16,000 Class-B addresses capable of serving more than 65,000 nodes. However, the worldwide corporate network to which this ID is assigned is composed of 12 international LANs with 75 to 100 nodes each. Instead of applying for 11 more network IDs, it is better to use subnetting to make more effective use of the assigned ID 144.100. The third octet of the IP address can be used as a subnet ID, to define the subnet mask 255.255.255.0. This splits the Class-B address into 254 subnets: 144.100.1 through 144.100.254, each of which can have 254 nodes. (Host IDs 0 and 255 should not be assigned to a computer; they are used as broadcast addresses, which are typically recognized by all computers.) Any 12 of these network addresses could be assigned to the international LANs in this example. Within each LAN, each computer is assigned a unique host ID, and they all have the subnet mask 255.255.255.0.

The preceding example demonstrates a simple (and common) subnet scheme for Class-B addresses. Sometimes it is necessary to segment only portions of an octet, using only a few

bits to specify subnet IDs (such as when subnets exceed 256 nodes). Each user should check with the local network administrator to determine the network's subnet policy and the correct subnet mask. For all systems on the local network, the subnet mask must be the same for that network ID.

Important

All computers on a logical network must use the same subnet mask and network ID; otherwise, addressing and routing problems can occur.

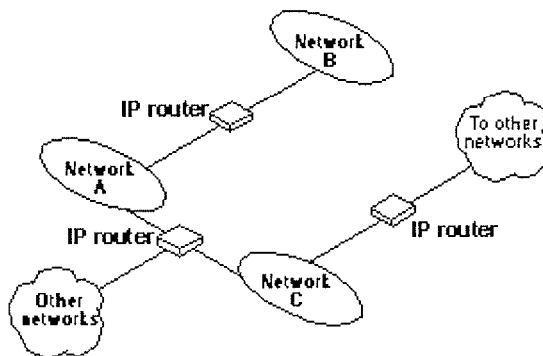
IP Addressing

Routing and IP Gateways

TCP/IP networks are connected by *gateways* (or routers), which have knowledge of the networks connected in the internetwork. Although each IP host can maintain static routes for specific destinations, usually the default gateway is used to find remote destinations. (The *default gateway* is needed only for computers that are part of an internetwork.)

When IP prepares to send a packet, it inserts the local (source) IP address and the destination address of the packet in the IP header and checks whether the network ID of the destination matches the network ID of the source. If they match, the packet is sent directly to the destination computer on the local network. If the network IDs do not match, the routing table is examined for static routes. If none are found, the packet is forwarded to the default gateway for delivery.

The default gateway is a computer connected to the local subnet and other networks that has knowledge of the network IDs for other networks in the internetwork and how to reach them. Because the default gateway knows the network IDs of the other networks in the internetwork, it can forward the packet to other gateways until the packet is eventually delivered to a gateway connected to the specified destination. This process is known as *routing*.



Internetwork Routing Through Gateways

On networks that are not part of an internetwork, IP gateways are not required. If a network is part of an internetwork and a system does not specify a default gateway (or if the gateway computer is not operating properly), only communication beyond the local subnet is impaired. Users can add static routes by using the **route** utility to specify a route for a particular system. Static routes always override the use of default gateways.

If the default gateway becomes unavailable, the computer cannot communicate outside its own subnet. Multiple default gateways can be assigned to prevent such a problem. When a computer is configured with multiple default gateways, retransmission problems result in the system trying the other routers in the configuration to ensure internetworking communications capabilities. To configure multiple default gateways in Windows NT, you must provide an IP address for each gateway in the Advanced Microsoft TCP/IP Configuration dialog box, as described in Chapter 2, "Installing and Configuring Microsoft TCP/IP and SNMP."

IP Addressing

Dynamic Host Configuration Protocol

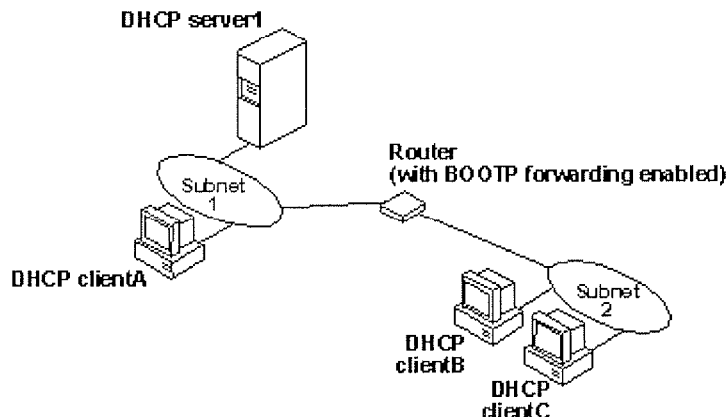
Assigning and maintaining IP address information can be an administrative burden for network administrators responsible for internetwork connections. Contributing to this burden is the problem that many users do not have the knowledge necessary to configure their own computers for internetworking and must therefore rely on their administrators.

The Dynamic Host Configuration Protocol (DHCP) was established to relieve this administrative burden. DHCP provides safe, reliable, and simple TCP/IP network configuration, ensures that address conflicts do not occur, and helps conserve the use of IP addresses through centralized management of address allocation. DHCP offers dynamic configuration of IP addresses for computers. The system administrator controls how IP addresses are assigned by specifying *lease durations*, which specify how long a computer can use an assigned IP address before having to renew the lease with the DHCP server.

As an example of how maintenance tasks are made easy with DHCP, the IP address is released automatically for a DHCP client computer that is removed from a subnet, and a new address for the new subnet is automatically assigned when that computer reconnects on another subnet. Neither the user nor the network administrator needs to intervene to supply new configuration information. This is a most significant feature for mobile computer users with portables that are docked at different computers, or for computers that are moved to different offices frequently.

The DHCP client and server services for Windows NT are implemented under Requests for Comments (RFCs) 1533, 1534, 1541, and 1542.

The following illustration shows an example of a DHCP server providing configuration information on two subnets. If, for example, ClientC is moved to Subnet 1, the DHCP server will automatically supply new TCP/IP configuration information the next time that ClientC is started.



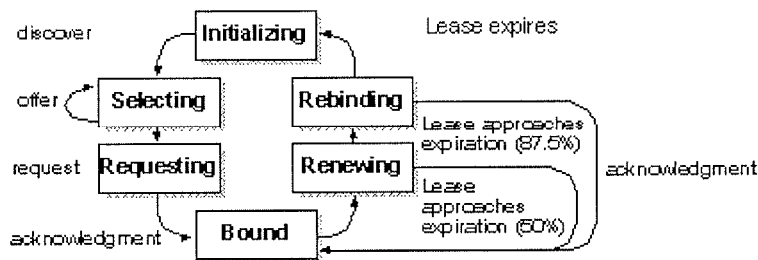
DHCP Clients and Servers on a Routed Network

DHCP uses a client-server model and is based on leases for IP addresses. During system startup (the *initializing* state), a DHCP client computer sends a *discover message* that is broadcast to the local network and may be relayed to all DHCP servers on the private

internetwork. Each DHCP server that receives the discover message responds with an *offer message* containing an IP address and valid configuration information for the client that sent the request.

The DHCP client collects the configuration offerings from the servers and enters a *selecting* state. When the client enters the *requesting* state, it chooses one of the configurations and sends a *request message* that identifies the DHCP server for the selected configuration.

The selected DHCP server sends a *DHCP acknowledgment message* that contains the address first sent during the discovery stage, plus a valid lease for the address and the TCP/IP network configuration parameters for the client. After the client receives the acknowledgment, it enters a *bound* state and can now participate on the TCP/IP network and complete its system startup. Client computers that have local storage save the received address for use during subsequent system startup. As the lease approaches its expiration date, it attempts to renew its lease with the DHCP server, and is assigned a new address if the current IP address lease cannot be renewed.



DHCP Client State Transition During System Startup

In Windows NT Server, the network administrator uses DHCP Manager to define local policies for address allocation, leases, and other options. For information about using this tool, see Chapter 4, "Installing and Configuring DHCP Servers." For information about the steps for setting up TCP/IP using DHCP, see "Configuring TCP/IP" in Chapter 2, "Installing and Configuring Microsoft TCP/IP and SNMP." For information about setting up DHCP relaying, see the documentation for your router.

Name Resolution for Windows Networking

Configuring Windows NT with TCP/IP requires the IP address and computer name, which are unique identifiers for the computer on the network. The IP address, as described earlier in this chapter, is the unique address by which all other TCP/IP devices on the internetwork recognize that computer. For TCP/IP and the Internet, the computer name is the globally known system name plus a DNS domain name. (On the local network, the computer name is the NetBIOS name that was defined during Windows NT Setup.)

Computers use IP addresses to identify each other, but users usually find it easier to work with computer names. A mechanism must be available on a TCP/IP network to resolve names to IP addresses. To ensure that both name and address are unique, the Windows NT computer using TCP/IP registers its name and IP address on the network during system startup. A Windows NT computer can use one or more of the following methods to ensure accurate name resolution in TCP/IP internetworks:

- Windows Internet Name Service

Windows NT computers can use WINS if one or more WINS servers are available that contain a dynamic database mapping computer names to IP addresses. WINS can be used in conjunction with broadcast name resolution for an internetwork where other name resolution methods are inadequate. As described in the following section, WINS is a NetBIOS over TCP/IP mode of operation defined in RFC 1001/1002 as p-node.

- Broadcast name resolution

Windows NT computers can also use broadcast name resolution, which is a NetBIOS over TCP/IP mode of operation defined in RFC 1001/1002 as b-node. This method relies on a computer making IP-level broadcasts to register its name by announcing it on the network. Each computer in the broadcast area is responsible for challenging attempts to register a duplicate name and for responding to name queries for its registered name.

- DNS name resolution

The Domain Name System (DNS) provides a way to look up name mappings when connecting a computer to foreign hosts using NetBIOS over TCP/IP or Windows Sockets applications such as FTP. DNS is a distributed database designed to relieve the traffic problems that arose with the exploding growth of the Internet in the early 1980s.

- An LMHOSTS file to specify the NetBIOS computer name and IP address mappings, or a HOSTS file to specify the DNS name and IP address

On a local computer, the HOSTS file (used by Windows Sockets applications to find TCP/IP host names) and LMHOSTS file (used by NetBIOS over TCP/IP to find Microsoft networking computer names) can be used to list known IP addresses mapped with corresponding computer names. LMHOSTS is still used for name resolution in Windows NT for small-scale networks or remote subnets where WINS is not available.

This section provides details about name resolution in Windows NT after first presenting some background information about the modes of NetBIOS over TCP/IP that can be used in Microsoft networks.

Name Resolution for Windows Networking

NetBIOS over TCP/IP and Name Resolution

NetBIOS over TCP/IP is the session-layer network service that performs name-to-IP address mapping for name resolution. This section describes the modes of NetBIOS over TCP/IP, as defined in RFCs 1001 and 1002 to specify how NetBIOS should be implemented over TCP/IP.

The modes of NetBIOS over TCP/IP define how network resources are identified and accessed. The two most important aspects of the related naming activities are registration and resolution. *Registration* is the process used to acquire a unique name for each node (computer system) on the network. A computer typically registers itself when it starts. *Resolution* is the process used to determine the specific address for a computer name.

The NetBIOS over TCP/IP modes include the following:

- b-node, which uses broadcasts to resolve names
- p-node, which uses point-to-point communications with a name server to resolve names
- m-node, which uses b-node first (broadcasts), then p-node (name queries) if the broadcast fails to resolve a name
- h-node, which uses p-node first for name queries, then b-node if the name service is unavailable or if the name is not registered in the WINS database

For DHCP users on a Windows NT network, the node type is assigned by the DHCP server. When WINS servers are in place on the network, NetBIOS over TCP/IP resolves names on a client computer by communicating with the WINS server. When WINS servers are not in place, NetBIOS over TCP/IP uses b-node broadcasts to resolve names. NetBIOS over TCP/IP in Windows NT can also use LMHOSTS files and DNS for name resolution, depending on how TCP/IP is configured on a particular computer. In Windows NT 3.5, the NETBT.SYS module provides the NetBIOS over TCP/IP functionality that supports name registration and resolution modes.

Windows NT version 3.5 supports all of the NetBIOS over TCP/IP modes described in the following sections. NetBIOS over TCP/IP is also used with the LAN Manager 2.x Server message protocol.

B-Node

The b-node mode uses broadcasts for name registration and resolution. That is, if NT_PC1 wants to communicate with NT_PC2 it will broadcast to all machines that it is looking for NT_PC2 and then wait a specified time for NT_PC2 to respond. B-node has two major problems:

- In a large environment, it loads the network with broadcasts.
- Routers do not forward broadcasts, so computers that are on opposite sides of a router will never hear the requests.

P-Node

The p-node mode addresses the issues that b-node does not solve. In a p-node environment, computers neither create nor respond to broadcasts. All computers register themselves with the WINS server, which is a NetBIOS Name Server (NBNS) with enhancements. The WINS server is responsible for knowing computer names and addresses and for ensuring no duplicate names exist on the network. All computers must be configured to know the address

of the WINS server.

In this environment, when NT_PC1 wants to communicate with NT_PC2, it queries the WINS server for the address of NT_PC2. When NT_PC1 gets the appropriate address from the WINS server, it goes directly to NT_PC2 without broadcasting. Because the name queries go directly to the WINS server, p-node avoids loading the network with broadcasts. Because broadcasts are not used and because the address is received directly, computers can span routers.

The most significant problems with p-node are the following:

- All computers must be configured to know the address of the WINS server (although this is typically configured via DHCP)
- If for any reason the WINS server is down, computers that rely on the WINS server to resolve addresses cannot get to any other systems on the network, even if they are on the local network

M-Node

The m-node mode was created primarily to solve the problems associated with b-node and p-node. This mode uses a combination of b-node and p-node. In an m-node environment, a computer first attempts registration and resolution using b-node. If that is successful, it then switches to the p-node. Because this uses b-node first, it does not solve the problem of generating broadcast traffic on the network. However, m-node can cross routers. Also, because b-node is always tried first, computers on the same side of a router continue to operate as usual if the WINS server is down.

M-node uses broadcasts for performance optimization, because in most environments local resources are used more frequently than remote resources. Also, in a Windows NT network, m-node can cause problems with NetLogon in routed environments.

H-Node

The h-node mode, which is currently in RFC draft form, is also a combination of b-node and p-node that uses broadcasts as a last effort. Because p-node is used first, no broadcasts are generated if the WINS server is running, and computers can span routers. If the WINS server is down, b-node is used, so computers on the same side of a router continue to operate as usual.

The h-node mode does more than change the order for using b-node and p-node. If the WINS server is down so that local broadcasts (b-node) must be used, the computer will continue to poll the WINS server. As soon as the WINS server can be reached again, the system switches back to p-node. Also, optionally on a Windows network, h-node can be configured to use LMHOSTS after broadcast name resolution fails.

The h-node mode solves the most significant problems associated with broadcasts and operating in a routed environment. For Microsoft TCP/IP users who configure TCP/IP manually, h-node is used by default, unless the user does not specify addresses for WINS servers when configuring TCP/IP.

B-Node with LMHOSTS and Combinations

Another variation is also used in Microsoft networks to span routers without a WINS server and p-node mode. In this mode, b-node uses a list of computers and addresses stored in an LMHOSTS file. If a b-node attempt fails, the system looks in LMHOSTS to find a name and then uses the associated address to cross the router. However, each computer must have this list, which creates an administrative burden in maintaining and distributing the list. Both Windows for Workgroups 3.11 and LAN Manager 2.x used such a modified b-node system. Windows NT uses this method if WINS servers are not used on the network. In Windows NT,

some extensions have been added to this file to make it easier to manage (as described in Chapter 6, "Setting Up LMHOSTS"), but modified b-node is not an ideal solution.

Some sites may need to use both b-node and p-node modes at the same site. Although this configuration can work, administrators must exercise extreme caution in doing so, using it only for transition situations. Because p-node hosts disregard broadcasts and b-node hosts rely on broadcasts for name resolution, the two hosts can potentially be configured with the same NetBIOS name, leading to unpredictable results. Notice that if a computer configured to use b-node has a static mapping in the WINS database, a computer configured to use p-node cannot use the same computer name.

Windows NT computers can also be configured as WINS proxy agents to help the transition to using WINS. For more details, see the next section.

Name Resolution for Windows Networking

Windows Internet Name Service and Broadcast Name Resolution

WINS provides a distributed database for registering and querying dynamic computer name-to-IP address mappings in a routed network environment. If you are administering a routed network, WINS is your best first choice for name resolution, because it is designed to solve the problems that occur with name resolution in complex internetworks.

WINS reduces the use of local broadcasts for name resolution and allows users to easily locate systems on remote networks. Furthermore, when dynamic addressing through DHCP results in new IP addresses for computers that move between subnets, the changes are automatically updated in the WINS database. Neither the user nor the network administrator needs to make manual accommodations for name resolution in such a case.

The WINS protocol is based on and is compatible with the protocols defined for NBNS in RFCs 1001/1002, so it is interoperable with any other implementations of these RFCs.

This section provides an overview of how WINS and name query broadcasts provide name resolution on Windows networks. For information about setting up WINS servers, see Chapter 5, "Installing and Configuring WINS Servers."

WINS in a Routed Environment

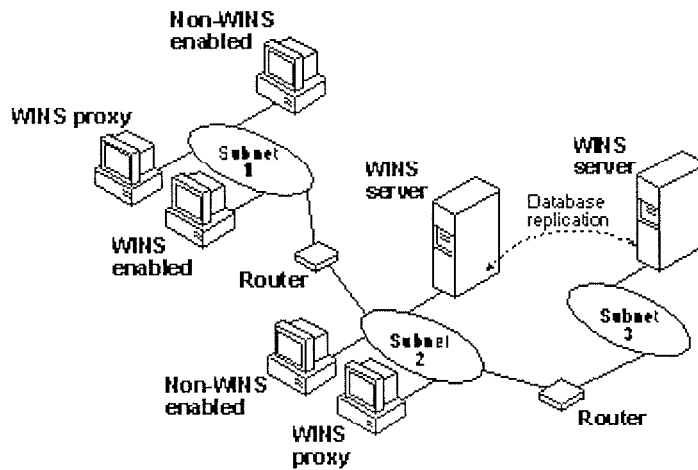
WINS consists of two components: the WINS server, which handles name queries and registrations, and the client software, which queries for computer name resolution.

Windows networking clients (WINS-enabled Windows NT or Windows for Workgroups 3.11 computers) can use WINS directly. Non-WINS computers on the internetwork that are b-node compatible as described in RFCs 1001 and 1002 can access WINS through proxies, which are WINS-enabled computers that listen to name query broadcasts and then respond for names that are not on the local subnet or are p-node computers.

On a Windows NT network, users can browse transparently across routers. To allow browsing without WINS, the network administrator must ensure that the users' primary domain has Windows NT Server or Windows NT Workstation computers on both sides of the router to act as master browsers. These computers need correctly configured LMHOSTS files with entries for the domain controllers across the subnet.

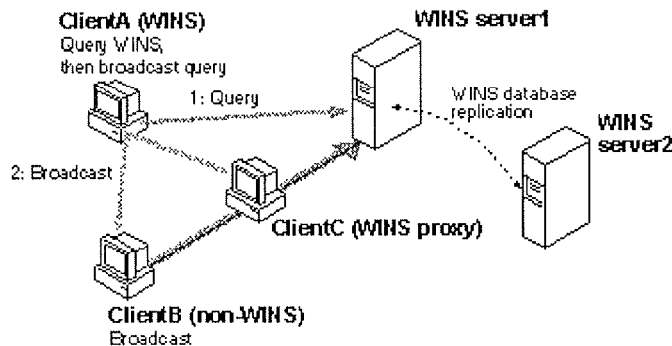
With WINS, such strategies are not necessary because the WINS servers and proxies transparently provide the support necessary for browsing across routers where domains span the routers.

The following illustration shows a small internetwork, with three local area networks connected by a router. Two of the subnets include WINS name servers, which can be used by clients on both subnets. WINS-enabled computers, including proxies, access the WINS server directly, and the computers using broadcasts access the WINS server through proxies. Proxies only pass name query packets and verify that registrations do not duplicate existing systems in the WINS database. Proxies, however, do not register b-node systems in the WINS database.



Example of an Internetwork with WINS Servers

The proxy communicates with the WINS server to resolve names (rather than maintaining its own database) and then caches the names for a certain time. The proxy serves as an intermediary, by either communicating with the WINS server or supplying a name-to-IP address mapping from its cache. The following illustration shows the relationships among WINS servers and clients, including proxies for non-WINS computers and the replication between WINS servers.



Example of Clients and Servers Using WINS

In the above illustration, ClientA can resolve names by first querying the WINS server and, if that fails, then using broadcast name queries. ClientB, which is not WINS-enabled, can only resolve names using broadcast name queries, but when ClientC receives the broadcast, it forwards the request to the WINS server and returns the address to ClientB.

However, a complex environment presents additional problems. For example, an internetwork might consist of two subnets, with all the computers belonging to DomainA attached to Subnet1, all the computers in DomainB attached to Subnet2, and computers from DomainC attached to either of the subnets. In this case, without WINS, DomainA computers can browse Subnet1, DomainB computers can browse Subnet2, and DomainC computers can browse both subnets as long as the primary domain controller for DomainC is available. With WINS, computers from all domains can browse all subnets if their WINS servers share databases.

If the Windows NT client computer is also DHCP-enabled and the administrator specifies WINS server information as part of the DHCP options, the computer will usually be automatically configured with WINS server information. You can manually configure WINS settings, as described in Chapter 2, "Installing and Configuring Microsoft TCP/IP and SNMP":

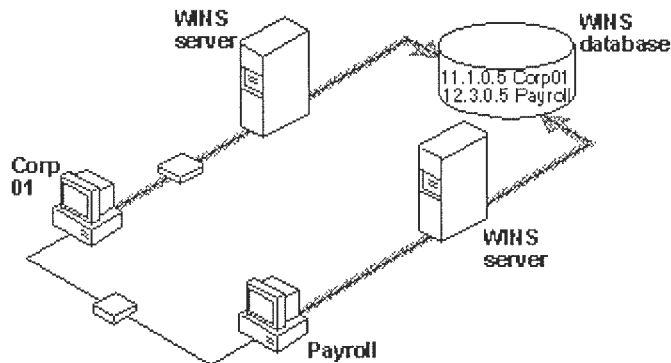
- To enable WINS name resolution for a computer that does not use DHCP, specify WINS server addresses in the TCP/IP Configuration dialog box
- To designate a proxy, check the Enable WINS Proxy Agent option in the Advanced Microsoft TCP/IP Configuration dialog box

With WINS servers in place on the internetwork, names are resolved using two basic methods, depending on whether WINS resolution is available and enabled on the particular computer. Whatever name resolution method is used, the process is transparent to the user after the system is configured.

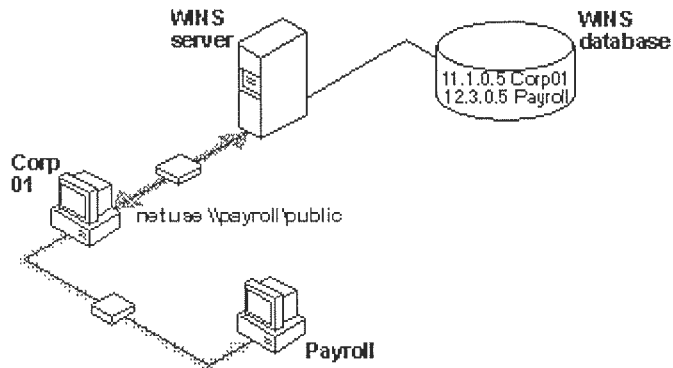
If WINS is not enabled The computer registers its name by broadcasting *name registration request* packets to the local subnet via UDP datagrams. To find a particular computer, the non-WINS computer broadcasts *name query request* packets on the local subnet, although this broadcast cannot be passed on through IP routers. If local name resolution fails, the local LMHOSTS file is consulted. These processes are followed whether the computer is a network server, a workstation, or other device.

If WINS is enabled The computer first queries the WINS server, and if that does not succeed, it broadcasts its name registration and query requests via UDP datagrams (h-node), in the following series of steps:

1. During TCP/IP configuration, the computer's name is registered with the WINS server, and the IP address of the WINS server is stored locally so the WINS server can be found on the internetwork. The WINS database is replicated among all WINS servers on the internetwork.



2. A *name query request* is sent first to the WINS server, including requests from remote clients that are routed through an IP router. This request is a UDP datagram. If the name is found in the WINS database, the client can establish a session based on the address mapping received from WINS.



3. If querying the WINS server does not succeed and if the client computer is configured as an h-node, the computer broadcasts *name query request* packets in the same manner as a non-WINS-enabled computer.
4. Finally, if other methods fail, the local LMHOSTS file is checked. This also includes a search of any centralized LMHOSTS files referred to in #INCLUDE statements, as described in Chapter 6, "Setting Up LMHOSTS."

WINS servers accept and respond to UDP name queries. Any name-to-IP address mapping registered with a WINS server can be provided reliably as a response to a name query. However, a mapping in the database does not ensure that the related device is currently running, only that a computer claimed the particular IP address and it is a currently valid mapping.

WINS Name Registration

Name registration ensures that the computer's name and IP address are unique for each device.

If WINS is enabled The name registration request is sent directly to the WINS server to be added to the database. A WINS server accepts or rejects a computer name registration depending on the current contents of its database. If the database contains a different address for that name, WINS challenges the current entry to determine whether that device still claims the name. If another device is using that name, WINS rejects the new name registration request. Otherwise, WINS accepts the entry and adds it to its local database together with a timestamp, an incremental unique version number, and other information.

If WINS is not enabled For a non-WINS computer to register its name, a *name registration request* packet is broadcast to the local network, stating its computer name and IP address. Any device on the network that previously claimed that name challenges the name registration with a *negative name registration response*, resulting in an error. If the registration request is not contested within a specific time period, the computer adopts that name and address.

Once a non-WINS computer has claimed a name, it must challenge duplicate name registration attempts and respond positively to name queries issued on its registered name by sending a *positive name query response*. This response contains the IP address of the computer so that the two systems can establish a session.

WINS Name Release

When a computer finishes with a particular name (such as when the Workstation service or Server service is stopped), it no longer challenges other registration requests for the name. This is referred to as *releasing a name*.

If WINS is enabled Whenever a computer is shut down properly, it releases its name to the WINS server, which marks the related database entry as *released*. If the entry remains released for a certain period of time, the WINS server marks it as *extinct*, and the version number is updated so that the database changes will be propagated among the WINS servers. *Extinct* entries remain in the database for a designated period of time to enable the change to be propagated to all WINS servers.

If a name is marked released at a WINS server and a new registration arrives using that name but a different address, the WINS server can immediately give that name to the requesting client because it knows that the old client is no longer using that name. (This might happen, for example, when a DHCP-enabled laptop changes subnets.) If that computer released its name during an orderly shutdown, the WINS server will not challenge the name. If the computer restarts because of a system reset, the name registration with a new address will cause the WINS server to challenge the registration, but the challenge will fail and the registration will succeed, because the computer no longer has the old address.

If WINS is not enabled When a non-WINS computer releases a name, a broadcast is made to allow any systems on the network that might have cached the name to remove it. Upon receiving name query packets specifying the deleted name, the computer simply ignores the request, allowing other computers on the network to acquire the name that it has released.

For non-WINS computers to be accessible from other subnets, their names must be added as static entries to the WINS database or in the LMHOSTS file(s) on the remote system(s), because they will only respond to name queries that originate on their local subnet.

WINS Name Renewal

A *renewal* is a timed reregistration of a computer's name with the WINS server. When the WINS server registers a name, it returns a renewal interval for the name, and the client must reregister within that time; otherwise, the WINS server will mark the name as released and available for use. A request for name renewal is treated the same as a new name registration.

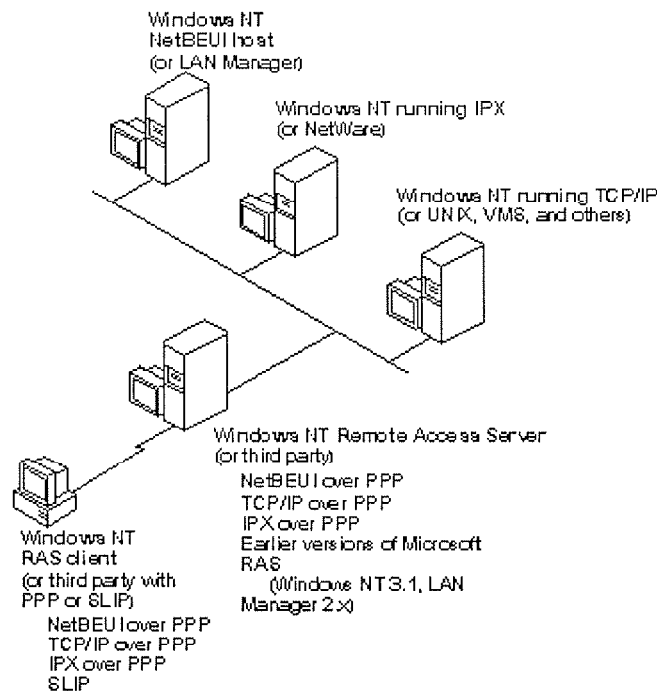
Renewal provides registration reliability through periodic reregistering of names with the WINS servers.

Name Resolution for Windows Networking

IP Addressing for RAS

Remote Access Service (RAS) provides remote networking for telecommuters, mobile workers, and system administrators who monitor and manage servers at multiple branch offices. Users with RAS on a Windows NT computer can dial in to remotely access their networks for services such as file and printer sharing, electronic mail, scheduling, and SQL database access.

Windows NT RAS works with IP routing for RAS servers so that RAS clients can use TCP/IP networks. (RAS can also work with IPX routing for clients that use NetWare networks.) Windows NT also uses the industry-standard Point to Point Protocol (PPP) and Serial Line IP (SLIP) standards. These standards ensure that Windows NT is interoperable with third-party remote-access server and client software. RAS clients can use DNS and WINS for name resolution services, and it can create TCP sessions with systems on the local network.



Network Access with RAS in Windows NT

The RAS server provides a pool of IP addresses that are reserved for static configuration during RAS installation. The IP addresses are automatically assigned to RAS clients using PPP when they dial in. If the administrator sets up the RAS server to use a static pool of addresses, all clients dialing into a particular RAS server are assigned the same network ID as the RAS server plus unique host IDs. (Of course, the network administrator must also reserve that range of static addresses on the DHCP server, if present, to make sure that those addresses are not assigned.)

RAS clients can connect to multiple TCP/IP networks that are logically joined (but physically separate) networks sharing the same address space. When using multiple connections, the

RAS client can still use DNS and WINS for name resolution.

For complete details about RAS, see the *Windows NT Server Remote Access Service* manual.

Name Resolution for Windows Networking

Name Resolution with Host Files

For computers located on remote subnets where WINS is not used, the HOSTS and LMHOSTS files provide mappings for names to IP addresses. This is the name resolution method used on internetworks before DNS and WINS were developed. The HOSTS file can be used as a local DNS equivalent. The LMHOSTS file can be used as a local WINS equivalent. Each of these files is also known as a *host table*. Sample versions of LMHOSTS and HOSTS files are added to the `\systemroot\SYSTEM32\DRIVERS\ETC` directory when you install Microsoft TCP/IP. These files can be edited using any ASCII editor, such as Notepad or Edit, which are part of Windows NT.

Microsoft TCP/IP can be configured to search HOSTS, the local host table file, for mappings of remote host names to IP addresses. The HOSTS file format is the same as the format for host tables in the 4.3 Berkeley Software Distribution (BSD) UNIX `/etc/hosts` file. For example, the entry for a computer with an address of 192.102.73.6 and a host name of `trey-research.com` looks like this:

```
192.102.73.6      trey-research.com
```

Edit the sample HOSTS file that is created when you install TCP/IP to include remote host names and their IP addresses for each computer with which you will communicate. This sample file also explains the syntax of the HOSTS file.

The LMHOSTS file is a local text file that maps IP addresses to NetBIOS computer names for Windows-networking computers that you will communicate with outside of the local subnet. For example, the LMHOSTS table file entry for a computer with an address of 192.45.36.5 and a computer name of `Finance1` looks like this:

```
192.45.36.5      finance1
```

The LMHOSTS file is read when WINS or broadcast name resolution fails, and resolved entries are stored in a system cache for later access.

When the computer uses the replicator service and does not use WINS, LMHOSTS entries are required on import and export servers for any computers on different subnets participating in the replication. LMHOSTS is also used for small-scale networks that do not have servers. For more information about the LMHOSTS file, see Chapter 6, "Setting Up LMHOSTS."

Name Resolution for Windows Networking

Domain Name System Addressing

The Domain Name System (DNS) is a distributed database providing a hierarchical naming system for identifying hosts on the Internet. DNS was developed to solve the problems that arose when the number of hosts on the Internet grew dramatically in the early 1980s. The specifications for DNS are defined in RFCs 1034 and 1035. Although DNS may seem similar to WINS, there is a major difference: DNS requires static configuration for computer name-to-IP address mapping, while WINS is fully dynamic and requires far less administration.

The DNS database is a tree structure called the domain name space, where each domain (node in the tree structure) is named and can contain subdomains. The domain name identifies the domain's position in the database in relation to its parent domain, with a period (.) separating each part of the names for the network nodes of the DNS domain.

The root of the DNS database is managed by the Internet Network Information Center. The top-level domains were assigned organizationally and by country. These domain names follow the international standard ISO 3166. Two-letter and three-letter abbreviations are used for countries, and various abbreviations are reserved for use by organizations, as shown in the following example.

DNS domain name abbreviation	Type of organization
com	Commercial (for example, microsoft.com)
edu	Educational (for example, mit.edu for Massachusetts Institute of Technology)
gov	Government (for example, nsf.gov for the National Science Foundation)
org	Noncommercial organizations (for example, fidonet.org for FidoNet)
net	Networking organizations (for example nsf.net for NSFNET)

Each DNS domain is administered by different organizations, which usually break their domains into subdomains and assign administration of the subdomains to other organizations. Each domain has a unique name, and each of the subdomains have unique names within their domains. The label for each network domain is a name of up to 63 characters. The *fully qualified domain name* (FQDN), which includes the names of all network domains leading back to the root, is unique for each host on the Internet. A particular DNS name could be similar to the following, for a commercial host:

accounting.trey.com

DNS uses a client-server model, where the DNS servers contain information about a portion of the DNS database and make this information available to clients, called *resolvers*, that query the name server across the network. DNS *name servers* are programs that store information about parts of the domain name space called *zones*. The administrator for a domain sets up name servers that contain the database files with all the resource records describing all hosts in their zones. DNS resolvers are clients that are trying to use name servers to gain information about the domain name space.

Windows NT includes the DNS resolver functionality used by NetBIOS over TCP/IP and by Windows Sockets connectivity applications such as **ftp** and **telnet** to query the name server and interpret the responses.

The key task for DNS is to present friendly names for users and then resolve those names to IP addresses, as required by the internetwork. Name resolution is provided through DNS by the name servers, which interpret the information in a FQDN to find its specific address. If a local name server doesn't contain the data requested in a query, it sends back names and addresses of other name servers that could contain the information. The resolver then queries the other name servers until it finds the specific name and address it needs. This process is made faster because name servers continuously cache the information learned about the domain name space as the result of queries.

All the resolver software necessary for using DNS on the Internet is installed with Microsoft TCP/IP. To use DNS for TCP/IP name resolution, you specify options in the DNS Configuration dialog box. For more information, see Chapter 2, "Installing and Configuring Microsoft TCP/IP and SNMP."

On computers with Windows NT Server 3.5, Windows NT Workstation 3.5, or Windows for Workgroups 3.11 with Microsoft TCP/IP-32 installed, Windows Socket applications can use either DNS or NetBIOS over TCP/IP for name resolution.

The following table compares DNS versus WINS name resolution.

WINS Versus DNS Name Resolution

Name provider capabilities	WINS	DNS
Provides scalable naming authority for large internetworks	Yes	Yes
Provides a dynamic, distributed naming authority for TCP/IP network names	Yes	Not dynamic
Supports MX records for electronic mail	No	Yes
Supports recursion and referral for name resolution	No	Yes
Provides hierarchical naming and resolution scheme	No	Yes
Includes DNS name server	No	Yes
Includes DNS name resolution client	Yes	Yes
Provides static name resolution	Yes (optional)	Yes (only)
Queries DNS servers	Yes ¹	Yes
Provides name server in operating system	Yes	No
Resolves NetBIOS-compatible names	Yes	No
Provides a name resolution solution for large peer-based TCP/IP networks (50,000+ systems)	Yes	No
Supports automatic name registration	For WINS clients only	No
Supports dynamic NetBIOS name registration and resolution	Yes	No
Supports managing hosts configured via DHCP	Yes	No
Supports easy administration, including browsing and managing dynamic and static registrations	Yes	No
Centralizes management of the name database	Yes	No
Defines server replication partners and policies	Yes	No
Alleviates LMHOSTS management requirements	Yes	No
Reduces IP broadcast traffic in Windows-based internetworks	Yes	No

¹ Queries DNS servers via Windows Sockets applications or, for Windows networking applications, via NetBIOS over TCP/IP (after using WINS first)

SNMP

Simple Network Management Protocol (SNMP) is used by administrators to monitor and control remote hosts and gateways on an internetwork. The Windows NT SNMP service allows a Windows NT computer to be monitored remotely but does not include an application to monitor other SNMP systems on the network.

Note

You must install the SNMP service to use the TCP/IP performance counters in Performance Monitor, as described in Chapter 8, "Using Performance Monitor with TCP/IP Services."

SNMP is a network management protocol widely used in TCP/IP networks. These kinds of protocols are used to communicate between a management program run by an administrator and the network management agent running on a host or gateway. These protocols define the form and meaning of the messages exchanged, the representation of names and values in the messages, and administrative relationships among hosts being managed. SNMP defines a set of variables that the host must keep and specifies that all operations on the gateway are side effects of getting, putting, or setting the data variables. Because different network-management services are used for different types of devices or for different network-management protocols, each service has its own set of objects. The entire set of objects that any service or protocol uses is referred to as its *management information base* (MIB).

The Windows NT SNMP service includes MIB II (based on RFC 1213) and LAN Manager MIB II plus MIBs for DHCP and WINS servers, as described in Appendix A, "MIB Object Types for Windows NT." The SNMP service allows SNMP-based managers to perform standard SNMP commands, such as reading the counters in the standard MIBs included with the service. Windows NT SNMP has an extensible architecture, so it can be used to create custom functionality on a Windows NT computer, such as starting and stopping specific services or shutting down the system.

The SNMP service works with any computer running Windows NT and the TCP/IP protocol. With the SNMP service, a Windows NT computer can report its current status to an SNMP management system on a TCP/IP network. The service sends status information to a host in two cases:

- When a management system requests such information
- When a significant event occurs on the Windows NT computer

The SNMP service can handle requests from one or more hosts, and it can also report network-management information to one or more hosts, in discrete blocks of data called *traps*.

The SNMP service uses the unique host names and IP addresses of devices to recognize the host(s) to which it reports information and from which it receives requests.

When a network manager requests information about a device on the network, SNMP management software can be used to determine object values that represent network status. MIB objects represent various types of information about the device. For example, the management station might request an object called **SvStatOpen**, which would be the total number of files open on the Windows NT computer.

The SNMP service for Windows NT supports multiple MIBs through an agent Application Programming Interface (API) extension interface. At SNMP service startup time, the SNMP service loads all of the extension-agent dynamic link libraries (DLLs) that are defined in the Windows NT Registry. Two extension-agent DLLs come with Windows NT; others may be

developed and added by users.

Installing and Configuring DHCP Servers

A Dynamic Host Configuration Protocol (DHCP) server is a Windows NT Server computer running Microsoft TCP/IP and the DHCP-compatible server software. DHCP is defined in Requests for Comments (RFCs) 1533, 1534, 1541, and 1542.

This chapter describes how to install and manage servers to support DHCP in Windows NT and also presents strategies for implementing DHCP. The following topics are included in this chapter:

- Overview of the DHCP client-server model
- Installing DHCP servers and using DHCP Manager
- Defining DHCP scopes
- Configuring DHCP options
- Administering DHCP clients
- Managing the DHCP database files
- Troubleshooting DHCP
- Advanced configuration parameters for DHCP
- Guidelines for setting local policies
- Planning a strategy for DHCP

Important

If you want to use a DHCP server to support subnetworks that span multiple routers, you may need a firmware upgrade for your routers. Your routers must support RFCs 1533, 1534, 1541, and 1542.

To find out about DHCP-relay agent support, contact your router vendor. For more information, refer to RFC1542.TXT available via anonymous FTP from [ftp.internic.net/rfc](ftp://ftp.internic.net/rfc).

Overview of DHCP Clients and Servers

Configuring DHCP servers for a network provides these benefits:

- The administrator can centrally define global and subnet TCP/IP parameters for the entire internetwork and define parameters for reserved clients.
- Client computers do not require manual TCP/IP configuration. When a client computer moves between subnets, it is reconfigured for TCP/IP automatically at system startup time.

DHCP uses a client-server model. The network administrator establishes one or more DHCP servers that maintain TCP/IP configuration information to be provided to clients that make requests.

The DHCP server database includes the following:

- Valid configuration parameters for all clients on the internetwork.
- Valid IP addresses maintained in a pool for assignment to clients, plus reserved addresses for manual assignment.
- Duration of leases and other configuration parameters offered by the server. The lease defines the length of time for which the assigned IP address can be used.

A Windows NT computer becomes a DHCP client if the Enable Automatic DHCP Configuration option is checked in the Windows NT TCP/IP Installation Options dialog box. When a DHCP client computer is started, it communicates with a DHCP server to receive the required TCP/IP configuration information. This configuration information includes at least an IP address and submask plus the lease associated with the configuration.

Note

DHCP client software is part of the Microsoft TCP/IP-32 for Windows for Workgroups software and the Microsoft Network Client 2.0 software that are included on the Windows NT Server compact disc. For information about installing this software, see the *Windows NT Server Installation Guide*.

For an overview of how DHCP works, see "Dynamic Host Configuration Protocol" in Chapter 3, "Networking Concepts for TCP/IP."

Note

DHCP can be monitored using SNMP. For a list of DHCP MIB object types, see Appendix A, "MIB Object Types for Windows NT."

Installing DHCP Servers

You install a DHCP server as part of the process of installing Microsoft TCP/IP. These instructions assume you have already installed the Windows NT Server operating system on the computer.

Caution

Before installing a new DHCP server, check for other DHCP servers on the network to avoid interfering with them.



You must be a member of the Administrators group for the computer you are installing or administering as a DHCP server.

► To install a DHCP server

1. Start the Network option in Control Panel. When the Network Settings dialog box appears, choose the Add Software button to display the Add Network Software dialog box.
2. In the Network Software list box, select TCP/IP Protocol And Related Components, and then choose the Continue button.
3. In the Windows NT TCP/IP Installation Options dialog box, check the appropriate options to be installed, including at least DHCP Server Service. Also check SNMP Service if you want to use Performance Monitor or SNMP to monitor DHCP.
4. Choose the OK button. Windows NT Setup displays a message asking for the full path to the Windows NT Server distribution files. Provide the appropriate location, and choose the Continue button.

All necessary files are copied to your hard disk. When the Network Settings dialog box reappears after you finishing configuring TCP/IP, choose the OK button.

5. Complete all the required procedures for manually configuring TCP/IP as described in "Configuring TCP/IP" in Chapter 2, "Installing and Configuring Microsoft TCP/IP and SNMP."

If this DHCP server is multihomed (has multiple network adapters), you must use the Advanced Microsoft TCP/IP Configuration dialog box to specify IP addresses and other information for each network adapter.

Also, if any adapter on the DHCP server is connected to a subnet that you do not want this server to support, then you must disable the bindings to that subnet for the particular adapter. To do this, choose the Network option in Control Panel, then choose the Bindings button in the Network Settings dialog box and disable the related binding.

Note

You cannot use DHCP to automatically configure a new DHCP server, because a computer cannot be a DHCP client and server simultaneously.

All the appropriate TCP/IP and DHCP software is ready for use after you reboot the computer.

The DHCP Client service is a Windows NT service running on a Windows NT computer. The supporting DHCP client software is automatically installed for computers running Windows NT Server or Windows NT Workstation when you install the basic operating system software.

The Microsoft DHCP Server service starts automatically during system startup if you have installed this service. You will probably want to pause the service while you are configuring scopes for the first time.

► **To pause the DHCP Server service at any Windows NT computer**

1. In Control Panel, choose the Services icon.

Or

In Server Manager, choose Services from the Computer menu.

2. In the Services dialog box, select the Microsoft DHCP Server service.
3. Choose the Pause button, and then choose the Close button.

You can also start, stop, and pause the DHCP service at the command prompt using the commands **net start dhcpserver** or **net stop dhcpserver** or **net pause dhcpserver**.

Using DHCP Manager

The DHCP Manager icon is added to the Network Administration Tools group in Program Manager when you set up a Windows NT Server computer to be a DHCP server. You must use DHCP Manager to perform these basic tasks:

- Create one or more DHCP scopes to begin providing DHCP services
- Define properties for the scope, including the lease duration and IP address ranges to be distributed to potential DHCP clients in the scope
- Define default values for options such as the default gateway, DNS server, or WINS server to be assigned together with an IP address, or add any custom options

The procedures for completing these tasks are described in the following sections.

► To start DHCP Manager

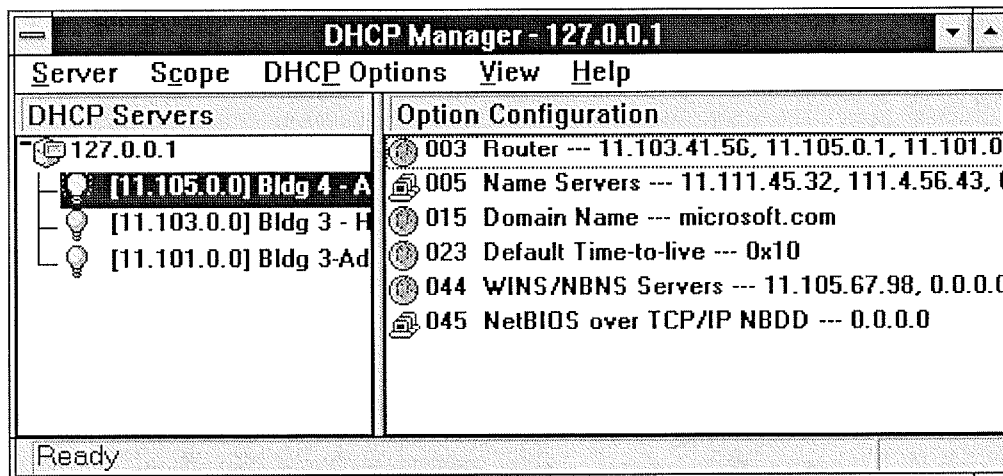


- Double-click the DHCP Manager icon in the Network Administration group in Program Manager.

Or

At the command prompt, type **start dhcpadm** and press Enter.

DHCP Manager window shows the local computer the first time you start DHCP Manager. Subsequently, the window shows a list of the DHCP servers to which DHCP Manager has connected, plus their scopes. The status bar reports the current DHCP Manager activities.

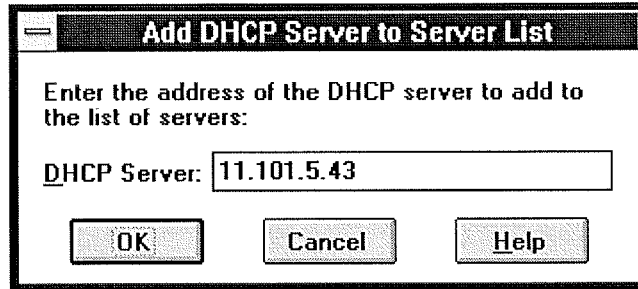


Important

When you are working with DHCP Manager, all computer names are DNS host names only, such as **accounting.trey.com**. The NetBIOS computer names used in Windows networking are not allowed.

► To connect to a DHCP server

1. From the Server menu, choose the Add command.



2. In the Add DHCP Server To Known Server List dialog box, type the DNS short name or IP address for the DHCP server you want to connect to, and then choose the OK button.

For example, type an address such as **11.1.26.30** or type a DNS name such as **corp01.trey.com** in this box.

► **To disconnect from a selected DHCP server**

- From the Server menu, choose Remove, or press Del.

Defining DHCP Scopes

A DHCP scope is an administrative grouping of computers running the DHCP Client service. You will create a scope for each subnet on the network to define parameters for that subnet.

Each scope has the following properties:

- A unique subnet mask used to determine the subnet related to a given IP address
- A scope name assigned by the administrator when the scope is created
- Lease duration values to be assigned to DHCP clients with dynamic addresses

Defining DHCP Scopes

Creating Scopes

You must use DHCP Manager to create, manage, or remove scopes.

► **To create a new DHCP scope**

1. In the DHCP Servers list in the DHCP Manager window, select the server for which you want to create a scope.
2. From the Scope menu, choose Create.

Create Scope - 127.0.0.1

IP Address Pool

Start Address: 11 .101 .0 .1

End Address: 11 .101 .50 .255

Subnet Mask: 255 .255 .0 .0

Exclusion Range:

Start Address: . . . Add ->

End Address: . . . <- Remove

Excluded Addresses:

Address 11.101.0.25

11.101.50.45 to 11.101.50.50

Lease Duration

Unlimited

Limited To: 3 Day(s) 00 Hour(s) 00 Minutes

Name: Bldg 3-Admin

Comment:

OK Cancel Help

3. To define the available range of IP addresses for this scope, type the beginning and ending IP addresses for the range in the Start Address and End Address boxes.

The IP address range will include the Start and End values.

Note

You must supply this information before this scope can be activated.

4. In the Subnet Mask box, DHCP Manager proposes a subnet mask, based on the IP address of the Start and End addresses. Accept the proposed value, unless you know that

a different value is required.

5. To define excluded addresses within the IP address pool range, use the Exclusion Range controls, as follows:
 - Type the first IP address that is part of the excluded range in the Start Address box, and type the last number in the End Address box. Then choose the Add button. Continue to define any other excluded ranges in the same way.
 - To exclude a single IP address, type the number in the Start Address box. Leave the End Address box empty and choose the Add button.
 - To remove an IP address or range from the excluded range, select it in the Excluded Addresses box, and then choose the Remove button.

The excluded ranges should include all IP addresses that you assigned manually to other DHCP servers, non-DHCP clients, diskless workstations, or RAS and PPP clients.

6. To specify the lease duration for IP addresses in this scope, select Limited To. Then type values defining the number of days, hours, and seconds for the length of the address lease.

If you do not want IP address leases in this scope to expire, select the Unlimited option.

7. In the Name box, type a scope name.

This is any name you want to use to describe this subnet. The name can include any combination of letters, numbers, and hyphens. Blank spaces and underscore characters are also allowed. You cannot use Unicode characters.

8. Optionally, in the Comment box, type any string to describe this scope, and then choose the OK button.

Note

When you finish creating a scope, a message reminds you that the scope has not been activated and allows you to choose Yes to activate the scope immediately. However, you should not activate a new scope until you have defined the DHCP options to be configured for this scope.

Now you can continue with the procedures described in "Configuring DHCP Option Types" and "Administering DHCP Clients" later in this chapter. After you have configured the options for this scope, you must activate it so that DHCP client computers on the related subnet can begin using DHCP for dynamic TCP/IP configuration.

► **To activate a DHCP scope**

- From the Scope menu, choose the Activate command to make this scope active.

The menu command name changes to Deactivate when the selected scope is currently active.

Defining DHCP Scopes

Changing Scope Properties

The subnet identifiers and address pool make up the properties of scopes. You can change the properties of an existing scope.

► **To change the properties of a DHCP scope**

1. In the DHCP Servers list in the DHCP Manager window, select the scope for which you want to change properties, and then from the Scope menu, choose Properties.

Or

In the DHCP Servers list, double-click the scope you want to change.

2. In the Scope Properties dialog box, change any values for the IP address pool, lease duration, or name and comment as described earlier in "Creating Scopes" or in online Help.
3. Choose the OK button.

Defining DHCP Scopes

Removing a Scope

When a subnet is no longer in use, or any other time you want to remove an existing scope, you can remove it using DHCP Manager. If any IP address in the scope is still leased or in use, you must first deactivate the scope until all client leases expire or all client lease extension requests are denied.

► **To remove a scope**

1. In the DHCP Servers list in the DHCP Manager window, select the scope you want to remove.
2. From the Scope menu, choose Deactivate. (This command name changes to Activate when the scope is not active.)

The scope must remain deactivated until you are sure the scope is not in use.

3. From the Scope menu, choose Delete.

The Delete command is not available for an active scope.

Configuring DHCP Options

The configuration parameters that a DHCP server assigns to a client are defined as *DHCP options* using DHCP Manager. Most options you will want to specify are predefined, based on standard parameters defined in RFC 1542.

When you configure a DHCP scope, you can assign DHCP options to govern all configuration parameters. You can also define, edit, or delete DHCP options. These tasks are described in the following sections.

Configuring DHCP Options

Assigning DHCP Configuration Options

Besides the IP addressing information, other DHCP configuration options to be passed to DHCP clients must be configured for each scope. Options can be defined globally for all scopes on the current server, specifically for a selected scope, or for individual DHCP clients with reserved addresses.

- Active global options always apply unless overridden by scope options or DHCP client settings.
- Active options for a scope apply to all computers in that scope, unless overridden for an individual DHCP client.

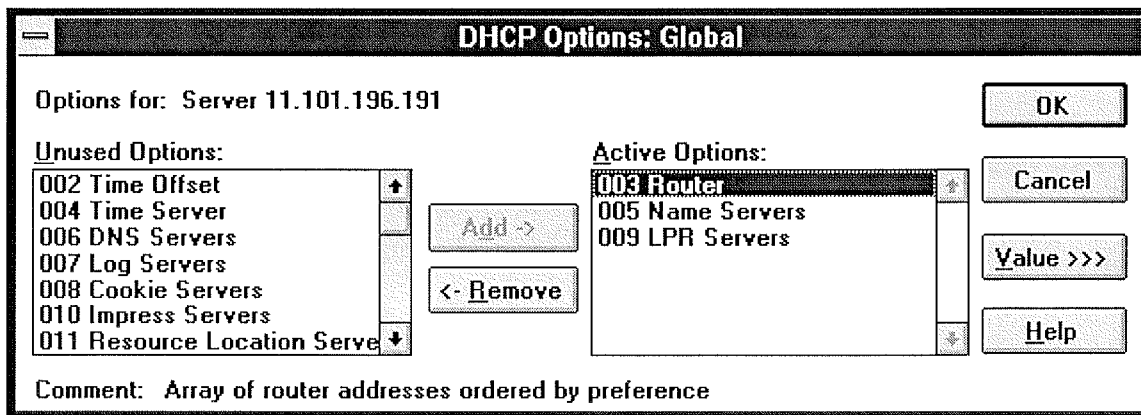
The built-in options are described in "Predefined DHCP Client Configuration Options" later in this chapter.

Note

Lease duration is defined for the scope in the Create Scope dialog box.

► To assign DHCP configuration options

1. In the DHCP Servers list in the DHCP Manager window, select the scope you want to configure.
2. From the DHCP Options menu, choose the Global or Scope command, depending on whether you want to define option settings for all scopes on the currently selected server or the scope currently selected in the DHCP Manager window.



3. In the Unused Options list in the DHCP Options dialog box, select the name of the DHCP option that you want to apply, and then choose the Add button to move the name to the Active Options list.

This list shows both predefined options and any custom options that you added.

For example, if you want to specify DNS servers for computers, select the option named DNS Servers in the Unused Options list and choose the Add button.

If you want to remove an active DHCP option, select its name in the Active Options box, and then choose the Remove button.

4. To define the value for an active option, select its name in the Active Options box, and choose the Values button. Then choose the Edit button, and edit the information in the Current Value box, depending on the data type for the option, as follows:
 - For an IP address, type the assigned address for the selected option
 - For a number, type an appropriate decimal or hexadecimal value for the option
 - For a string, type an appropriate ASCII string containing letters and numbers for the option

For example, to specify the DNS name servers to be used by DHCP clients, select DNS Servers in the Active Options list. Then choose the Edit button and type a list of IP addresses for DNS servers. The list should be in the order of preference.

For details about the Edit Array and Edit Address dialog boxes, see the online Help.

5. When you have completed all your changes, choose the OK button.

Tip

If you are using DHCP to configure WINS clients, be sure to set options #44 WINS Servers and #46 Node Type. These options will allow DHCP-configured computers to find and use the WINS server automatically.

Configuring DHCP Options

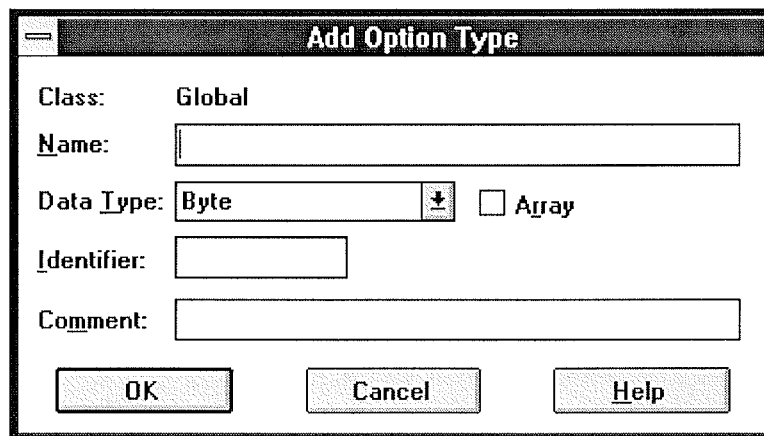
Creating New DHCP Options

You can add custom parameters to be included with DHCP client configuration information. You can also change values or other elements of the predefined DHCP options. The option you add will appear in the list of available DHCP options in the DHCP Options dialog boxes for defining options globally, per scope, and per individual reserved DHCP client.

► To add new DHCP options

1. From the DHCP Options menu, choose Defaults.
2. In the Option Class list in the DHCP Options: Default Values dialog box, select the class for which you want to add new DHCP options, and then choose the New button.

The option class can include the DHCP standard options or any custom options that you add.



3. In the Name box of the Add Option Type dialog box, type a new option name.
4. From the Data Type list, select the data type for this option as described in the following list. If this data type represents an array, check the Array box.

Data type	Meaning
Binary	Value expressed as an array of bytes
Byte	An 8-bit, unsigned integer
Encapsulated	An array of unsigned bytes
IP address	An IP address of the form w.x.y.z
Long	A 32-bit, signed integer
Long integer	A 32-bit, unsigned integer
String	An ASCII text string
Word	A 16-bit, unsigned integer

If you select the wrong data type, an error message will appear or the value will be truncated or converted to the required type.

5. In the Identifier box, type a unique code number to be associated with this DHCP option. This must be a number between 0 and 255.
6. In the Comment box, type a description of the DHCP option, and then choose the OK button.
7. In the DHCP Options: Default Values dialog box, select the option, choose the Edit button, and type the value to be configured by default for this DHCP option.
8. Choose the OK button.

You can delete custom DHCP options, but you cannot delete any predefined DHCP options.

► **To delete a custom DHCP option**

1. From the DHCP Options menu, choose Defaults.
2. In the DHCP Options: Default Values dialog box, select the related class in the Option Class list.
3. In the Option Name list, select the option you want to delete, and then choose the Delete button.

Configuring DHCP Options

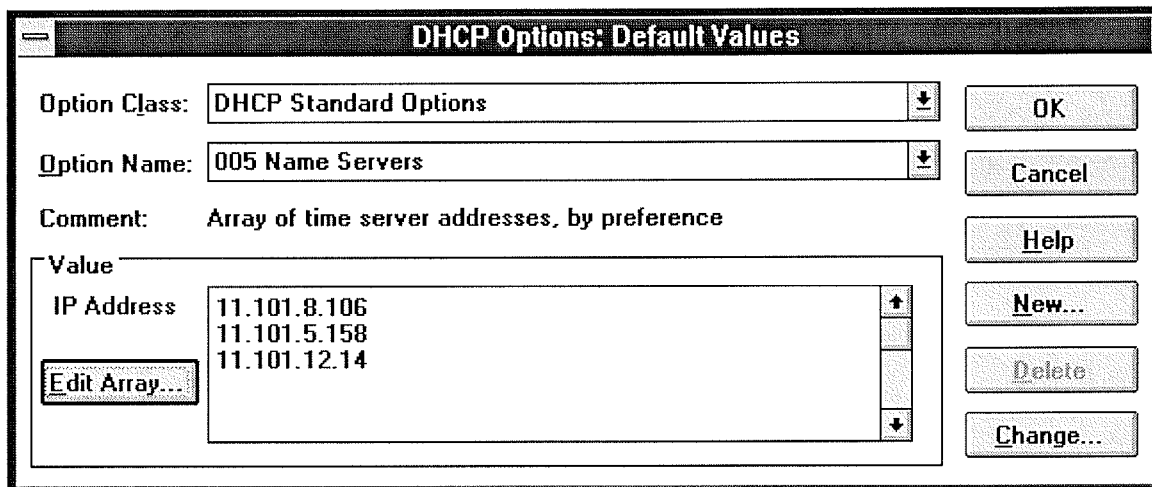
Changing DHCP Option Values

You can change the values for the predefined and custom DHCP options for configuring clients. For example, you could change the default values for these built-in options:

- 3 = Router, to specify the IP addresses for the routers on the subnet
- 6 = DNS Servers, to specify the IP addresses of the DNS name servers used at your site
- 15 = Domain Name, to specify the DNS domain names to be used for host name resolution

► To change a DHCP option value

1. From the DHCP Options menu, choose Defaults.



2. In the Option Class list in the DHCP Options: Default Values dialog box, select the option class for which you want to change values.
3. If you want to change the default value for an option, select the option you want to change in the Option Name list, choose the Edit button, and then type a new value in the Value box.

Choosing the Edit button displays a special dialog box for editing strings, arrays of IP address, or binary values. For information about using the special editing dialog boxes, see the online Help for DHCP Manager.

4. If you want to change basic elements of a custom option, select it in the Option Name list, and then choose the Change button.

You can change the name, data type, identifier, and comment for a DHCP option, following the procedures described earlier in "Creating New DHCP Options."

5. When you complete all the changes you want to make, choose the OK button.

Configuring DHCP Options

Defining Options for Reservations

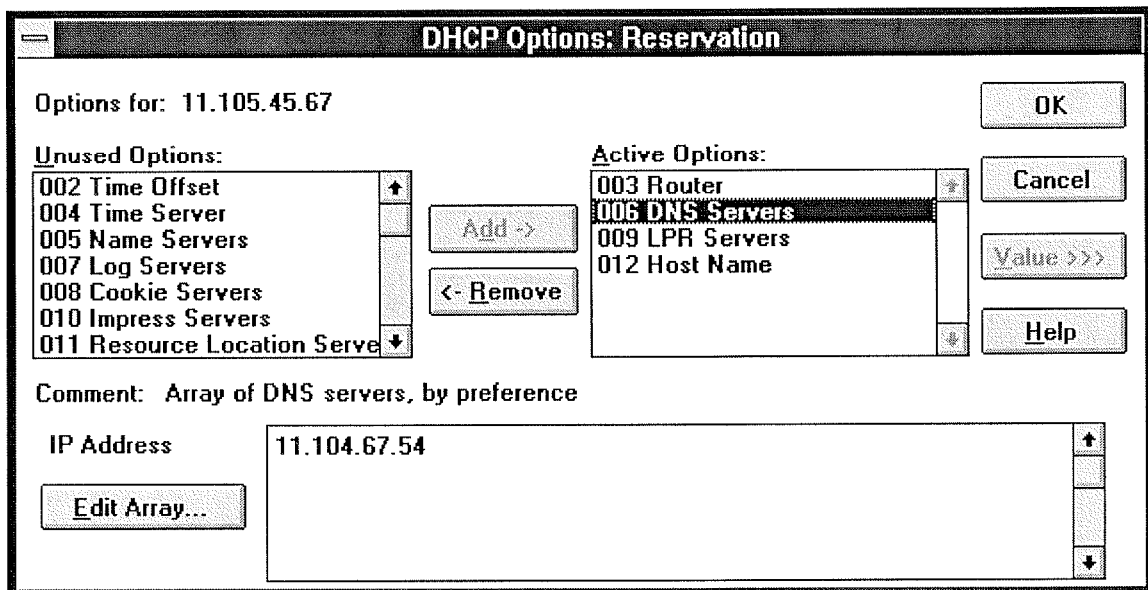
You can assign DHCP options and specify custom values for DHCP clients that use reserved IP addresses.

For information about how to reserve IP configuration information for DHCP clients, see "Managing Client Reservations" later in this chapter.

► **To change DHCP options for reservations**

1. From the Scope menu, choose Active Leases.
2. In the IP Address list of the Active Leases dialog box, select the reserved address whose options you want to change, and then choose the Options button.

The Options button is only available for reserved addresses; it is not available for DHCP clients with dynamic addresses.



3. In the DHCP Options: Reservation dialog box, select an option name in the Unused Options list, and then choose the Add button to move the name to the Active Options list.

If you want to remove a DHCP option that has been assigned to the scope, select its name in the Active Options box, and then choose the Remove button.

4. To change a value for an option selected in the Active Options list, choose the Value button. Then choose the Edit button and ENTER a new value in the Current Value box.

Configuring DHCP Options

Predefined DHCP Client Configuration Options

The tables in this section describe the predefined options available for configuration of DHCP clients. These options are defined in RFC 1533.

Basic Options

Code	Option name	Meaning
0	Pad	Causes subsequent fields to align on word boundaries.
255	End	Indicates end of options in the DHCP packet.
2	Time offset	Specifies the Universal Coordinated Time (UCT) offset in seconds.
3	Router	Specifies a list of IP addresses for routers on the client's subnet. ¹
4	Time server	Specifies a list of IP addresses for time servers available to the client. ¹
5	Name servers	Specifies a list of IP addresses for name servers available to the client. ¹
6	DNS servers	Specifies a list of IP addresses for DNS name servers available to the client. ¹
7	Log servers	Specifies a list of IP addresses for MIT_LCS User Datagram Protocol (UDP) log servers available to the client. ¹
8	Cookie servers	Specifies a list of IP addresses for RFC 865 cookie servers available to the client. ¹
9	LPR servers	Specifies a list of IP addresses for RFC 1179 line-printer servers available to the client. ¹
10	Impress servers	Specifies a list of IP addresses for Imagen Impress servers available to the client. ¹
11	Resource location servers	Specifies a list of RFC 887 Resource Location servers available to the client. ¹
12	Host name	Specifies the host name of up to 63 characters for the client. The name must start with a letter, end with a letter or digit, and have as interior characters only letters, numbers, and hyphens. The name can be qualified with the local DNS domain name.
13	Boot file size	Specifies the size of the default boot image file for the client, in 512-octet blocks.
14	Merit dump file	Specifies the ASCII path name of a file where the client's core image is dumped if a crash occurs.
15	Domain name	Specifies the DNS domain name the client should use for DNS host name resolution.
16	Swap server	Specifies the IP address of the client's swap server.
17	Root path	Specifies the ASCII path name for the client's root disk.
18	Extensions path	Specifies a file retrievable via TFTP containing

18 Extensions path Specifies a file retrievable via TFTP containing information interpreted the same as the vendor-extension field in the BOOTP response, except the file length is unconstrained and references to Tag 18 in the file are ignored.

1 List is specified in order of preference.

The following table lists IP layer parameters on a per-host basis.

IP Layer Parameters per Host

Code	Option name	Meaning
19	IP layer forwarding	Enables or disables forwarding of IP packet for this client. 1 enables forwarding; 0 disables it.
20	Nonlocal source routing	Enables or disables forwarding of datagrams with nonlocal source routes. 1 enables forwarding; 0 disables it.
21	Policy filter masks	Specifies policy filters that consist of a list of pairs of IP addresses and masks specifying destination/mask pairs for filtering nonlocal source routes. Any source routed datagram whose next-hop address does not match a filter will be discarded by the client.
22	Max DG reassembly size	Specifies the maximum size datagram that the client can reassemble. The minimum value is 576.
23	Default time-to-live	Specifies the default time-to-live (TTL) that the client uses on outgoing datagrams. The value for the octet is a number between 1 and 255.
24	Path MTU aging timeout	Specifies the timeout in seconds for aging Path Maximum Transmission Unit (MTU) values (discovered by the mechanism defined in RFC 1191).
25	Path MTU plateau table	Specifies a table of MTU sizes to use when performing Path MTU Discovered as defined in RFC 1191. The table is sorted by size from smallest to largest. The minimum MTU value is 68.

The following table lists IP parameters on a per-interface basis. These options affect the operation of the IP layer on a per-interface basis. A client can issue multiple requests, one per interface, to configure interfaces with their specific parameters.

IP Parameters per Interface

Code	Option name	Meaning
26	MTU option	Specifies the MTU discovery size for this interface. The minimum MTU value is 68.
27	All subnets are local	Specifies whether the client assumes that all subnets of the client's internetwork use the same MTU as the local subnet where the client is connected. 1 indicates that all subnets share the same MTU; 0 indicates that the client should assume some subnets may have smaller MTUs.
28	Broadcast address	Specifies the broadcast address used on the client's subnet.
29	Perform mask discovery	Specifies whether the client should use Internet Control Message Protocol (ICMP) for subnet mask discovery. 1 indicates the client should perform mask discovery; 0 indicates the client should not.
30	Mask supplier	Specifies whether the client should respond to subnet mask requests using ICMP. 1 indicates the

		subnet mask requests using ICMP. 1 indicates the client should respond; 0 indicates the client should not respond.
31	Perform router discovery	Specifies whether the client should solicit routers using the router discovery method in RFC 1256. 1 indicates that the client should perform router discovery; 0 indicates that the client should not use it.
32	Router solicitation address	Specifies the IP address to which the client submits router solicitation requests.
33	Static route	Specifies a list of IP address pairs that indicate the static routes the client should install in its routing cache. Any multiple routes to the same destination are listed in descending order of priority. The routes are destination/router address pairs. (The default route of 0.0.0.0 is an illegal destination for a static route.)

The following table lists link layer parameters per interface. These options affect the operation of the data link layer on a per-interface basis.

Link Layer Parameters per Interface

Code	Option name	Meaning
34	Trailer encapsulation	Specifies whether the client should negotiate use of trailers (RFC 983) when using the ARP protocol. 1 indicates the client should attempt to use trailer; 0 indicates the client should not use trailers.
35	ARP cache timeout	Specifies the timeout in seconds for ARP cache entries.
36	Ethernet encapsulation	Specifies whether the client should use Ethernet v. 2 (RFC 894) or IEEE 802.3 (RFC 1042) encapsulation if the interface is Ethernet. 1 indicates that the client should use RFC 1042 encapsulation; 0 indicates the client should use RFC 894 encapsulation.

The following table shows TCP parameters. These options affect the operation of the TCP layer on a per-interface basis.

TCP Parameters

Code	Option name	Meaning
37	Default time-to-live	Specifies the default TTL the client should use when sending TCP segments. The minimum value of the octet is 1.
38	Keepalive interval	Specifies the interval in seconds the client TCP should wait before sending a keepalive message on a TCP connection. A value of 0 indicates that the client should not send keepalive messages on connections unless specifically requested by an application.
39	Keepalive garbage	Specifies whether the client should send TCP keepalive messages with an octet of garbage data for compatibility with older implementations. 1 indicates that a garbage octet should be sent; 0 indicates that it should not be sent.

The following table shows application layer parameters. These miscellaneous options are used to configure applications and services.

Application Layer Parameters per

Code	Option name	Meaning
------	-------------	---------

40	NIS domain name	Specifies the name of the Network Information Service (NIS) domain as an ASCII string.
41	NIS servers	Specifies a list of IP addresses for NIS servers available to the client. ¹
42	NTP servers	Specifies a list of IP addresses for Network Time Protocol (NTP) servers available to the client. ¹

¹ List is specified in order of preference.

The following options are for vendor-specific information.

Vendor-Specific Information

Code	Option name	Meaning
43	Vendor specific info	Binary information used by clients and servers to exchange vendor-specific information. Servers not equipped to interpret the information ignore it. Clients that don't receive the information attempt to operate without it.

κ DHCP:options:NetBIOS over TCP/IPκ Parameters:DHCP options:NetBIOS over TCP/IPκ NetBIOS over TCP/IP:DHCP options**NetBIOS over TCP/IP**

Code	Option name	Meaning
44	WINS/NBNS servers	Specifies a list of IP addresses for NetBIOS name servers (NBNS). ¹
45	NetBIOS over TCP/IP NBDD	Specifies a list of IP addresses for NetBIOS datagram distribution servers (NBDD). ¹
46	WINS/NBT node type	Allows configurable NetBIOS over TCP/IP clients to be configured as described in RFC 1001/1002, where 1=b-node, 2=p-node, 4=m-node, and 8=h-node.
47	NetBIOS scope ID	Specifies as a string that is the NetBIOS over TCP/IP Scope ID for the client, as specified in RFC 1001/1002.
48	X Window system font	Specifies a list of IP addresses for X Window font servers available to the client. ¹
49	X Window system display	Specifies a list of IP addresses for X Window System Display Manager servers available to the client. ¹

¹ List is specified in order of preference.

DHCP Extensions

Code	Option name	Meaning
58	Renewal (T1) time value	Specifies the time in seconds from address assignment until the client enters the renewing state.
59	Rebinding (T2) time value	Specifies the time in seconds from address assignment until the client enters the rebinding state.