Multiserver Network Operating Systems

A Report from NSTL

In this report:

Synopsis

Focus

NSTL compared five network operating systems' (NOS') features, performance, and usability, focusing on single-server and multiserver installation and configuration, internal and external bridging, and remote connections.

Programs Tested

VINES/386
Banyan Systems, Inc.

OS/2 LAN Server
IBM Corp.

LAN Manager
Microsoft Corp.

NetWare 2.2
Novell, Inc.

NetWare 3.11
Novell, Inc.

Program Recommendation

- Banyan VINES/386
- Novell NetWare 3.11

Source

Based on data generated by tests designed and conducted by National Software Testing Laboratories, Inc. (NSTL), a division of Datapro Information Services Group, Plymouth Meeting, PA 19462. Telephone (800) 223-7093.

Ratings Key
(On a scale of 0 to 10)
Ratings
● 7.0 - 10.0
○ 5.0 - 6.9
◎ under 5.0
★ Recommended

Overall Evaluation	Product Name	Version Tested	Performance	Versatility	Ease of Learning	Ease of Use	Price
External Bridging							
7.8	Novell NetWare 3.11	3.11	○	●	●	●	$3,495★ (20 users)
7.5	Banyan VINES/386	4.0	○	○	●	●	$2,495★ (10 users)
7.1	Novell NetWare 2.2	2.2	○	○	●	●	$895 (5 users)
6.7	Microsoft LAN Manager	2.0	●	○	○	○	$995 (5 users)
5.6	IBM OS/2 LAN Server	1.30.1	○	○	○	○	$1,040
Internal Bridging							
8.1	Banyan VINES/386	4.0	●	○	●	●	$2,495★ (10 users)
8.0	Novell NetWare 3.11	3.11	●	●	●	●	$3,495★ (20 users)
7.4	Novell NetWare 2.2	2.2	●	○	●	●	$895 (5 users)

Overview

Integrating local networks spanning multiple floors or buildings, or disparate geographic regions, dramatically increases the network's physical complexity as well as its administration, troubleshooting, performance tuning, and user support needs. NSTL's evaluation focuses on multiserver network installation and administration, system features, and performance characteristics.

Evaluation Criteria

NSTL evaluated multiserver network operating systems using the three leading high-end networking technologies; all support IBM 16/4 token-ring adapters. IBM OS/2 LAN Server Version 1.3 and Microsoft LAN Manager 2.0 share common code origins and are considered to be similar LAN technologies despite noticeable differences in implementation. NSTL compared LAN Server and LAN Manager functions, highlighting their natural similarities and subtle differences. In future versions of LAN Server, IBM plans to align the product's functionality with LAN Manager.

Novell has the largest market share, and its NetWare products have extensive features, connectivity options, and support for third-party applications. NetWare 2.2 combines the features of Advanced NetWare, SFT NetWare, and ELS NetWare I and II.

NSTL tested Revision 5 (the most recent update) of Banyan VINES/386 Version 4.0. Although Banyan officially announced VINES/386 Version 4.1 in May 1991, the product did not ship until mid-June and was not available in time for in-depth testing. Other popular systems, such as LANtastic, PowerLan 10, and 10NET Plus, are covered in Report 810-301, "Entry-Level LAN Operating Systems."

Once a LAN is installed and configured, its reliability, functionality, and performance become the key concerns, but NSTL focuses much of this overview on installation and configuration, which can be frustrating and very costly. Large networks require repeated installations, and advanced administrative tasks can become impossibly complicated. Planning, installing, and configuring multiserver networks are fraught with unexpected problems. Multiple software revisions contribute to synchronization problems, as do dissimilar software and documentation.

Installation and Configuration

IBM OS/2 LAN Server

IBM LAN Server 1.3 requires OS/2 Extended Edition Version 1.3. First-time installers will often encounter problems even when documentation is closely followed.

The OS/2 base operating system, Communications Manager, and its LAN Requester component must be installed on a server system before the LAN Server software. The OS/2 Extended Edition installation is time consuming and short on feedback. When formatting large partitions, users may think the system has locked up. When using a keyboard instead of a mouse, some keystroke sequences can be confusing to those who are unfamiliar with IBM menu design standards. Once Communications Manager and LAN Requester are configured properly, a single LAN Server disk is installed. Users familiar with OS/2 Extended Edition will have few problems; others will struggle to varying degrees.

Extended Edition's Getting Started manual must be read closely, with particular attention to the planning sections. A complete server installation also requires the LAN Server's Getting Started manual and Network Administrator's Guide. Additional insights can be gained from the Server Installation and Configuration Guidelines manual or from on-line Help functions. IBM's optional Parameter and Tuning Guide for OS/2 Extended Edition and LAN Server is very helpful in understanding performance issues.

Despite the wealth of information in the IBM manuals, some concepts and procedures are buried or difficult to understand. Much of the Extended Edition and LAN Server command documentation is now on-line, but information is not intuitively located. Some descriptions of network commands are found in the on-line reference or the DOS LAN Requester User's Guide, rather than in the Administrator's Guide as expected. (Microsoft LAN Manager's Administrator's Guide and Administrator's Reference contain all network commands.)

The LAN Server installation procedure does not automatically set up an HPFS disk cache. IBM's current HPFS implementation imposes a 2M-byte cache limit and 2K-byte read/write limit; the new 1.30.1 corrective service disk can surpass these limits on PS/2 systems (see Performance Results). LAN Server does not currently support HPFS386.

Microsoft LAN Manager

Microsoft LAN Manager's single-server installation and configuration are less difficult than LAN Server's. It uses OS/2 Standard Edition instead of Extended Edition, and its administrative utilities are easier to learn. Microsoft recommends installing LAN Manager 2.0 on top of OS/2 Standard Edition 1.3, although it works with Version 1.2 using corrective service disk level XR04053 and above. (LAN Manager 2.0 does not install on top of Extended Edition 1.3.) First-time LAN Manager installers will often encounter problems even when documentation is closely followed.

LAN Manager automatically replaces HPFS with HPFS386 (if an HPFS partition was defined under OS/2) and sets up a default disk cache using available system memory. HPFS386's 32-bit code design and the larger disk cache improve performance over HPFS. Local server security can be defined under HPFS386 to prevent user access to network files from the server (a security problem in earlier versions of LAN Manager and in the current LAN Server, which permit nondedicated servers). LAN Manager requires the Config.sys Protectonly=Yes parameter when running HPFS386, preventing local users from running DOS applications in a DOS box. (NetWare 3.11 and VINES/386 do not support nondedicated servers.)

With command-line operations, IBM and Microsoft provide similar methods of creating network users, sharing network resources, and setting up permissions. Their character-based menu interfaces are entirely different. Both menuing systems can be confusing without a mouse, but LAN Manager's menus are easier to use. Both products offer on-line Help for specific error messages.

LAN Server versus LAN Manager

Compared to LAN Server, LAN Manager has the advantage of being capable of defining server profiles that recall

the status of shared resources between network server reboots. IBM administrators must define aliases for shared network resources so that they remain shared until the resource or alias is deleted by the administrator.

LAN Manager installers can choose user-level or share-level security. With user-level security, each user has a login ID and password with specific rights to network resources. Share-level security assigns a password to each network resource and is rarely used. IBM LAN Server offers only user-level security.

The now quite famous Lanman.ini parameter file in LAN Manager and Ibmlan.ini in LAN Server are positively threatening and must eventually be dealt with to boost performance above specific user, workstation, or session limits. These files may force administrators to a higher level of complexity than desired. Microsoft and IBM recommend leaving most of the defaults intact and publish white papers or manuals on tuning.

Novell NetWare

Although NetWare 2.2's single-server installation has been improved significantly from Version 2.15, a diskette shuffle must be performed with the OSOBJ, System-2, and OSEXE disks. Netgen has been replaced with the Install utility, and the corresponding documentation has been cut in half. Shgen has been replaced with Wsgen, and the documentation has been reduced from 72 to 7 pages. A new function called Ztest (replaces Compsurf) tests disk track 0 to ensure that a Novell partition can be created on the drive (Compsurf is still available). Attempting to designate a "user-definable" drive type in NetWare 2.2 may cause the installation procedure to abort. Modifying an existing NetWare 2.2 installation (e.g., changing an adapter or adding a hard disk) is not nearly as easy as in NetWare 3.11, and reconfiguration or relinking steps (poorly documented) are often required. The NetWare 3.11 basic server installation is painless except for a few documentation glitches. The most difficult step is defining network adapters and their protocol bindings.

Once installed, NetWare 3.11 and 2.2 require little tweaking. NetWare 3.11's dynamic performance tuning feature internally adjusts key operating system parameters depending on usage. For extra performance in specific situations, the Set command can be used to alter communication or file system parameters. A variety of installation options is available for maintenance purposes.

Novell's revised documentation is generally impressive, but it is confusing for first-time installers. The NetWare 3.11 server installation documentation directs the installer to the wrong disk to load the ISADISK driver. Setting up a DOS partition on a server is discussed out of sequence in the NetWare 3.11 installation manual. Communication buffers are not defined thoroughly in the NetWare 2.2 installation, but they were in NetWare 2.15. The NetWare 2.2 manual does not define the difference between the Basic and Advanced installations; instead, the explanation appears in the on-line Help. The NetWare 2.2 Concepts manual has an index; the 3.11 manual does not. The Concepts manuals in both NetWare versions are great learning tools for users at any level, and the error message documentation and suggested actions are exceptionally detailed.

Banyan VINES/386

The VINES/386 installation requires 18 disks. Users must first install a server key on the system parallel port (not well documented). The server key functions like a copy protection mechanism; it contains a bit map of all activated VINES/386 software services. Users may falter a bit when deciding how to partition server disks, but the documentation covers partitioning quite thoroughly. After disks are partitioned and verified, the long and arduous task of feeding 17 more disks begins. One hour later, the administrator is asked to choose between full initialization of the server and reloading a system backup.

After the full initialization selection, the system asks whether any optional software will be installed (e.g., Banyan Mail). Because all disks have been loaded, all VINES/386 options are already installed, but not necessarily activated. Each server option comes with an option key that loads onto the server key, activating the option. The administrator is then asked to define a unique server name, first user, group, and organization (see Naming Services). Upon completing these steps, the server initializes itself.

Banyan administrators should quickly assimilate the system management menus, as most functions are presented clearly and organized intuitively. Command line operations are available. Given access to management commands, novice administrators can easily learn VINES/386 administration by studying the management menu structure; actual changes are rejected.

Banyan does a great job of sheltering administrators from its UNIX foundations; however, the complexities of UNIX introduce hardware sensitivities that preclude VINES/386 from being loaded on any system. Banyan abdicates all responsibility for VINES/386 installations on noncertified hardware platforms. (Few platforms are certified, compared to Novell's server certification list.) Noncertified disk drives are also subject to problems. NSTL used Micropolis 1664-7 ESDI drives with no problems, but attempts to run VINES/386 off a 200M-byte Seagate 1239A IDE disk drive resulted in frequent server lockups.

Adapter configuration, access rights assignments, and user profile setups take some time. Access rights are assigned with the Setarl command invoked from a menu or the command line. Access rights are prioritized based on the order of assignment. For instance, if a user with read-only rights to a directory also belongs to a group that has read/write access, and the group's rights are listed before the user's rights in the access rights list, the group's rights apply. (LAN Manager and LAN Server default to the user's rights in all cases, and NetWare combines group and user permissions.) Similar to login scripts, user profiles assign network resources at login time. VINES' user profile definitions can be powerful administrative tools when implemented properly, but they take time to set up.

VINES/386 manuals provide good direction, are well organized, and appear to be quite accurate, if light on technical detail. Error messages are not documented in manuals, but an on-line error message facility is provided. The Administrator Planning Guide presents a high-level view of network functionality and exposes readers to the many considerations of multiserver networking. Implementation details are covered in the Administrator's Reference and Server Operations Guide.

Network Adapters

LAN Manager and LAN Server

LAN Server and LAN Manager support token-ring and Ethernet hardware. Adapter installation is slightly more complicated in LAN Server. IBM LAN Support Program furnishes the NETBIOS interface used by LAN Server and

must be loaded on all LAN Server workstations. Documentation covering LAN Requester's connection with the LAN Support Program is sketchy. The LAN Support Program supports all versions of IBM token-ring adapters and handles Micro Channel and AT-bus versions of 3Com Etherlink II and Western Digital EtherCard Plus adapters. Microsoft provides all those board drivers plus Ungermann-Bass, Racal InterLan, NCR, and more.

Ethernet adapters running on IBM LAN Requester workstations and within the server's Communications Manager use the Network Device Interface Specification (NDIS) created by Microsoft and 3Com. All LAN Manager MAC-layer drivers and the NetBEUI transport driver are written to NDIS specifications. NDIS defines a standard programmatic interface between MAC-layer adapter drivers and LLC-layer protocols. With minor configuration changes, multiple NDIS-compliant protocol stacks can use the same NDIS-compliant network adapter. LAN Manager also permits installation of monolithic drivers that combine transport and MAC drivers. Monolithic drivers are not NDIS compliant, but they do provide a NETBIOS interface to LAN Manager.

IBM LAN Server currently supports a single network adapter in the server. Although LAN Manager supports up to 12 adapters in the server, it does not support internal bridging. External bridges must be used to connect LAN Server and LAN Manager segments.

VINES/386 and NetWare

Novell and Banyan support up to four different network adapters in a server. Routing functions are enabled between all cards, permitting communications between servers and users on all attached segments. Internally routed backbones were tested in the NSTL performance tests.

Banyan has developed a fair number of VINES/386 drivers for popular network adapters, but users should be sure that specific adapters are supported. Few board manufacturers develop Banyan drivers. Adapter installation uses a server administration menu, and Banyan's adapter installation manual is very good. VINES/386 4.1 will support NDIS multiple protocol capabilities.

Novell's NetWare 2.2 and 3.11 support a wide range of adapter cards, and Novell supplies a number of adapter drivers with its base products, although virtually all adapter vendors write NetWare drivers. Third-party adapters and drivers are subject to substandard performance (not tested by Novell) and compatibility problems with the current versions of NetWare.

Novell's proprietary Open Data-Link Interface (ODI) standard is similar to NDIS and permits multiple protocol stacks to run atop a single network adapter. Users can run a number of ODI-supported boards and protocol stacks interchangeably without compatibility problems. ODI is simple to set up for IPX/SPX, but it must be configured with advanced parameters for Novell's TCP/IP-based LAN Workplace for DOS or other third-party protocols.

Multiserver Configuration

After planning and installing the physical components of a multiserver network (i.e., servers, workstations, adapters, cabling systems), the logical configuration of the internetwork is critically important to ongoing network administration and performance.

Multiserver installations of LAN Manager, LAN Server, and NetWare are significantly improved by the use of domains. Domains and organizations represent groupings of servers, workstations, users, and related resources. IBM, Microsoft, and Novell's new NetWare Naming Service (NNS) use domains, and Banyan's StreetTalk naming system uses organizations. Domains and organizations are defined during installation and can be modified at any time. The domain concept applies to all installations, even a single server, and multiple domains or organizations can be defined on a network.

With a single login, users access resources on multiple servers within a domain. In nondomain networks such as NetWare without NetWare Naming Service, multiple logins must be maintained for access to multiple servers. A downside to the domain model is that user login IDs are domain specific. Administrators attempting to manage a large number of domains must manage a number of different login IDs for administrators and users needing to cross domain boundaries. In comparison, Banyan's naming system requires only one login ID per user across the entire network.

LAN Manager and LAN Server

IBM LAN Server and Microsoft LAN Manager domains can contain four types of servers: primary domain controller, backup domain controller, member server, and standalone server. Primary domain controllers hold the primary user accounts database and validate user logins within the domain. The Net.acc user accounts file contains user IDs, passwords, and group information. The primary domain controller distributes Net.acc to all backup and member servers in the domain to validate access to server resources.

During normal operations, LAN Manager backup controllers can actively perform login validations to balance the login processing load. LAN Server backup controllers validate API logins, but not menu- or command line-based logins. Backup or member servers can be changed to primary servers in the event of a system crash or network segment outage. When a primary domain controller fails, LAN Manager users can be validated by a backup controller, but LAN Server users are locked out until a backup controller can take over as primary.

IBM notifies installers that most multiserver networks need a primary domain controller and simplifies the process of defining a primary domain controller. Microsoft's Installation Guide concludes its coverage of server installation with "this computer is now installed as a standalone server not participating in domain-wide security." After searching the Administrator's Guide or calling Microsoft, installers will eventually figure out how to set up the server properly. Setting up backup or member servers can test the installer's resolve, and NSTL strongly recommends following the documentation to the letter.

NetWare

Novell defines no explicit roles for multiple NetWare servers with or without NetWare Naming Service (NNS). All servers are peers, and administrators control user access to multiple servers.

Without NNS, a user must explicitly log in to each server, where his or her username and login ID are defined. For the sake of simplicity, administrators can give each user a single user ID on all servers. Users can use the same password for all servers and place an Attach command for each server in their login scripts. A user logging into the first server would then automatically be logged in to the Attached servers. Drive mappings can be assigned to disk

resources on any attached server in the user's login script. At password expiration, the system queries the user to synchronize passwords on all Attached servers. (Cumbersome, but it works.)

NetWare Naming Service (NNS) improves the installation and maintenance of multiple-server networks by introducing the domain concept (see Naming Services). NNS eases administration of groups and users, provides users with a simpler means of logging in to multiple servers in the domain, and improves printer queue access. NNS installs on a server from a network workstation (five installation disks). Large networks require planning of domains, groups, users, and login scripts. Layering NNS over existing NetWare networks can result in name conflicts between old NetWare servers and the existing NNS domain.

VINES/386

Multiple VINES/386 servers are also peer-to-peer oriented. Assuming network connections have been made, the VINES/386 installation process detects the presence of other servers; prompts for server name, administrator name, time, and adapter information; and integrates the second server into the network. Administrators can then proceed to create organizations, groups, and users on the added server and set up resource and access permissions. Banyan servers are not subject to the problems associated with primary or backup domain controllers because VINES' naming database is distributed without a single point of failure.

Workstation Installation

LAN Manager and LAN Server

Microsoft LAN Manager and IBM LAN Server support DOS and OS/2 workstations. LAN Manager's remote boot facility supports diskless OS/2 and DOS workstations. LAN Server currently provides remote booting only for DOS Requester stations. Neither supports Macintosh workstations. LAN Server refers to network workstations as Requesters. The workstation-based Lanman.ini or Doslan.ini files may require manual modifications if associated performance parameters are adjusted on the server. The menu-based installations of both products automatically modify basic parameters.

Installing LAN Server DOS Requesters requires four 3.5-inch diskettes and a rather straightforward procedure. The LAN Support Program must be installed on DOS systems to provide driver-level support. OS/2 Extended Edition systems connect to LAN Server networks using the LAN Requester component of Communications Manager. OS/2 Standard Edition 1.3 workstations currently cannot connect to LAN Server, but the Requester component will be available to the SE operating system in future releases. The DOS Requester installation script requires IBM PC-DOS on the workstation, but actual use of DOS Requester does not require PC-DOS. Non-IBM DOS stations can be set up using Fastwire or similar methods.

LAN Manager DOS workstations can be set up in enhanced or basic mode. Enhanced mode provides named pipes support, an extended network command set, the LAN Manager interface screen, messaging to LAN users, and the capability to define user profiles. Basic workstations use less memory; have fewer network commands available; and do not include the LAN Manager interface screen, messaging, and named pipes support. Both modes can use Himem.sys to load portions of the network redirector into high memory to free lower memory. The enhanced mode installation script provides a Microsoft Windows selection to run under Windows. LAN Server workstations can also use Himem.sys, and MS-DOS 5.0 supports "zero footprint" network drivers fully loadable and executable above 640K bytes.

Microsoft's OS/2 stations have all the functionality of enhanced mode DOS stations plus peer-to-peer configuration capability. LAN Manager's Peer Service permits limited server functions on OS/2 workstations, such as sharing of file, print, and communications devices. More important, Peer Service stations can be set up as SQL servers even with limitations on resource sharing because their named pipes (interprocess communications) support is unlimited. Users need not purchase another copy of LAN Manager server software in order to install an SQL server. Peer Service is currently not implemented in IBM LAN Server.

Large IBM customers benefit from Extended Edition's integration with IBM mainframe environments. Extended Edition's Database and Communication Manager components permit simultaneous graphical connections to a variety of IBM host-based resources over a range of connections. OS/2 Extended Edition's full range of features is best exploited with a powerful workstation.

NetWare

NetWare 2.2 and 3.11 support DOS, OS/2, and Windows 3.0 workstation clients. NFS and FTAM clients are optionally supported in NetWare 3.11, as is Macintosh connectivity (at extra cost). NetWare 2.2 includes Macintosh workstation support. Both versions support diskless DOS and OS/2 workstations.

NetWare DOS workstations are by far the easiest to install among the tested systems. The new DOS workstation generation (Wsgen) program is fast and easy to use. IPX packet sizes can be altered depending on the network adapter's capabilities. The DOS Open Data-Link Interface workstation software included with both NetWare versions allows multiple protocols to work in a NetWare client station including SPX/IPX, TCP/IP, SNA, OSI TP4, and AppleTalk. HIMEM or expanded memory can be used with the XMSNETx or EMSNETx redirectors.

NetWare 3.11's NetWare Requester for OS/2 connects OS/2 workstations. NetWare 2.2 users can return a response card to Novell or a reseller to get the OS/2 Requester at no cost. The maximum number of workstations on named pipes has been increased to 255, and support for HPFS extended attributes and long names added.

VINES/386

The VINES/386 workstation installation is only slightly more complicated than the NetWare installation, but simpler than LAN Manager and LAN Server. A VINES/386 workstation installs with two installation disks and Pcconfig utility. Once the first workstation is installed, all the pertinent files can be generated on a single diskette for installing other workstations with the same basic hardware configuration. Memory usage can be improved by using DOS version-specific redirectors and HIMEM.

Version 4.1 supports OS/2 workstations with named pipes and extended attributes and provides much better support for Windows 3.0, but it still does not support Macintosh clients.

Naming Services

Network naming services are very important for easy administration of multiserver networks. Naming services let administrators assign names to physical network resources (e.g., print queues, disk directories), individual users, and groups of users. Naming makes it easier for administrators to set up and manage user login names and permissions and simplifies user login procedures and access to network resources. Domains (and organizations) are essential to naming service implementations. Important distinctions between the network operating systems' naming implementations are not always obvious. None of the naming systems currently comply with CCITT X.500 directory service standards.

Banyan StreetTalk

Banyan's StreetTalk is by far the most comprehensive naming service available, delivering superior integration of network resources and applications. StreetTalk is a fully distributed global naming database system that specifies network entities using a hierarchical three-part Item@Group@Organization name (@ functions as a separator). The Item can be a user, list of users, server, or network service. Group refers to a collection of items with a common attribute (e.g., marketing or engineering groups). An Organization can include a number of different groups and related items within the groups. Examples of StreetTalk names might be Joe Analyst@LANlab@NSTL or Myfiles@LANlab@NSTL. StreetTalk effectively promotes an organizational view of a network by definition. Banyan users need not know the names or physical locations of resources; only server administrators need know the underlying hardware and physical locations. Nicknames or aliases for StreetTalk names simplify referencing of users, lists, network services, or other nicknames.

StreetTalk groups are defined by administrators and must reside on a particular home server. Multiple group definitions can reside on a server, which stores the group's details (e.g., users, services, and security rights). When a user logs in to a server (login server) other than his or her home server, the login server compares the user's group name with the StreetTalk database and attempts to connect with the user's home server to validate the login, check for security restrictions, and interpret the user's profile for network resource assignments and permissions. High-level information about each group is distributed network wide to ensure transparent user logins from any server and transparent access to resources as permitted.

Unlike group definitions, organizations can span multiple servers. Administrators often logically divide the internetwork into organizations corresponding to business units or similar entities.

Users can log in with a complete StreetTalk name specification or nickname. Up to three default StreetTalk groups can be defined on a user workstation in a searchlist format for login purposes. The users need enter only a full username or nickname, and VINES fills in the rest of the StreetTalk name to complete the login.

StreetTalk's global naming feature permits a single login ID for each user, an important distinction between StreetTalk and other naming services. In other systems, users must have a different login in each domain in order to cross domains. Although users do not routinely cross domain boundaries, a multiple login requirement arbitrarily enforces restrictions, hampers usability, and increases administrative chores.

(Using a single user ID and password for all domains, LAN Manager and LAN Server users can access all domains with a single login, but a password change requires manual updates in all participating domain databases. An extremely remote possibility exists that two users might be defined with the same user ID on different domains, and if they happen to choose the same password, each could gain access to the other's privileges and data.)

StreetTalk maintains a high level of integration with network services beyond print queues and disk directories. Banyan Mail, the 3270 mainframe gateway, asynchronous terminal emulation services, and all other services are defined with the same, consistent, three-part naming system and can be set up with Banyan's standard security methods. The three-part naming scheme provides an additional level of identification over two-part schemes and may be useful in companies with large numbers of servers or business units.

The StreetTalk Directory Assistance utility lets users search for usernames, lists, and services and assists in addressing Banyan Mail messages. Directory Assistance can be loaded memory-resident and invoked via a hot key. The master service maintains its own database, and smaller versions of the database (satellite services) can be defined to improve lookup response time in large networks. The master database is not updated automatically, so database rebuilds must be scheduled. A single point of failure does exist with a master database, but Directory Assistance is not critical to network operation. A VINES/386 Application Development Toolkit provides developers with program hooks into the StreetTalk and Directory Assistance databases for custom network applications.

LAN Server and LAN Manager

IBM and Microsoft use similar two-part naming systems. One component manages users' names and logins within a domain, and the other allows specification of network resources such as directories and print queues. Users log in to a domain with a username, password, and domain name (defaults to the most commonly accessed domain). Groups exist only as administrative tools for setting up access permissions.

Network resources such as printers and file services are referenced using the MS-NET//computername/sharename method. LAN Server supports the use of aliases for network resources that dispense with the //computername component and essentially provides location-independent resource referencing within a domain.

IBM and Microsoft provide reasonable network interface shells (menu selection of server resources) that effectively shield beginners from command-line parameters. Users are defined with a username, computername, and domain name. (IBM refers to computername as "machine ID" or "requester name," depending on the manual and whether the reference is to a server or a workstation.) Computernames must be unique across all domains because NETBIOS demands unique computernames to establish communications sessions.

None of the vendors, including Novell, adequately document multiple-domain operations. Because domains do not exchange naming database information, a complete "view" of the network is not available to all users without additional administrative actions. Administrators must

set up different user login IDs in all domains to be accessed; therefore, these systems are not truly "global" naming systems like StreetTalk.

NetWare Naming Service

NetWare Naming Service (NNS), Novell's first attempt at a naming service, is more aptly described as an administrative login management tool with print queue redirection capability. Users, groups, profiles, and print queues are the primary participants in an NNS database. Profiles are group-level login scripts that allow up to eight server connections. Like the LAN Manager and LAN Server domain naming schemes, NNS does not encompass all network resources, such as file services. NNS facilitates management of groups of users and noticeably improves user access to multiple servers. NNS is supported on NetWare 3.X, 2.15, and above; Advanced and SFT NetWare; and ELS NetWare.

Server changes that affect the NNS database are immediately propagated to other servers in the domain. Server synchronization ensures that all servers are current and that users can effectively log in from any of the domain's servers and use printer resources transparently. If a server is down during domain synchronization, the administrator can manually invoke a synchronization. Novell recommends that synchronization be initiated from a "template" server designated to hold the "most accurate" copy of the NNS database and that all domain changes occur through the template server to ensure accuracy. The use of template servers or even backup template servers goes against the concept of distributed naming system without a single point of failure.

The NNS uses a two-part naming scheme for users (e.g., Joe Tester@NSTL for Joe Tester in domain NSTL). NNS logically replicates physical printer queues to all servers within a domain so printing functions need not specify the server to which the printer is attached. A user need only specify the name of a replicated print queue; the print queue can be attached to any server in the domain. (The user must be attached to the server with the actual print queue.)

Three levels of login scripts can be installed: domain login scripts, profile login scripts, and user login scripts. The domain login script is similar to the system login script of non-NNS networks and applies to all users in a domain. Domain login scripts include greetings, announcements, and environment settings, but not search drive mappings. Profile login scripts (new with NNS) are geared to managing groups and users. Profile login scripts, executed after the domain login script, attach groups of users to particular servers and set up their environments and search drives. User login scripts are executed after profile scripts and can be tailored by individual users to access resources within a domain, such as mapping to drives on servers.

NNS integrates non-NNS servers into a domain in one of three ways: by combining server and domain names (duplicate usernames are replaced with the existing domain name, but print queue name conflicts are resolved); by prompting the administrator to resolve server and domain name conflicts; or by replacing all incoming server names with domain names.

A number of NetWare administrative commands have been modified to include NNS functionality. Netcon replaces Syscon and provides domain creation and management selections. Attach now attaches users to domains. Slist lists domains on the internetwork. Whoami lists attached servers and corresponding domains. Login, Logout, Pconsole, Nprint, Makeuser, Setpass, and Capture have been changed. The improved NetWare Workgroup Manager feature lets supervisors assign workgroup managers to create and manage NNS users, groups, and profiles. Currently priced at $1,995, NNS should be packaged with the operating system to be competitive with the other systems.

Server Connection Methods

Server interconnection methods are governed by a number of factors including server hardware, server locations, wiring choices, network operating system bridging capabilities, cable restrictions and physical obstructions, security issues, link redundancy, network traffic levels, number of servers, telecommunications circuit availability, and cost restraints. The optimum setup is often accomplished only with experience and time.

Backbones

A small number of servers at a single building site are often physically attached to the same local network with all network traffic traveling on the same wire. Server backbones improve performance, preventing traffic on one segment from crossing to another segment unless specifically destined for that segment. Novell and Banyan servers are intrinsically capable of supporting a backbone network using multiple cards in each server (one dedicated to backbone communications and the other[s] connected to attached network segments). Because LAN Manager and LAN Server systems do not support internal bridging, backbone configurations must be accomplished externally. External bridging costs more than internal bridging, but performance is far better.

Bridging and Routing

Novell and Banyan networks provide routing functions between network adapters in a server. A NetWare workstation can act as an external router for added flexibility and performance enhancement. Novell external routers can be created on NetWare 2.2 or 3.11 workstations.

Routers exist at the Network layer of the OSI model and are inherently more intelligent than bridges (Link layer) in managing communications between multiple network segments or geographically dispersed LANs. When multiple paths are available between LANs, routers base path selection on the fewest hops or predefined transmission cost criteria.

The complex task of choosing a Link-layer bridge, Network-layer router, routing bridge, or bridging router depends on traffic volume, link costs, transmission facilities, protocol support, and overall network delay factors. All the network operating systems can be used with third-party bridges to improve network design and performance. Third-party routers can coexist with NetWare and VINES/386 routers provided the third-party routers are built to operate with underlying network operating system protocols.

LAN Manager networks rely on third-party bridges or routers to connect disparate network segments. Connection of different LAN Manager network segments running on token-ring adapters requires source-routing token-ring bridges. Banyan and Novell networks can communicate across source-routing token-ring bridges when their source routing drivers are enabled. NetWare requires that source routing be enabled at the server and workstation, while

VINES/386 requires activation only in the server for most network configurations. With optional software, Banyan servers can emulate IBM source-routing bridges.

IBM LAN Server networks can be bridged with third-party bridges or routers depending on the type of adapter. IBM's Token-Ring Network Bridge Program provides a source-routing bridge that operates in a network workstation. Large IBM customers with multiple mainframe installations can benefit from the IBM LAN-to-LAN Wide Area Network Program, which connects LANs through SNA or X.25 backbones without host interference. Ethernet network adapters and third-party bridges can also be used.

Remote Server Connectivity Products

Novell and Banyan offer many different methods of connecting servers at remote locations. NetWare Async Remote Router software comes with NetWare 2.2 and is available for NetWare 3.11 free of charge. The Async Remote Router installs in a server or network workstation (2.1X and higher) and enables the use of COM ports up to 2400 bps (workstations) or Wide Area Network Interface Module (WNIM adapter) ports up to 19.2K bps (server or workstation). Each WNIM contains four ports. Two WNIM adapters can be installed in a network workstation router and one WNIM in a server. Novell recommends installing the asynchronous routing function in a network workstation to prevent compromising server performance or reliability. Internal Async Remote Routers cannot be installed in NetWare 3.X servers.

VINES remote connections require installation of the server-to-server WAN option and Banyan Intelligent Communications (ICA) adapter in each server. VINES/386 servers use the ICA to connect servers asynchronously at speeds to 19.2K bps. Each ICA card has six ports capable of supporting different protocols including asynchronous, synchronous HDLC, X.25, and 3270. The ICA can be installed only in servers, which support up to four ICA cards each (total of 24 ports).

Novell's Link/X.25, Link/64, and Link/T1 products act as NetWare routers, establishing server connections using NetWare X.25, T1, and leased lines. The documentation for all three products is one or two releases behind the server software. Manuals refer to old utilities, and installation files are dated 11/89. Link/X.25 installs only as an external router in network workstations. Link/T1 and Link/64 can be installed as internal routers in NetWare 2.1X file servers or as external routers. Internal routers are not possible in NetWare 3.X.

Novell supplies useful Rules of Thumb documents with its remote connection products, detailing common hardware and software installation problems, performance issues, and "known compatible" third-party products.

Remote Server Management

All the test systems support some form of server management from workstations. NetWare 2.2 administrators can use Fconsole to view server disk and link statistics, take down file servers, and purge files. NetWare 3.11's more powerful Remote Management Facility (RMF) allows remote server console operation. Standard utilities such as Syscon and Netcon (with NNS) manage multiple server resources and users from network workstations.

NetWare RMF is the most powerful remote management facility tested. Given the proper files in the server and workstation, remote server management can be established via standard network communications paths or asynchronous dial-up connections. RMF enables execution of server console commands from workstations, file transfers between the workstation and server directories, modification of server start-up and autoexec files, rebooting of file servers, server operating system upgrades, and even remote server installation.

VINES/386 administrators with the appropriate privileges can manage multiple file servers across the internetwork using the Manage, Operate, and Setdrive utilities. Manage handles server services, users, groups, organizations, lists, and nicknames. Operate generates server log reports, controls print queues, governs access to server serial links, and controls server services. VINES/386 utilities do not provide the level of control available with NetWare's RMF utilities.

LAN Manager and LAN Server permit remote server administration using the Net Admin command from a network workstation. LAN Server allows limited remote administration from an OS/2 client station. Net Admin focuses on a specific server and enables standard resource and user management functions.

Other Features

The Versatility table compares and contrasts operating system features that address the multifaceted nature of multiserver networks. Businesses should consider backup services, server link security, resource assignment across multiple servers using login scripts, workgroup or subadministrator assignments, file replication services, data and password encryption, security (general server, resource, and workstation), application toolkits, host connectivity, auditing features, distribution of print services, network protocol support, file system support, performance monitoring tools, and network management compatibility and options.

Resellers

For many organizations, selecting a good reseller can be as important as product selection. For businesses engineering large networks, a good reseller will recommend or install server hardware and cabling, estimate installation and operational costs, project and plan for maximum server loads, perform network traffic analysis, design custom user interfaces, set up gateways, train users and administrators, and plan for disaster recovery. Good resellers are not easy to find, and they often are found only by word of mouth or vendor recommendation.

Summary

Novell continues to dominate the networking business with a stratified product line under constant refinement, a large user base, many seasoned resellers, numerous third-party options, a powerful marketing engine, a well-designed and extremely popular engineering certification program, and a savvy business alliance (i.e., Blue NetWare). Novell has not yet implemented a true global naming system, but with each revision NetWare expands its server platforms, client and file system support, and network management options. Important product marketing issues for NetWare and other vendors include continued OSI protocol development and cultivation of international

markets. International sales should add considerably to network vendors' bottom lines in the 1990s.

Banyan's positioning as a high-end, enterprise-wide system may contribute to its lower market share in terms of installed LANs; in terms of high-end installations alone, Banyan does quite well with its very effective VINES product. Little marketing and press and substantial senior management turnover have hampered Banyan's rise over the years. While competing with products from IBM and Microsoft, Banyan's product speaks for itself to those who listen. A Version 5.0 is rumored to improve user interfaces and provide Macintosh support.

As Microsoft LAN Manager matures, it will act as the foundation for distributed computing applications under OS/2 and the proposed 32-bit New Technology (NT) kernel. A number of important new features are slated for release in the next 12 months, and Microsoft has been steadily deploying networking sales and support staff throughout the country. A new Industry Specialist program directed at ISVs offers sizable discounts on runtime versions of LAN Manager and SQL Server. Microsoft's recent acquisition of Banyan's technology VP may signal improved multiserver capabilities in the near future.

Through its ties to OS/2 Extended Edition, IBM LAN Server flourishes in IBM environments, but its future may depend on whether IBM customers implement LAN Server or Blue NetWare. Either way, IBM customers receive first-class support. IBM has committed to bringing LAN Server up to LAN Manager's level of functionality later this year, probably with the release of OS/2 2.0.

Program Evaluations

Banyan VINES/386

Strengths

- True global naming system
- Easy to learn and use
- Good performance across internal bridges
- Good remote server management
- Good documentation
- Multiprocessing support on Compaq Systempro
- NDIS compliance (Version 4.1)
- TCP/IP bridging and tunneling options
- Supports internal bridging/routing
- Many connectivity options
- Excellent performance monitoring option

Limitations

- No Macintosh support
- No disk mirroring/duplexing
- Hardware copy protection
- Weak print queue features
- Slow-reacting server console menus

IBM OS/2 LAN Server

Strengths

- Aggressive pricing; lowest cost per user
- Domain-based naming system
- Integrates with advanced OS/2 Extended Edition features
- Supports alias definitions
- Good user and resource security
- LANs can be bridged through IBM mainframe networks
- Remote server management
- NDIS compliance
- File replication system
- Good auditing features
- Strong print queue management features

Limitations

- Inefficient network protocols
- No global naming of all network objects
- Users require multiple login IDs across domains
- 128-user limit with basic server license
- Does not implement HPFS386
- No system or group login scripts
- Time-consuming workstation installation
- No Macintosh support
- Extremely limited LAN adapter support
- Backup service not provided
- Requires primary domain controller
- No disk mirroring/duplexing
- No TCP/IP support

Microsoft LAN Manager

Strengths

- Aggressive pricing
- Domain-based naming system
- Uses high-performance 32-bit HPFS386
- Very fast network protocols
- Allows subadministrators
- Multiprocessing support
- Remote server management
- Good user and resource security
- NDIS compliance
- Microsoft Mail and SQL Server options
- Peer-to-peer networking for OS/2 workstations
- File replication system
- Fault tolerance system
- Strong print queue management features
- Good auditing features

Limitations

- No global naming (multidomain) of all network objects
- Documentation needs improvement
- Performance tuning difficult to learn
- Requires primary domain controller
- Users require multiple login IDs across domains
- No system or group login scripts
- No Macintosh support
- No wide area connectivity options
- No TCP/IP support

Novell NetWare 2.2

Strengths

- Easy to use
- High-performance dedicated file server operating system
- Market leader; large reseller and third-party base
- Broadest LAN adapter support
- Macintosh support standard
- Strong print queue management features
- Comprehensive documentation
- Simple workstation installation; fast shell updates
- Supports internal bridging/routing
- ODI multiprotocol workstation support
- Many connectivity options
- Transaction tracking system
- Strong accounting features
- Good performance monitoring tools

Limitations

- Separate domain-based naming system
- Lacks memory protection and preemptive scheduling
- No global naming of all network objects
- Documentation errors
- Users require multiple login IDs across domains
- Changing server configuration is time consuming

Novell NetWare 3.11

Strengths

- High-performance dedicated file server operating system
- Large reseller and third-party base
- Broad LAN adapter support
- Simple workstation installation; fast shell updates
- Strong print queue management features
- Macintosh support optional
- Comprehensive documentation
- TCP/IP bridging and tunneling standard
- LAN WorkPlace for DOS and OS/2
- Excellent remote management features
- Workgroup administrators
- Supports internal bridging/routing
- ODI multiprotocol workstation support
- Many connectivity options
- Transaction tracking system
- Strong accounting features

Limitations

- High price
- Lacks memory protection and preemptive scheduling
- No global naming of all network objects
- Netware Naming Service purchased separately
- Documentation content and indexing errors
- Users require multiple login IDs across domains

Program Recommendations

Banyan VINES/386

VINES/386 is a natural fit for large network implementations. The usability and logical organization of resources afforded by StreetTalk are unrivaled. StreetTalk Directory Assistance improves access to resources and users across expanded networks. Host connectivity, TCP/IP, OS/2, and Windows environments are supported. Macintosh support will be included in Version 5.0. Banyan has a loyal following of committed resellers, and it is very responsive to technical problems, issuing regular software patch updates and site-specific patches. Based on UNIX System V, VINES/386 is positioned well for future connectivity requirements, open systems designs, and multiplatform implementations.

Novell NetWare 3.11

Without a doubt, NetWare 3.11 is a strong product capable of large multiserver network implementations. NetWare 3.11's many enhancements expand connectivity and interoperability with other environments. Although the optional NetWare Naming Service is not as powerful as Banyan's StreetTalk, it is useful for managing users and printer access. NetWare 3.11 server performance is generally impressive; large packet throughput using internal bridges could stand improvement. NetWare's reliability in NSTL tests is outstanding, and its speedy server configuration and general console and utility responsiveness make routine administration less painful.

Rating Summaries

Overall Evaluation

NetWare and VINES/386 are the best choices for multiple server networking, but any of the operating systems can accomplish network design goals with varying degrees of effort and cost.

The NetWare products provide the strongest feature suites, but NetWare 3.11 is quite expensive for over 100 users. NetWare Naming Service adds key functionality for multiple-server networks, but it does not compare to VINES' StreetTalk architecture. Novell's documentation is riddled with minor indexing errors, but the organization and depth of information presented are by far the best. Although it improves on NetWare 2.1X methods, NetWare 2.2 still lacks the usability of NetWare 3.11. NetWare 3.11 multiserver network performance is hampered when IPX packets larger than 512 bytes are sent through an internal router because the larger packets must be fragmented and reduced to multiple 512-byte packets. Advanced interoperability features in NetWare 3.11 may appeal to large businesses, universities, and government agencies.

Businesses with large network design decisions would be foolish to ignore VINES/386. An unlimited-user level of VINES/386 costs far less than NetWare 3.11. UNIX foundations provide VINES/386 servers with powerful communications capabilities. StreetTalk simplifies administration of multiple servers and provides servers with a level of integration unmatched in large network implementations. True global naming of all network objects accommodates location-independent resource referencing. Users need never know the locations of physical servers, file directories, communications links, and other objects. Administrative menu systems are easy to learn and use, but server installation is an 18-disk, one- to two-hour chore on all servers.

VINES/386 performance across internal server bridges shows a marked advantage over NetWare for large-block reads and writes. The tightly integrated Banyan Mail system has the look and feel of other VINES/386 utilities and does not require a separate mail database. StreetTalk Directory Assistance provides directory services. VINES/386 lacks Macintosh support and does not have server offerings on hosts other than PCs.

Microsoft LAN Manager 2.0 is far better than earlier revisions and is priced to sell, but it is still lacking in usability. Multiple server setup and management are not as

Figure 1.
Banyan VINES/386 Ratings

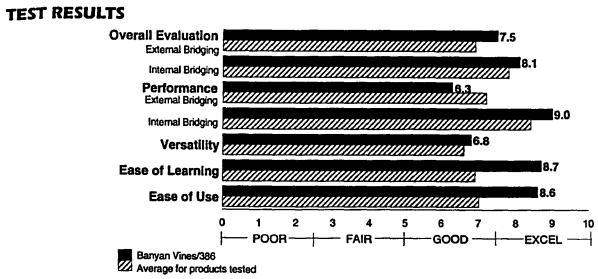


Figure 2.
IBM OS/2 LAN Server Ratings

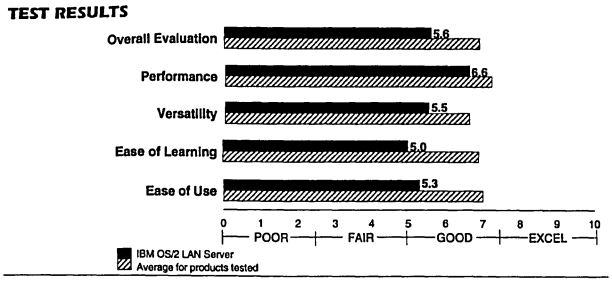


Figure 3.
Microsoft LAN Manager Ratings

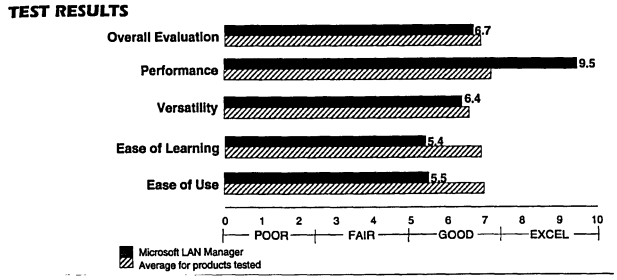


Figure 4.
Novell NetWare 2.2 Ratings

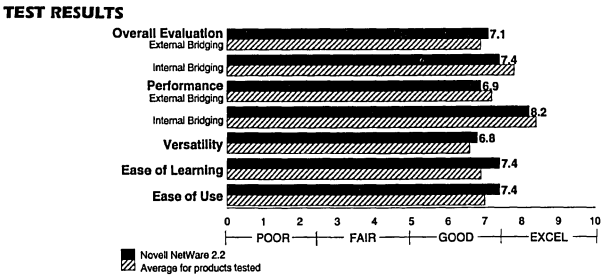
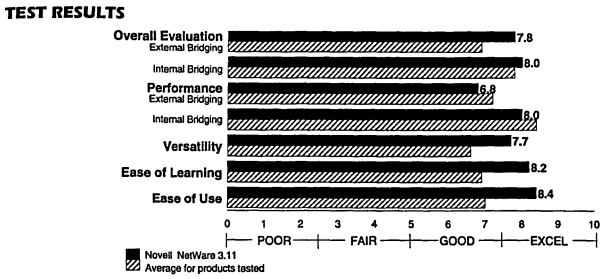


Figure 5.
Novell NetWare 3.11 Ratings



easy as in VINES/386, and LAN Manager administrators must define multiple login IDs for users needing multidomain access. Performance is astoundingly fast across the network wire because of NetBEUI's sliding windows. General server performance is good due to enhanced buffer transfers between protocol stacks and disk drivers and because of HPFS386's disk caching and 32-bit architecture. Microsoft provides countless tunable performance parameters. A well-defined set of APIs provides development hooks into the core of the system.

IBM continues to enhance its aggressively priced version of LAN Manager with features such as alias definitions, performance monitoring, and on-line references, but IBM OS/2 LAN Server still does not match Microsoft LAN Manager 2.0's feature set. LAN Server's integration with OS/2 Extended Edition adds overhead to server installations, and Extended Edition's advanced features are accessible only on 386-level systems with a lot of memory. Of course, the LAN Requester for DOS would satisfy standard user networking needs. Optional utilities automate multiple-server installations and help diagnose server and network performance problems. An optional LAN-to-LAN Wide Area Network Program bridges geographically remote LANs through existing SNA networks.

LAN Server performance is hindered by dual acknowledgments generated at the LLC and NETBIOS layers for most packet transmissions (NETBIOS sits on top of the LLC driver, and LAN Server uses NETBIOS). An upcoming LAN Server release will implement a faster file system and sliding windows NetBEUI. IBM environments needing to integrate powerful workstation-to-mainframe connectivity features with local area networking capability would be remiss not to investigate the benefits of LAN Server. Once administrators learn the architectural details of managing multiple LAN Server sites, the end-user benefits can be substantial.

Methodology

The Overall Evaluation is a weighted average of scores for the individual criteria.

Overall Evaluation Score = (4 x Performance Score) + (6 x Versatility Score) + (3 x Ease of Learning Score) + (5 x Ease of Use Score) ÷ 18.

Performance

In benchmarks focused on measuring communications speeds between network segments using an external bridge, Microsoft LAN Manager's NetBEUI protocol certainly shines. Although connecting LAN Manager network segments requires external bridges or routers, NetBEUI's efficient sliding window algorithm may be worth the added expense in some environments. Aside from network wire issues, LAN Manager uses a newer, 32-bit HPFS386 with improved caching capability. The lazy write option found in the LAN Manager (and LAN Server) cache program improves disk write performance.

NetWare and VINES/386 support network connections using internal routers. Using internal bridging, VINES/386 outperforms NetWare in transmissions of medium-sized and large blocks. New versions of NetWare's IPX protocol can transmit packets larger than 512 bytes between a workstation and server on the same segment, but the server-to-server bridge link is held to 512 bytes and IPX is not a sliding window protocol. (A new "burst-mode" version of IPX is scheduled to ship soon.) VINES/386 can send larger blocks (1,500-byte packet maximum) intact and uses sliding windows. NetWare supports a workstation-based external router, which may improve overall system performance at the expense of a network workstation.

IBM OS/2 LAN Server is not based on the same NETBIOS protocol stack as Microsoft LAN Manager, and it currently does not have sliding window capability. (Future versions will integrate NetBEUI functionality.) The LAN Server protocol stack generates many small packets, attributable to the LLC driver working under the Banyan NETBIOS driver. (Network General's Sniffer reveals double acknowledgments occurring at the NETBIOS and LLC layers for each data packet transmitted.) IBM plans to fix the problem in future versions. HPFS lazy writes appear to speed LAN Server writes to the server.

Methodology

Performance tests measure network operating system speed using two LAN segments bridged with external and internal bridges. Tests are conducted without traffic and with traffic. All workstations access the opposite host across the bridge. Multiple test runs for each segment are averaged, and results for the two segments are also averaged. Products are scored relative to the fastest product for each subtest. The overall performance rating is a weighted average of the individual benchmarks.

Methodology Score = (Lotus 1-2-3 w/no traffic) + (Lotus 1-2-3 w/cross-traffic) + (Xcopy to Server w/no traffic) + (Xcopy to Server w/traffic) + (Xcopy from Server w/no traffic) + (Xcopy from Server w/traffic) + (2 x Sequential Read, 512-byte blocks) + (2 x Sequential Write, 512-byte blocks) + (Sequential Read, 4K-byte blocks) + (Sequential Write, 4K-byte blocks) + (2 x Sequential Read from Cache) + (Sequential Write from Cache) ÷ 15.

Versatility

The NetWare products provide a multitude of useful administrative and user utilities. NetWare Naming Service facilitates multiple-server administration, but it lacks true global naming and automatic synchronization capabilities. Numerous connectivity options are available from Novell and third parties for server-to-server connections including asynchronous, synchronous, T1, X.25, and TCP/IP links. IBM host access, NetWare for VMS, and remote user dial-in features are also available.

NetWare 3.11 supports a variety of workstations and file systems, including OS/2 and HPFS, Macintosh and AFP, Windows, VAX/VMS, TCP/IP using LAN WorkPlace for DOS or OS/2, FTAM, and NFS. Multiple protocols can be used in DOS workstations using Open Datalink Interface (ODI) drivers. Novell's Print Server product supports up to 16 printers (server or workstation attached) with queues serviceable on up to eight servers. A large number of development tools are available. NetWare 3.11 remote administration tools are the most powerful and provide the most integrated and efficient direct- or asynchronously attached remote console capability.

Novell has stratified its NetWare 2.2 and 3.11 products to meet different customer requirements; Version 2.2 supports up to 100 users, while 3.11 supports 250 users per server. NetWare 3.11 now offers NetView and SNMP network management support. NetWare products continue to offer detailed security, accounting, and auditing features

but lack substantial alert services. Both versions offer system backup and restore from network workstations, and NetWare 3.11 adds a server-based backup utility implemented as an NLM.

VINES/386 integrates the powerful StreetTalk naming system for managing large networks. StreetTalk's distributed database system is automatically synchronized on all servers, and frequent updates between internal server routers validate and configure network communications paths. The StreetTalk Directory Assistance facility displays network users and resources and integrates with Banyan Mail's addressing function. VINES/386 does not set hard code limits on the number of concurrent clients per server, but memory and process limitations govern the number of connections.

The recently announced VINES/386 Version 4.1 improves Windows 3.0 interoperability, supports OS/2 workstations, and includes DOS named pipes and NDIS multiprotocol support. It still does not support Macintosh workstations. Restricted access options are integral to VINES/386 server-to-server communications links and dial-in users. Asynchronous, HDLC, X.25, and TCP/IP server-to-server links are available. Scheduled server-to-server connections are possible.

Banyan's VANGuard security system provides standard features such as time and station restrictions and account lockout. Directory and file permission levels are less extensive than the competition. Banyan's optional network management tool does not yet support NetView or SNMP. VINES/386's two management commands, Manage and Operate, enable remote server administration from any workstation. Server management across asynchronous links requires special considerations, and servers cannot be reconfigured and rebooted remotely.

VINES/386's integrated Banyan Mail system does not require a separate name database (as do most third-party E-Mail products) and uses the same wide area links used for server-to-server communications.

Microsoft LAN Manager and IBM OS/2 LAN Server share similar administrative functions, but with different interfaces. User account and file system permissions rival NetWare and VINES/386, and LAN Manager can optionally use share-level security. Neither product supports Macintosh workstations, and neither implements true global naming. Domain-based naming services used in both systems have design advantages over NetWare Naming Service but do not rival Banyan's StreetTalk. An IBM LAN Server license serves 128 users and with extensions supports to 254 users. Microsoft sells 5-user LAN Manager packages with 10-user upgrades, or an unlimited-user upgrade per server.

Although Microsoft does not directly supply wide area networking products, the LAN Manager architecture supports third-party bridging and routing products. Various OEM versions of LAN Manager on different platforms may soon become interoperable with Microsoft LAN Manager 2.0. Related optional products such as Microsoft SQL Server and Microsoft Mail (Network Courier) strengthen LAN Manager's market position.

IBM LAN Server ties into large IBM mainframe architectures via OS/2 Extended Edition, but LAN Server 1.3 does not yet provide all of the LAN-based features of the more current LAN Manager 2.0. LAN Server currently permits definition of aliases for referencing network resources independent of server or location. IBM connectivity products join LAN Server networks through SNA networks; surprisingly, LAN Server is not yet integrated with NetView. IBM recently forged an alliance with Network Equipment Technologies to provide LAN-to-WAN connectivity products for LAN Server that can be managed with NetView.

Methodology

Versatility is a weighted average of scores based on each operating system's standard and advanced network services. Features and their methodology weights are listed in the Versatility table.

Ease of Learning

Given proper and efficient network administration, network users will find any of the systems equally easy to learn. Inexperienced administrators, however, may find the systems equally difficult. Banyan's system architecture is well designed, inherently logical, and easy to learn. Novell's systems have been fine-tuned for easy setup and learning based on user feedback. Microsoft and IBM need to improve product usability overall, and both should consider options for basic and advanced installation procedures. NSTL strongly recommends vendor or reseller training classes for better understanding of system capabilities and to reduce learning time.

The NetWare 3.11 and VINES/386 installations are easy to learn and need little server parameter tuning out of the box. Banyan's integrated StreetTalk global naming system does not require the separate installation and ongoing administration required by NetWare Naming Service.

Multiple-domain administration and integration are poorly documented in NetWare, Microsoft LAN Manager, and IBM OS/2 LAN Server. Novell and Microsoft provide assorted quick-start tools; all the vendors provide worksheets and network planning recommendations. Novell provides excellent "rules of thumb" documents with its server-to-server communications products that include suggested hardware and software configurations based on engineering experience.

LAN Manager and LAN Server multiple-server setup requirements can be difficult to understand. Defining a server's role in a domain involves many seemingly bizarre steps. The administrative menuing systems in both products are clumsy and more difficult to learn than the Novell and Banyan menus. IBM is caught between making LAN Server easy to learn and OS/2 Extended Edition easy to use. The management screen for setting up LAN Server users is found in the Extended Edition menus to prevent defining the same users for other Extended Edition functions. Assimilating LAN Server's menu flow takes some time.

Banyan and Novell document primary administrative tasks well, but both require a few usability revisions. Novell users may experience learning setbacks because of documentation omissions and errors. Novell has significantly modified and improved its manuals from previous versions, but installation information has been corrupted in the process and index references botched. Microsoft and IBM need to improve the flow of their documentation, which requires many cross-references during installation. Performance tuning LAN Manager and LAN Server is better left to experts.

New administrators will struggle to understand statements like Novell's "BIND IPX TO NE2000 PORT=340 INT=4 FRAME = ETHERNET802.3 NET=26" or IBM's "/SRV:8 /ASG:29 /NBC:4 /NBS:4 /BBC:0 /BBS:6 /PBC:4 /PBS:128" or Microsoft/IBM's statement

"WRKHEURISTICS=
11111111113111111100010111201112 2," in which each number represents a poorly documented performance tuning parameter.

Methodology

After studying the manuals and other reference materials supplied with each program, technicians assess how easy it is to learn standard tasks such as installing and setting up multiple servers using provided facilities. Ease of Learning is a weighted average of scores for the individual criteria.

Ease of Learning Score = (Operating System Installation Score) + (2 x Connecting Multiple Servers Score) + (3 x Single Domain Management Score) + (3 x Multiple Domain Management Score) + (Remote Management Score) + (Adapter Installation Score) + (Documentation Score) + (2 x Security Administration Score) + (Printer Administration Score) + (Share/Link Score) + (Workstation User Score) + (2 x Performance Tuning Score) + (Overall Ease of Learning Score) ÷ 20.

Ease of Use

VINES/386's multiserver architecture naturally simplifies management of a large network. StreetTalk provides a logical and global view of all network resources. Although the load time for 18 VINES/386 disks is over an hour per server, once installed, the system automatically integrates itself into an existing network and requires no manual synchronization of naming databases between servers. The administrator need not define primary, backup, or member servers as in Microsoft LAN Manager and IBM LAN Server. Banyan's communications hardware (e.g., Intelligent Communications Adapter) and software options (Server-to-Server WAN, PC Dial-In, X.25 Server-to-Server, 3270/SNA) facilitate communications link management.

When new software versions are loaded on VINES/386 servers, all attached workstations run an automatic upgrade utility. (NetWare now provides a similar feature.) Network services can be moved between servers without disrupting network operations using backup/restore procedures or DOS Copy operations. Minor drawbacks relate to time required to perform seemingly easy tasks, such as restarting a server or copying an option key, and its outdated interface lacking mouse support.

NetWare 3.11 administrators managing multiple servers in a dynamically changing environment will enjoy the fast response of NetWare utilities. NetWare Naming Service simplifies administration with better login and group management and simplified print queue management. Administrators may resent having to manage a template server and manually ensure domain synchronization, but without the naming service option, the administrator must explicitly attach every server. Access to another domain's resources requires a login ID and password in the other domain. NetWare can be installed on multiple servers from an existing network. A new utility automates updates to existing workstation software.

All the systems support remote server management. Banyan's easy Manage and Operate utilities are available to administrators from any workstation. IBM OS/2 LAN Server permits remote control only from OS/2 workstations. NetWare's Remote Management Facility lets administrators install NetWare on a remote system, modify server start-up scripts, run console commands, and reboot servers.

Network resource permission assignments are conceptually similar on all the systems, but implementations vary. All provide user- and group-based resource assignments. Novell's trustee assignments apply directory rights by user or group; Banyan's Setarl sets user rights by directory. Once learned, Banyan's Setarl function is quite easy to use, but it should be integrated into the Manage menu system. The group profile login script in the NetWare Naming System provides an advantage for administering multiple resource assignments per group. LAN Manager and LAN Server permission assignment menus are informative, but difficult to use with a keyboard.

Basic installation and advanced administration are somewhat involved in LAN Manager and LAN Server. Domains assist in login and group administration. The domain naming system is automatically synchronized at predefined intervals in LAN Manager and LAN Server. LAN Server installation requires that OS/2 Extended be loaded. Keeping track of system parameters managed by the Communications Manager, LAN Requester, and LAN Server is a continuing source of confusion. LAN Manager is spared the added complexity of the Communications Manager but shares a similar number of tunable parameters. The amazing level of operating system tunability with corresponding APIs comes at the expense of usability. IBM has reduced the number of necessary parameters in its Doslan.ini file, but it has assigned cryptic acronyms to those that remain. Administrators deploying LAN Manager or LAN Server networks will be forced into proficiency with topics like the number of big buffers, the size of request buffers, and the server heuristics settings. Basic administration tasks in either system are not bad when well understood. A mouse is strongly recommended for both administration utilities.

LAN Manager and LAN Server administrators must use multiple installation disks when first setting up each network user. User parameter files often have to be modified. LAN Server can define aliases for network resources. Aliases permit resource referencing with logical names and do not require that a server name be specified. LAN Manager provides a command utility reference manual; LAN Server administrators must access an on-line reference.

Methodology

After learning each program, technicians install and set up each network system, set up multiple servers, tune them for performance, use security features, and perform other tasks. Ease of Use is a weighted average of scores for the individual criteria.

Ease of Use Score = (Single Installation Score) + (2 x Multiple Installation Score) + (2 x Connecting Multiple Servers Score) + (3 x Single Domain Management Score) + (3 x Multiple Domain Management Score) + (Remote Management Score) + (Adapter Installation Score) + (Documentation Score) + (2 x Security Administration Score) + (Printer Administration Score) + (Share/Link Score) + (Workstation User Score) + (2 x Performance Tuning Score) + (Overall Ease of Use Score) ÷ 22.

Performance Results

Test Configuration

NSTL performance tests measured network operating system performance characteristics with two servers operating on different token-ring network segments. Each segment included a server and five workstations using IBM 16/4 Token-Ring Adapters running at 16M bps.

Tests were run with the segments connected in two different configurations: a server-to-server backbone arrangement using two network adapters in each server, and an external bridge. The backbone used a separate MAU. Microsoft LAN Manager and IBM OS/2 LAN Server are capable of connecting different network segments only through external bridges or routers. NetWare and VINES/386 are capable of internal bridging/routing (internal bridging and internal routing will be used interchangeably, although routing is technically accurate). All the network operating systems were tested through an external bridge, and NetWare and VINES/386 were also tested with internal bridging. Testing with two configurations helps determine which network operating system is the most efficient at managing communications over the server links.

Four 16MHz 386SX traffic workstations and one 33MHz 386 superstation were attached to each 33MHz 386 server. The servers were AT-bus compatible, and each contained a 330M-byte Micropolis 1664-7 ESDI drive, Ultrastor 12F controller, and 12M bytes of RAM. Each superstation was equipped with MS-DOS 4.01, an 80M-byte Western Digital IDE drive, and 8M bytes of RAM. Traffic workstations were equipped with MS-DOS 4.01, 4M bytes of RAM, and a 40M-byte hard disk. All stations were connected to both servers with the appropriate logins and rights. Tests measured the elapsed time for both superstations to complete assigned tasks (loading and saving of data from the opposite server). The traffic workstations generated network traffic to the opposite server. Tests were run multiple times and averaged.

External Bridging

External bridging incurs less processing overhead than internal bridging. NSTL used a Netronix TokenMaster 100 bridge, a leading source routing bridge that is 100% compatible with IEEE 802.5 and IBM source routing protocols. LAN Manager and LAN Server use source routing fields within their protocols. NetWare and VINES/386 do not use source routing fields in their native protocols, but source routing options are available for both products. The latest source routing drivers available from Novell and Banyan were loaded per vendor documentation. Source routing transparent bridges, which are new to the market, support source routing and non-source routing protocols and therefore need no special drivers for NetWare or VINES.

For LAN Manager and LAN Server, NSTL set up two domains, each with a server, superstation, and four workstations. NetWare was set up with one domain using the NetWare Naming System, and all servers and workstations were defined within the domain. Performance is not affected by using one or two domains with any of the systems. NSTL also tested LAN Manager and LAN Server with two servers residing in one domain and observed no difference in performance. VINES/386 was set up with two organizations, each containing a single group.

A Network General Sniffer running its Token-Ring 16/4 Analysis package was used to analyze network traffic and ensure that performance parameters were set up properly. Network General Token-Ring Monitor was used to characterize network traffic generated by the network operating systems.

The performance results show that a dedicated bridge is much faster than internal bridging/routing of network traffic. Different operations and different data request sizes contribute to significant differences between the systems.

Performance Tuning

Microsoft LAN Manager's automatic performance tuning feature is not well documented, but it was selected in the installation procedure. Internal buffers and structures are adjusted depending on the number of users and other factors. NetWare 3.11's automatic tuning feature adapts or self-tunes based on network usage. NSTL attempted to set up 4K-byte transmit and receive buffers at the MAC level for all the network operating systems. VINES/386 software responds with a maximum packet size of 1,500 bytes, which is the VINES/386 IP limit. LAN Manager is similarly throttled to 2K-byte packets across the wire, which Microsoft acknowledges is the product's limit. LAN Manager request buffers at the operating system level are still set to 4K bytes. IBM LAN Server and NetWare permit 4K-byte packets across the wire.

Total cache size and individual cache buffer sizes were left at the defaults for VINES, NetWare, and LAN Manager. The IBM LAN Server cache was set to 2M bytes per IBM's recommendation. Lazy writes were enabled in LAN Server and LAN Manager. NSTL kept NetWare 3.11's Write Verify=ON default and set VINES/386 to Write Verify=ON. The Write Verify=ON setting has a nominal effect on NetWare 3.11 performance in NSTL's tests, but it slows VINES/386 a bit. NetWare 2.2 was left with its Write Verify=OFF default selection.

Microsoft's NETBIOS protocol (NetBEUI) has a dynamic window sizing function called the adaptive window algorithm. As seen in the performance results, this effective performance feature permits transmission of a number of packets across a communications link without immediate acknowledgment. LAN Server does not provide an adaptive window algorithm or an operating system automatic tuning feature, but both will be added to future releases of LAN Server and the LAN Support program.

Optimum operating system performance can be achieved with laborious experimentation. Vendors are often unable to recommend an optimal parameter mix due to the variety of processing scenarios. NetWare and VINES are easier to tune than LAN Manager and LAN Server. The following performance parameters were tuned in each of the network operating system servers per vendor recommendations; corresponding workstation parameters were set to match server parameters.

Novell NetWare 3.11 and 2.2

Server: STARTUP.NCF—Set maximum physical receive packet size=4202 (Version 3.02A server token-ring driver).

Workstation: AUTOEXEC.BAT—IPX o,PRIMARY, TBZ=4202 (Version 2.62 workstation token-ring driver).

Banyan VINES/386

Server: Token-Ring Transmit Buffer Size = 2K (did not allow a 4K-byte setting; Sniffer reveals a 1,502-byte maximum transmitted per packet).

Microsoft LAN Manager

Server: LANMAN.INI—Sizreqbuf=4K; PROTOCOL.INI—Sessions = 20, Selectors = 20; NETBEUI DRIVER—Maxtransmits = 6 (default); IBM Token-Ring Driver—Maxtransmits=6 (default); CONFIG.SYS—Protectonly=YES.

Workstation: LANMAN.INI—Sizworkbuf = 4K.

Attempts to set the actual link-level token-ring frame to 4K bytes were unsuccessful. Microsoft was unable to help in the matter, and IBM informed us that Microsoft link protocols were permanently set to 2K-byte maximums even when request buffers and work buffers are set to 4K bytes. Manually setting the token-ring driver's Xmitbufsize to 4K bytes in PROTOCOL.INI appeared to be overridden by NetBEUI.

IBM LAN Server

Server: IBMLAN.INI—Sizreqbuf = 2K, Numbigbufs = 15; CONFIG.SYS—Protectonly = YES; COMM MANAGER 802.2 Parameters—Transmit Buffer Size = 4224, Number of Transmit Buffers = 2, Receive Buffer Size = 512, Minimum number of Receive Buffers = 50.

Per IBM, the server variable, Sizreqbuf, and /NBS parameter in the workstation Doslan.ini file were set to 2K bytes to match the 2K-byte cache read and write limit of IBM's version of HPFS. When an application performs a 4K-byte write, LAN Server breaks the request into two 2K-byte writes (verified using the Sniffer). When performing reads larger than 2K bytes, such as a 4K-byte read, the IBM protocol converts to "raw SMB read" mode and reads and transmits 4K bytes across the network wire. These results are seen in the low-level disk tests, and they also influence the high-level test results.

Workstation: DOSLAN.INI—/NBS:2K;CONFIG.SYS—DXMT0MOD.SYS DS=4224 DN=2.

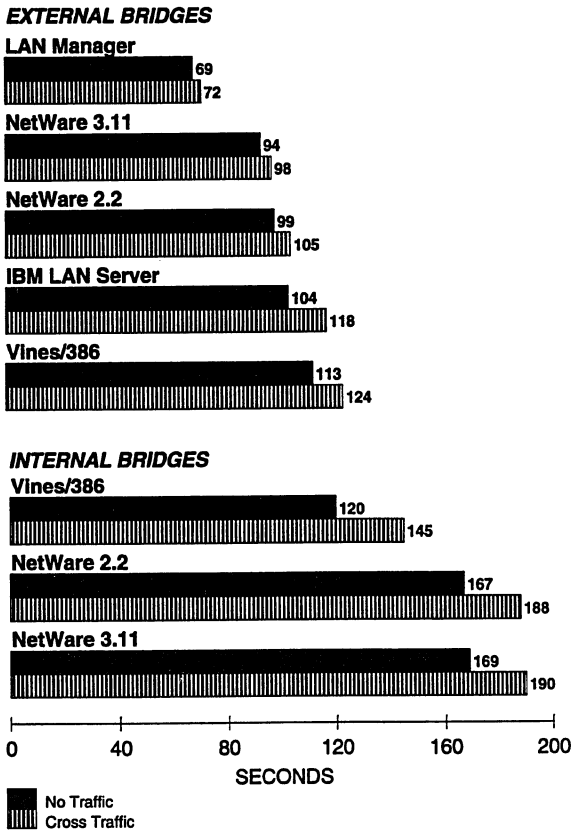
Lotus 1-2-3

A Lotus macro loaded and saved a 3M-byte spreadsheet, using the network to move substantial amounts of data. The superstations ran the test at the same time, and each was linked to the opposite server (server not directly attached on the same MAU, but attached through a backbone or an external bridge). The test was repeated with the traffic workstations concurrently performing metered loads and saves of Lotus files to the opposite server.

Analysis

Microsoft LAN Manager network protocols prove more efficient than the competitors' protocols. The Lotus test generates 1K-byte, 2K-byte, and 4K-byte application-level reads and writes, which are translated into similar-sized

Figure 6.
Lotus 1-2-3



blocks by the Server Message Block (SMB) and NetWare Core Protocols (NCPs). (SMB is used by all but NetWare.) Although not an overall measure of performance, the Microsoft protocol transmits approximately 6,000 fewer packets overall without traffic than its nearest competitor, VINES/386 (16,200 versus 22,500). Microsoft uses larger packets on the ring than VINES/386 (2K bytes versus 1,500 bytes). Disk drivers and operating system overhead affect this and other benchmarks, but protocol analysis appears to track closely with the test results.

Over the backbone, NetWare suffers from the need to scale down the maximum packet size to 512 bytes. (The internal NetWare router is presently unable to transmit any more than 512 bytes per packet.) The transmitting workstation actually negotiates the transmit buffer size with each attached server (a function of the NetWare Core Protocols and router capabilities). The server accessed over the internal router returns 512 bytes upon inquiry, while the local server returns 4,096 bytes. The 512-byte routing limit is a serious performance flaw of NCP (applies to all NetWare performance tests through the router). NetWare SPX/IPX protocols have no sliding window capability, but a "burst-mode" IPX is imminent.

VINES/386's internal bridge performance is somewhat slower than its speed through the dedicated Netronix external bridge. VINES/386 is considerably faster than NetWare over internal bridges because it uses sliding windows and permits larger packets.

IBM OS/2 LAN Server protocols are very inefficient transmitting 77,700 packets in the no-traffic scenario.

Figure 7.
Xcopy to Server

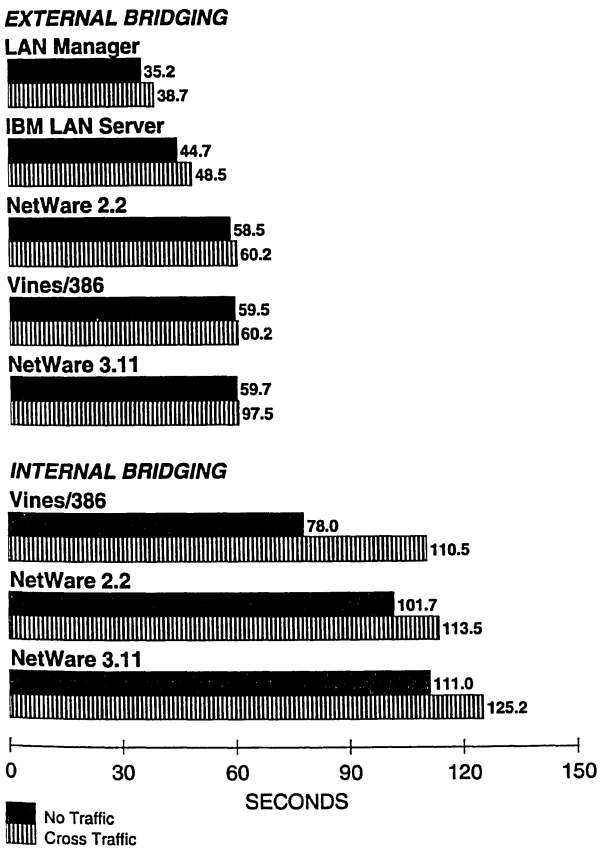
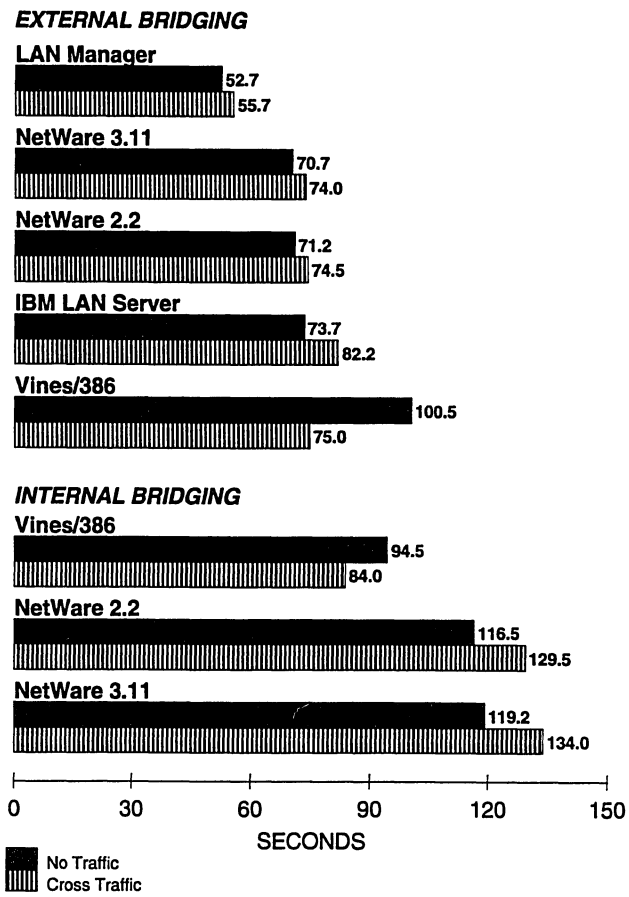


Figure 8.
Xcopy from Server



LAN Server protocols appear to issue double acknowledgments for each packet sent. The Sniffer shows both LLC- and NETBIOS-level acknowledgments being generated for each packet transmitted, with up to nine small packets ping-ponging between packets. According to IBM, its present protocol stack uses NETBIOS on top of 802.2, as evidenced when loading LAN Support Program drivers. Other IBM applications that use only 802.2 (such as APPC) must also be supported. IBM plans to decouple the LAN Server protocol from the SNA requirements to provide more efficient LAN processing.

The traffic scenarios maintain similar relationships to the no-traffic results, with superstation performance degrading as expected.

Xcopy to Server

Five-megabyte directory trees (130 files, 40K bytes each, in 13 directories) were copied to each server (command issued with the /s parameter) from the opposite superstation; the source trees were located on the superstations' local hard disks. The test was repeated with concurrent Lotus traffic on the traffic workstations.

Analysis

Xcopy generates large 40K-byte reads equal to the 40K-byte benchmark file size; these large reads are translated into very large SMB "raw writes." The SMB requests are broken into smaller NETBIOS packets equal to 2K bytes in Microsoft LAN Manager and 4K bytes in IBM LAN Server. LAN Manager's sliding window protocol sends up to 18 NETBIOS data packets without requiring an acknowledgment. (Sliding window frame counts vary based on dynamic analysis of line conditions.) LAN Manager and LAN Server also benefit from HPFS lazy (deferred) disk writes in this test. IBM is again slowed by a tremendous number of small acknowledgment packets, but the larger data packets contribute to better performance. VINES/386 is markedly faster than NetWare across the internal bridge and comparable through the source routing Netronix bridge. NetWare maintains 4K-byte packet sizes through the external bridge.

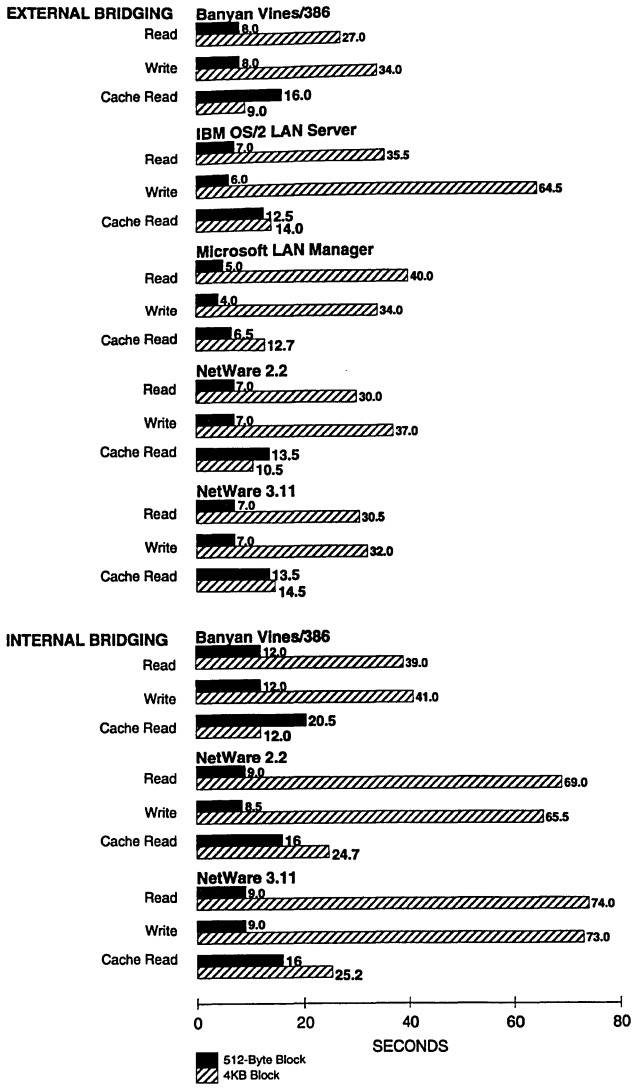
Xcopy from Server

Five-megabyte directory trees (130 files in 13 directories) were copied from each server to the opposite superstation (command issued with the /s parameter). The test was repeated with concurrent Lotus traffic on the traffic workstations.

Analysis

Performance tendencies exhibited in the Xcopy to Server benchmark are also found in this benchmark. VINES/386 maintains its edge over NetWare across the internal bridge. Across multiple runs and with cache flushes between runs, VINES/386 provides better performance with

Figure 9.
Low-Level Disk Reads/Writes



traffic than without. This anomalous condition is not exhibited by any of the other systems. VINES/386 may be tuning disk or communications buffers based on load, causing it to actually benefit in this instance.

Low-Level Disk Reads/Writes

The low-level disk benchmark, written in Microsoft C, used the C language mechanism for issuing standard DOS INT 21 functions 3Fh (read from a file) and 40h (write to a file). Repetitive sequential disk reads and writes of 512 bytes and 4,096 bytes forced a large amount of data over the network links. This low-level test not only stressed the network protocols, but tested 512-byte block reads to balance the large block reads of the Lotus and Xcopy tests. Each superstation ran the test to the opposite server (not attached to the same MAU). The two tests were run multiple times to fully stress the network links and to ensure that the data was being cached and subsequently read from cache. Observation and test results indicated the disks were not being accessed on repeat runs.

Analysis

Microsoft LAN Manager exhibits fast disk and network transport code. VINES/386 proves effective with large block reads, while NetWare excels at 512-byte reads and writes. NetWare 2.2 and 3.1 are competitive with internal and external bridging. Write verification set OFF in NetWare 2.2 does not give it an unfair advantage over NetWare 3.11 because Version 3.11 does not lose speed with write verification set ON in the NSTL tests.

According to IBM's recommendations, LAN Server's server variable, Sizreqbuf, and /NBS parameter in the workstation Doslan.ini file are set to 2K bytes to match the 2K-byte cache read and write limits of HPFS. When the low-level test performs a 4K-byte write, LAN Server breaks the requests into two 2K-byte writes (verified using the Sniffer). When performing reads larger than 2K bytes, such as a 4K-byte read, the IBM protocol converts to "raw SMB read" mode and reads and transmits 4K bytes across the network wire.

Vendors

Banyan Systems, Inc.
120 Flanders Road
Westborough, MA 01581 (508) 898-1000

IBM
Old Orchard Road
Armonk, NY 10504
Contact your local IBM representative.

Microsoft Corp.
One Microsoft Way
Redmond, WA 98073-9717 (206) 882-8080

Novell, Inc.
122 E. 1700 South
Provo, UT 84606 (801) 429-5900

Specifications

Features/Functions

Features	Banyan VINES/ 386 4.0	IBM OS/2 LAN Server 1.30.1	Microsoft LAN Manager 2.0	Novell NetWare 2.2	Novell NetWare 3.11
Drives	40MB hard disk	4.6MB (Requester); 6.2MB (server)	20MB hard disk, high-density diskette drive	10MB hard disk	20MB hard disk
Server Memory	4MB; 16MB-24MB maximum	4.8MB; 16MB maximum	5MB; 16MB maximum	2.5MB; 12MB maximum	2.5MB; 4GB maximum
Workstation Memory	640KB; 16MB maximum	3.5MB (OS/2); 640KB (DOS)	512KB, 640KB recommended (DOS); 2.5MB, 4MB recommended (OS/2)	640KB; drivers require 55KB to 70KB	640KB; drivers require 55KB to 70KB
Operating System	UNIX	OS/2 EE 1.3 (server); OS/2 EE 1.3 or DOS 3.3, 4.01, or 5.0 (workstation)	OS/2 1.2 (server); OS/2 1.1 or DOS 3.1 (workstation)	NetWare	NetWare
Processor	80386, 80486; symmetric multiprocessing for multiple processor server platforms	80286, 80386, 80486	80286, 80386, 80486	80286, 80386, 80486	80386
Network Adapter Support	Contact vendor for list	IBM Token-Ring Network PC Adapter, Adapter II, Adapter 16/4; 3Com EtherLink II; Ungermann-Bass NIU PC; Western Digital EtherCard Plus	All cards with NDIS support, including IBM Token-Ring; 3Com 501, 503, 523, 505b, 603 EtherLink; Western Digital EtherCard; Racal InterLan	Over 100 cards including IBM Token-Ring 16/4, Adapter II, PC N2; Novell NE1000, NE2000, NE/2, RX-Net, RX-Net/2; 3Com 3C501, 503, 505, 523	Over 100 cards supported including IBM Token-Ring 16/4; Novell NE1000, NE2000, NE2100, NE/2-32, NE3200, RX-Net, RX-Net/2; Proteon ProNET-4 (MCA and ISA); 3Com 3C503; Standard Microsystems PC Series; Western Digital WD800; Ungermann-Bass NIU PC
Supplier Support	Newsletter, technical bulletin, marketing notices, forum on CompuServe	Via Operating System Service Coordinator (8 a.m.-5 p.m.); calls returned within 8 hours	Microsoft Online, forum on CompuServe	Assurance ($2,000) includes updates for one year; Support Contract ($10,000); Technical Support Incident ($100); CompuServe NetWire Information Service ($12.50/hour); training courses ($295-$595 each)	Toll-free telephone support ($50/15 min.); Assurance ($2,000) includes updates for one year; Support Contract ($10,000); Technical Support Incident ($100); CompuServe NetWire Information Service ($12.50/hour); training courses ($295-$595 each)

Versatility

	Weights	Banyan VINES/386 4.0	IBM OS/2 LAN Server 1.30.1	Microsoft LAN Manager 2.0	Novell NetWare 2.2	Novell NetWare 3.11
Server Parameters (Weight=0)						
Maximum simultaneous users	0	BA1	M1	D	100	250
Maximum server volume	0	BA2	2GB	2GB	2GB	B
Maximum volumes	0	10	26	24	32	C
Maximum shared printers	0	10	6	5	16	16
Maximum simultaneous DOS 3.1 locks	0	1K	E	E	M	M
Maximum open files	0	5K	8K	8K	1K	100K
Minimum server memory	0	4MB	4.8MB	M2	2.5MB	4MB
Maximum server memory	0	A	16MB	16MB	DS	32GB
Naming Services (Weight=4)						
Global design	4	▲	—	—	—	—
User/group names within domain	1	▲	▲	▲	F	F
All objects within domain	1	▲	AL1	—	—	—
Names directory service	2	▲	—	—	—	—
X.500-compliant naming	1	—	—	—	—	—
Automatic distribution	2	▲	▲	▲	N1	N1
Security (Weight=4)						
User-based security	4	▲	▲	▲	▲	▲
MS-NET type share security	0	—	—	▲	—	—
Security groups	2	▲	▲	▲	▲	▲
Security equivalences	0	▲	—	▲	▲	▲
Account expiration date	1	▲	▲	▲	▲	▲
Time restrictions	1	▲	▲	▲	▲	▲
Lock account after failed passwords	1	▲	—	—	▲	▲
Intruder-detect threshold	1	▲	▲	▲	▲	▲
Login count retention	1	—	—	—	▲	▲
Mandatory password change	1	▲	▲	▲	▲	▲
Limit concurrent connections	1	▲	▲	—	▲	▲
User-set password	1	▲	▲	▲	▲	▲
Minimum password length	1	▲	▲	▲	▲	▲
Disable/lock accounts	1	▲	▲	▲	▲	▲
Require unique passwords	1	▲	▲	▲	▲	▲
Restrict user to workstation	1	▲	▲	▲	▲	▲
Disconnect after inactive period	1	—	▲	▲	—	—
Password encryption	1	▲	▲	G	▲	▲
Server console protection	2	▲	▲	▲	—	▲
Link security	2	▲	▲	▲	—	—
Share-Level Permissions (Weight=0)						
Read files	0	—	—	▲	—	—
Write to files	0	—	—	▲	—	—
Create files	0	—	—	▲	—	—
Delete files	0	—	—	▲	—	—
Execute only	0	—	—	▲	—	—
Share-level password protection	0	—	—	▲	—	—
User Account Permissions (Weight=4)						
Read files	1	▲	▲	▲	▲	▲
Write to files	1	I	▲	▲	▲	▲
Create files	1	I	▲	▲	▲	▲

See footnotes on Page 226.

Versatility (Continued)

	Weights	Banyan VINES/386 4.0	IBM OS/2 LAN Server 1.30.1	Microsoft LAN Manager 2.0	Novell NetWare 2.2	Novell NetWare 3.11
User Account Permissions (Weight=4)						
Delete files	1	I	▲	▲	▲	▲
Scan files/directories	1	—	—	—	—	▲
Grant permissions	1	▲	▲	▲	▲	▲
Execute only	1	H	▲	▲	H	H
Modify file attributes	1	▲	▲	▲	▲	▲
Limit simultaneous users	1	MSU	▲	▲	▲	▲
Assign permissions to directories	2	▲	▲	▲	▲	▲
Assign permissions to files	1	▲	▲	▲	—	▲
Assign permissions to queues	1	▲	▲	▲	▲	▲
Administrator rights by directory	1	▲	▲	▲	—	▲
Pass rights to subdirectories	1	▲	▲	▲	▲	▲
Masked directory rights	1	—	—	—	—	▲
Inherit masked directory rights	0	—	—	—	—	▲
Alter inherited directory rights	0	—	—	—	—	▲
Group pass group rights to new member	1	▲	▲	▲	▲	▲
User Utilities (Weight=1)						
Create/modify login scripts	1	▲	▲	▲	▲	▲
Explicit file locking	1	—	—	—	▲	▲
Display logged-in users	1	▲	▲	▲	▲	▲
Display network resources	1	▲	▲	▲	▲	▲
Display rights	1	▲	▲	J	▲	▲
Execute server program from workstation	1	—	L	L	—	—
Administrative Utilities (Weight=2)						
System login script	1	—	—	—	▲	▲
Group login scripts	3	GL1	—	—	NNS	NNS
User login scripts	1	▲	▲	▲	▲	▲
Nested scripts	1	▲	▲	▲	—	—
Forced logout	1	▲	▲	▲	▲	▲
Security check utility	1	—	—	—	▲	▲
List group access limits	1	▲	—	—	▲	▲
List user access limits	1	▲	—	—	▲	▲
List user access rights by resource	1	▲	▲	▲	▲	▲
Realtime status: files/volumes	1	▲	▲	▲	▲	▲
Automatic update of workstation shell	2	▲	—	▲	▲	▲
Assign group administration to users	2	▲	IBM1	▲	▲	▲
Server-to-server generation	2	—	DM2	—	▲	▲
Network Management Support (Weight=2)						
Agent for NetView	1	—	IBM1	CM1	—	▲
SNMP	1	▲	—	—	—	▲
Remote server administration	4	▲	▲	▲	—	▲
Connectivity (Weight=2)						
OS/2 workstations	2	V4.1	▲	▲	▲	▲
OS/2 processes with private sessions	1	—	▲	▲	▲	▲
Macintosh workstations	2	—	—	MAC1	▲	N
Macintosh file server	0	—	—	—	—	—
VAX workstations	0	TP	—	—	—	OPT

See footnotes on Page 226.

Versatility (Continued)

	Weights	Banyan VINES/386 4.0	IBM OS/2 LAN Server 1.30.1	Microsoft LAN Manager 2.0	Novell NetWare 2.2	Novell NetWare 3.11
Connectivity (Weight=2)						
VAX file server	0	P	—	DEC	OPT	OPT
NFS workstations	1	TP	—	LMX	—	OPT
NFS file server	0	TP	—	LMX	—	OPT
327X coaxial gateway	1	OPT	CM2	CM1	OPT	OPT
327X remote SDLC gateway	1	OPT	CM2	CM1	OPT	OPT
327X token-ring gateway	1	OPT	CM2	CM1	OPT	OPT
327X bisynchronous gateway	0	OPT	CM2	—	OPT	OPT
327X terminal emulation	1	OPT	CM2	CM1	OPT	OPT
Asynchronous dial-out gateway	1	OPT	CM2	TP	NACS	NACS
Maximum COM ports in asynchronous gateway	1	24	CM2	TP	16	16
Queue access to serial devices	1	—	CM2	▲	—	—
Asynchronous terminal emulation	1	ATE	CM2	—	OPT	OPT
AT&T UNIX Streams	1	—	—	—	—	▲
Open data link interface	0	—	—	—	▲	▲
NDIS	0	V4.1	▲	▲	—	—
DOS diskless workstations	1	▲	TR1	TR1	▲	▲
OS/2 diskless workstations	1	—	IBM1	▲	▲	▲
Server Bridging and Remote Access (Weight=4)						
Remote workstation	2	PCD	RNAF	—	NACS	NACS
Remote servers	1	WAN1	BR1	BR1	▲	▲
Maximum adapter types per server	2	4	IBM2	12	4	16
Workstation external bridge	1	—	—	—	▲	▲
Maximum adapters per external bridge	0	—	NA	NA	▲	▲
Internal server routing	4	▲	—	—	▲	▲
TCP/IP bridge	2	TCPT	—	—	—	▲
TCP/IP tunneling	2	TCPS	—	—	TUN1	▲
HDLC/synchronous bridge	1	WAN2	TP	TP	L64	L64
T1 bridge	1	TP	TP	TP	LT1	LT1
X.25 point-to-point bridge	1	X.25	TP	TP	LX25	LX25
X.25 multipoint packet switched bridge	2	X.25	TP	TP	LX25	LX25
IBM mainframe bridging	1	TP	LW1	TP	TP	TP
Asynchronous bridge	1	WAN1	TP	TP	▲	▲
Scheduled connections	1	▲	TP	TP	—	—
Line drop after idle time	1	▲	TP	TP	▲	▲
Token-ring source routing	1	DR	▲	▲	DR	DR
Accounting (Weight=2)						
Limit disk space	1	—	IBM1	▲	▲	▲
User access time	1	AF	▲	▲	▲	▲
User data reads	1	—	—	—	▲	▲
User data writes	1	—	—	—	▲	▲
User server requests	1	—	—	—	▲	▲
User space usage	1	—	—	▲	▲	▲
Charge users for services	1	—	—	—	▲	▲
Variable rates for service	1	—	—	—	▲	▲
User account balances	1	—	—	—	▲	▲
User credit limits	1	—	—	—	▲	▲
Logout at credit limit	1	—	—	—	▲	▲

See footnotes on Page 226.

Versatility (Continued)

	Weights	Banyan VINES/386 4.0	IBM OS/2 LAN Server 1.30.1	Microsoft LAN Manager 2.0	Novell NetWare 2.2	Novell NetWare 3.11
Auditing (Weight=2)						
Logins	1	▲	▲	▲	▲	▲
Unsuccessful login attempts	1	▲	▲	▲	▲	▲
Last successful login	1	▲	▲	▲	▲	▲
Attempted security violations	1	▲	▲	▲	Q	Q
Logouts	1	▲	▲	▲	▲	▲
File open	1	▲	▲	▲	▲	▲
Selective audit	1	▲	▲	▲	—	—
Audit-specific resources	1	▲	▲	▲	—	—
Alert Service (Weight=2)						
Drive full	1	▲	▲	▲	▲	▲
Excessive errors	1	—	▲	▲	—	—
Intruder alert	1	—	▲	▲	—	—
Printer problem	1	—	▲	▲	▲	▲
Print request complete	1	—	▲	▲	▲	▲
Server shutting down	1	▲	—	UPS	▲	▲
Performance Monitoring (Weight=2)						
Average response time	1	—	▲	▲	—	—
Cache statistics	1	NMS	TP	▲	▲	▲
CPU utilization	1	NMS	SPM	—	▲	▲
Packets/bytes sent and received	1	NMS	—	▲	▲	▲
Packets/bytes per second	1	NMS	—	▲	▲	▲
Bad packets	1	NMS	—	▲	▲	▲
Open files	1	NMS	▲	▲	▲	▲
Peak files open	1	NMS	—	▲	▲	▲
Record locks	1	NMS	—	▲	—	▲
Peak record locks	1	NMS	—	▲	—	—
Connections	1	▲	▲	▲	▲	▲
Peak connections	1	▲	TP	▲	▲	▲
Disk blocks read/written	1	NMS	SPM	▲	▲	▲
Disk blocks per second	1	NMS	SPM	—	—	—
Disk utilization	1	NMS	SPM	—	▲	▲
Disk demand versus service	1	NMS	SPM	—	—	—
Drive I/O errors	1	NMS	—	▲	▲	▲
Packets routed	1	NMS	TP	—	▲	▲
Peak packets routed per second	1	NMS	TP	—	R1	R1
Clear statistics	1	NMS	▲	▲	—	—
Identify beacon sender	1	NMS	NM	—	—	—
Messages/Chatting (Weight=1)						
Send messages	1	▲	▲	▲	▲	▲
Group messages	1	▲	▲	▲	▲	▲
Broadcast message	1	▲	▲	▲	▲	▲
Block messages	1	▲	▲	▲	▲	▲
Log messages	1	—	▲	▲	—	—
Chatting	1	▲	—	—	—	—
Maximum chatters	1	5	0	0	0	0

See footnotes on Page 226.

Versatility (Continued)

	Weights	Banyan VINES/386 4.0	IBM OS/2 LAN Server 1.30.1	Microsoft LAN Manager 2.0	Novell NetWare 2.2	Novell NetWare 3.11
E-Mail (Weight=1)						
Mail groups	1	BM	TP	MM	TP	TP
Certified mail	1	BM	TP	MM	TP	TP
Forward mail	1	BM	TP	MM	TP	TP
Forward with comments	1	BM	TP	MM	TP	TP
CC lists	1	BM	TP	MM	TP	TP
Edit/save received mail	1	BM	TP	MM	TP	TP
Date/time stamp	1	BM	TP	MM	TP	TP
Maximum attached files	1	BM	TP	MM	TP	TP
Import text	1	BM	TP	MM	TP	TP
Print mail	1	BM	TP	MM	TP	TP
Inter-post office mail	1	BM	TP	MM	TP	TP
Mail gateways	1	BM	TP	MM	TP	TP
Hot key E-Mail	1	BM	TP	MM	TP	TP
Encryption	1	BM	TP	MM	TP	TP
Mail folders	1	—	TP	MM	TP	TP
Sort mail	1	BM	TP	MM	TP	TP
E-Mail via WAN link	1	BM	—	—	—	—
Specify WAN route	1	BM	TP	MM	TP	TP
Archival Services (Weight=1)						
Back up/restore server disk	1	▲	TP	SY	▲	▲
Back up/restore selected directories	1	▲	TP	SY	▲	▲
Back up modified files	1	▲	TP	SY	▲	▲
Server-based backup	1	▲	TP	SY	—	▲
Back up system files	1	▲	TP	SY	▲	▲
On-line backup of account files	1	▲	TP	SY	▲	▲
Skip open files	1	▲	TP	SY	▲	▲
Scheduled backups	1	▲	TP	SY	▲	▲
Back up to tape	1	R2	TP	SY	▲	▲
Multiple tape drives	1	—	TP	SY	—	—
Back up to diskette	1	▲	▲	SY	▲	▲
Back up Macintosh files on server	1	—	—	—	▲	▲
Removable media	1	▲	—	SY	—	▲
Backup spans multiple disks	1	▲	—	—	—	—
Network Printing (Weight=2)						
Automatic clear	1	▲	▲	▲	▲	▲
Print banner	1	▲	▲	▲	▲	▲
Printer/queue availability	1	▲	▲	▲	▲	▲
List current redirections	1	▲	▲	▲	▲	▲
Printer status	1	▲	▲	▲	▲	▲
End spool from application	1	API	▲	▲	API	API
End spool time-out	1	▲	▲	▲	▲	▲
Print to network file	1	—	▲	▲	▲	▲
Select print mode	1	—	▲	▲	▲	▲
Select form type	1	▲	▲	▲	▲	▲
PostScript font download	1	—	▲	▲	API	API
LaserJet font download	1	—	▲	▲	API	API
Print screen	1	▲	▲	▲	▲	▲
Print notification	1	—	▲	▲	▲	▲

See footnotes on Page 226.

Versatility (Continued)

	Weights	Banyan VINES/386 4.0	IBM OS/2 LAN Server 1.30.1	Microsoft LAN Manager 2.0	Novell NetWare 2.2	Novell NetWare 3.11
Network Printing (Weight=2)						
Multiple printer configurations	1	▲	▲	▲	▲	▲
Schedule print job	1	—	AT	AT	▲	▲
Printing Queues (Weight=2)						
Multiple queues per printer	2	—	▲	▲	▲	▲
Multiple printers per queue	2	—	▲	▲	▲	▲
Multiple queues on multiple printers	1	—	▲	▲	▲	▲
Restrict queue hours	1	—	▲	▲	S	S
Queue priority levels	1	—	▲	▲	▲	▲
Print preprocessor	1	—	▲	▲	—	—
Queue status	1	▲	▲	▲	▲	▲
Reorder queue	1	AD	▲	▲	▲	▲
Switch queues	1	—	—	—	—	—
Insert job into queue	1	—	API	API	▲	▲
Delete active job	1	AD	—	—	▲	▲
Delete job from queue	2	▲	▲	▲	▲	▲
Hold/release print job	1	▲	▲	▲	▲	▲
Restart job at beginning	1	▲	▲	▲	T	T
Pause printer	1	AD	▲	▲	T	T
Pause queue	1	AD	▲	▲	▲	▲
Close queue	1	AD	▲	▲	▲	▲
Fault Tolerance (Weight=1)						
UPS monitoring	1	▲	▲	▲	▲	▲
Disk mirroring	2	TP	IBM1	EX1	▲	▲
Disk duplexing	2	TP	IBM1	EX1	▲	▲
Server duplexing	1	TP	REP	REP	—	—
Split seeks	1	TP	▲	▲	▲	▲
Read verification	1	▲	▲	▲	▲	▲
Hot fix	1	▲	▲	▲	▲	▲
Sector recovery on mirrored drives	1	TP	IBM1	▲	▲	▲
Distributed naming database	1	▲	▲	▲	NNS	NNS
File replication across servers	1	—	▲	▲	—	—
Application Program Interfaces (Weight=1)						
Named pipes	2	▲	▲	▲	▲	▲
NETBIOS	3	▲	▲	▲	▲	▲
APPC	1	AP1	CM2	CM1	▲	▲
E-Mail API	1	▲	TP	▲	▲	▲
Accounting API	1	—	—	▲	▲	▲
Auditing API	1	—	—	▲	▲	▲
Indexed file manager	1	—	—	SQL	▲	▲
Transaction logging and rollback	1	—	DBM	SQL	▲	▲
Peer Resource Sharing (Weight=1)						
Share hard disk	1	—	TP	OS2,TP	TP	TP
Share printers	1	▲	TP	OS2,TP	▲	▲
Share modem	1	—	—	OS2	NACS	NACS

See footnotes on Page 226.

Versatility (Continued)

	Weights	Banyan VINES/386 4.0	IBM OS/2 LAN Server 1.30.1	Microsoft LAN Manager 2.0	Novell NetWare 2.2	Novell NetWare 3.11
File System Support (Weight=1)						
AFP	1	GATE	—	MAC1	▲	▲
NFS	1	—	—	LMX	—	NFS
FTAM	1	—	—	3CM1	—	FTAM
OS/2 HPFS	1	V4.1	▲	▲	—	▲
DOS	3	▲	▲	▲	▲	▲
Miscellaneous Utilities (Weight=1)						
Multiple OS-specific logins	1	▲	▲	▲	▲	▲
Recover deleted server files	1	—	▲	—	▲	▲
Purge deleted files	1	—	▲	—	▲	▲
Multiple processor support	1	▲	IBM1	▲	—	—

▲—Yes, has feature.
A—6M bytes; 256K bytes on SMP version.
AD—Requires administrator privilege.
AF—Using Auditing feature.
AT—Using LAN Manager's AT utility, which manages deferred task execution.
AL1—Using Alias definitions for resources.
AP1—Using optional software.
API—API call provided for application developers to include this ability.
ATE—Using optional VINES Asynchronous Terminal Emulation software.
B—Theoretical maximum of 32T bytes in 32 volumes; Novell has tested 75G-byte configurations.
BM—Using optional Banyan Mail.
BA1—Unlimited; Banyan recommends reasonable limits depending on usage.
BA2—Limited by disk size; volumes do not span multiple disks.
BR1—Requires optional connectivity product (e.g., bridge, router, mainframe pass-through).
C—64 volumes: 32 volumes with 1 volume capable of spanning 32 disks; maximum 1,000 disks.
CM1—Using optional DCA/Microsoft Communications Server.
CM2—Using OS/2 Extended Edition Communications Manager.
D—Theoretical maximum of 1,000; license covers 5 users; additional user packs (10 or unlimited users upgrades) available.
DR—Driver must be loaded (included with product).
DS—12M bytes with dedicated server.
DBM—Using OS/2 Extended Edition Database Manager
DEC—Using Digital's PathWorks for Ultrix OEM version of LAN Manager.
DM2—Using optional NetView Distribution Manager/2.
E—8,000 simultaneous locks for networks that include DOS workstations.
EX1—In the event of a primary partition crash, the secondary (mirrored) drive must be "exposed" to the system in order to be used; it is not automatic.
F—With optional NetWare Naming Service, $1,995.
FTAM—Using optional FTAM software.
G—On OS/2 or enhanced DOS workstations.
GATE—Via third-party gateway.
GL1—Using Banyan's nested profile feature, an administrator can set up a group profile by including the nested profile in each user profile.
H—Implemented as file attribute.
I—Modify privilege gives ability to read, write, create, and delete files and subdirectories.
IBM1—In next release.
IBM2—One; up to four adapters in future release.
J—Requires ADMIN rights.
L—OS/2 programs only; request must be made from OS/2 workstation.
L64—Using optional NetWare Link/64.
LMX—Using LAN Manager/X version available from various vendors.
LT1—Using optional NetWare Link/T1.
LW1—Using optional IBM LAN-to-LAN Wide Area Network Program.
LX25—Using optional NetWare Link/X.25.
M—Limited by available memory.
M1—Server license specifies 128 users; licensing upgrade to 254; up to 1,000 users supported in next version.
M2—6M bytes; 9M bytes when using HPFS on 386 server.
MM—Using optional Microsoft Mail (formerly Network Courier).
MAC1—With a 3Com 3+Open Server running 3+Open MAC software on the network and 3+Open MAC client software running on a LAN Manager workstation.
MSU—No explicit setting for maximum users of a resource; Access Rights List (ARL) can be set up to permit only specified users or groups.
N—NetWare for Macintosh 3.0 required; 100 users, $1,995; 20 users, $895.
N1—NetWare Naming Service may require periodic manual synchronization.
NM—Using optional IBM LAN Network Manager.
NACS—Using optional NetWare Asynchronous Communications Server.
NFS—Using optional NFS software.
NMS—Requires Network Management System option.
NNS—With NetWare Naming Service.
OPT—Optional purchase available from vendor.
OS2—On OS/2 workstations only.
P—Announced; not shipped.
PCD—Using optional VINES PC Dial-in software.
Q—Supervisor can view last intruder's node address.
R1—Peak number of routing buffers used.
R2—Banyan offers several optional tape drives for VINES/286 and /386 even though it has stopped selling server hardware.
REP—Replication Service allows active and continuous backups of important server directories to another network server. Although not server duplexing, this option provides fault tolerance for specified data.
RNAF—Using optional IBM Remote Network Access Facility.
S—Individual jobs can be deferred.
SY—Sytron Sytos Plus backup software included.
SPM—Using optional IBM System Performance Monitor/2 Version 1.0.
SQL—Using optional Microsoft SQL Server.
T—Requires access to print server.
TP—Available from third parties.
TR1—With token-ring adapters only.
TCPS—Using optional VINES TCP/IP Server-to-Server software.
TCPT—Using optional VINES TCP/IP Routing software.
TUN1—NetWare 2.X client can load IPTUNNEL and DOS ODI drivers and communicate with a NetWare 3.11 server at the other end of the tunnel.
U—Unlimited.
UPS—Provided by LAN Manager UPS device driver if UPS is installed.
V4.1—Supported in VINES/386 Version 4.1.
WAN1—Using optional Banyan Server-to-Server WAN.
WAN2—Using optional Banyan Server-to-Server WAN and Intelligent Communications Adapter.
X.25—Using optional VINES X.25 Server-to-Server.
3CM1—Using 3Com 3+Open 1.1 workstation support for AFP and OSI. ■

Entry-Level LAN Operating Systems

A Report from NSTL

In this report:

Focus
This report describes the advantages of implementing an entry-level LAN and compares the programs' features, usability, performance, and suitability for particular installations.

Programs Tested
LANtastic
Artisoft, Inc.
Network-OS
CBIS
10Net Plus
DCA 10Net
LAN Manager
Microsoft Corp.
ELS NetWare Level II
Novell, Inc.
PowerLan 10
Performance Technology
TOPS Network Bundle for DOS
Sitka Corp.

Program Recommendations
Novell ELS NetWare Level II
Performance Technology PowerLan 10
Artisoft LANtastic

Source
Based on data generated by tests designed and conducted by National Software Testing Laboratories (NSTL), Inc., Plymouth Meeting, PA 19462. Telephone (800) 223-7093.

Ratings Key
(On a scale of 0 to 10)
Ratings
● 7.0 - 10.0
○ 5.0 - 6.9
◎ under 5.0
★Recommended

Overall Evaluation	Product Name	Version Tested	Performance	Features	Error Handling	Ease of Learning	Ease of Use	Price
8.0	Novell ELS NetWare Level II	2.15	●	●	○	○	●	$1,895★(8 users)
6.9	Performance Technology Powerlan 10	1.3	●	◎	◎	○	●	$1,495★(10 users)
6.7	Artisoft LANtastic	3.0	○	◎	◎	●	●	$495★(per server)
6.5	Microsoft LAN Manager	2.0	●	●	●	◎	○	$1,990 (10 users)
6.1	CBIS Network-OS	7.0A	○	◎	◎	○	●	$1,520 (8 users)
5.5	DCA 10Net Plus	4.2	◎	○	◎	○	●	$895 (10 users)

Overview

Entry-level local area network operating systems fulfill several roles in the evolution of a networking strategy. A small company with few employees may need a LAN only to facilitate occasional file transfers, with extremely light network traffic and few workstations. Such a small network may not need an actual file server, instead basing usage on peer-to-peer operation. A company anticipating rapid growth might want a network for immediate use with the intention of upgrading or expanding to a more elaborate and powerful network later. A workgroup or small department within a larger company might set up a LAN for an intimate scale of networking with possible connections to a larger collection of corporate LAN or WAN installations.

Each of these entry-level LAN scenarios entails specific LAN capacities, and no one of the currently available LAN operating systems is optimal for every situation. Entry-level LANs are lower in price and (usually) performance than higher level LANs; also, there are usually restrictions in the number of workstations or users supported.

Evaluation Criteria

NSTL evaluated seven network operating systems that support standard Ethernet adapter hardware, run on PC-compatible systems, operate with nondedicated servers, and cost under $3,000 for an eight-workstation configuration. All seven systems support DOS workstations. ELS NetWare Level II and Microsoft LAN Manager require specialized operating systems at the server (Novell's operating system for NetWare and OS/2 for Microsoft LAN Manager); the others are supported by DOS at the server.

In calculating the Overall Evaluations, NSTL weights ease of use highest on the assumption that entry-level LANs are not intended for power users nor should they require full-time network administrators. The evaluations also emphasize features. Performance benchmarks test the systems running typical business applications, and the systems are also assessed on their ease of learning and installation. With these ratings, NSTL tries to evaluate the systems' relative suitability for specific entry-level LAN strategies.

Entry-Level LAN Configurations

Beyond the obvious hardware requirements (Ethernet, token-ring, or Arcnet cabling and adapters), DOS workstations require one or more layers of network software. The software layers act as driver for the adapter card, manager of the network's communication protocol, and DOS interceptor or redirector channeling application requests (such as reading a file or printing) to network resources used or mounted by the workstation.

Peer-to-peer networking implies primarily local system use by individuals with occasional sharing of resources (printers or disk areas) with other workstations in the network. When a workstation is sharing resources, it may be acting as a server and may require installation of server options, but machines described as servers are often primarily (or exclusively) devoted to resource sharing activity.

A server can have a base operating system other than DOS; for example, Microsoft LAN Manager uses OS/2 as its server operating system. A server, or a machine sharing its resources in a peer-to-peer fashion, will have adapter driver and protocol manager software; it will also have either a server network operating system kernel or modified redirector to permit sharing or publishing of resources for use by other machines. A server will usually be configured with disk caching. With the test network operating systems, the servers operate in a nondedicated mode, which means they offer local workstation facilities.

The entry-level operating systems use a few commonly implemented network system designs. LANtastic, Network-OS, PowerLan 10, and 10Net Plus are MS-Net derivatives based on a peer-to-peer network definition with a NETBIOS protocol. Microsoft's LAN Manager, itself a descendant of MS-Net, constitutes a separate system design with modifications made necessary and possible by the use of an OS/2 (instead of DOS) server. In addition to Microsoft LAN Manager 2.0, IBM OS/2 LAN Server and 3Com's 3+Open are also LAN Manager-based systems. NetWare systems from Novell also constitute a basic system design with

several implementations in addition to ELS NetWare Level II (e.g., NetWare 386 Version 3.1). TOPS represents a Macintosh network system ported to DOS.

Installation

Network Adapter

Each LAN server and workstation must have a physical connection or interface to the network. Some of the network operating systems (e.g., TOPS) are very restrictive in terms of supported adapter hardware; others that encourage use of the network operating system vendor's proprietary cards are often incompatible with standard cards. All of the test workstations contained the AT bus.

Cabling

The choice of network adapter (Ethernet, Arcnet, or token-ring) generally dictates cabling options. Ethernet usually runs over thin coaxial cabling, though thick coaxial and twisted pair Ethernet cable runs are possible. Token-ring uses specialized cables or (sometimes) twisted pair, and Arcnet offers thin coaxial or twisted-pair options. In any case, the expense and effort of cabling are often a surprisingly large part of network installation, especially when installing new coaxial cable runs or wrestling with the reliability of existing telephone wiring for twisted-pair connections. NSTL tested all the systems using thin coaxial Ethernet cabling.

Memory

Available memory is primarily an issue for systems used as servers or to share resources, but at all network nodes, network software may consume a noticeable portion of the 640K-byte conventional DOS memory.

Most of the DOS-based systems can make use of extended or expanded memory to load portions of the driver or redirector into higher memory. Users allocating extended or expanded memory to network software should be aware of potential conflicts with other applications accessing high memory. NSTL tested the operating systems running in the workstations' real (640K-byte) memory.

Disks

None of the operating systems require particularly large disks at the workstations, but hard disks are recommended for all. Microsoft LAN Manager requires substantial disk space for the OS/2 installation at the server and even more for the server software. All the operating systems are most effective with servers configured with large hard disks.

Printers

Printer sharing is commonly the impetus behind network installation. Printer sharing typically involves a printer attached to a system set up as a network print server. The network operating system provides print spooling and queuing. Printer sharing can effectively maximize the use of expensive printers, including differing kinds of printers and local and remote printers. Users should keep in mind that many applications require a choice of printer at installation or configuration, and a printer driver for a local dot matrix printer may not work with a network laser printer.

Operating System Software

Operating system installation procedures place the appropriate software onto servers and workstations. ELS NetWare requires a long, somewhat complex server installation procedure involving many diskettes. Once the NetWare workstation files (driver and redirector) are generated for the chosen adapter cards, workstation installation is as easy as copying the files. LANtastic's installation requires only one or two disks (depending on drivers) for servers and workstations and a simple installation procedure.

Microsoft LAN Manager's multistep installation is time consuming and needlessly complex. For example, after the server is apparently fully installed, if it is the first or only server and logging on is desired, the server must be made into a primary domain controller in a separate process that Microsoft should have automated in the original installation process.

CBIS' Network-OS and Performance Technology's PowerLan 10 use basically the same installation and configuration procedures requiring several disks, but easy steps. Some options are poorly explained, but the default choices are generally adequate.

TOPS Network Bundle for DOS installs relatively simply because of the paucity of configuration options. Unlike the other systems, TOPS enforces licensing restrictions by requiring a separate copy of the software for each system on the

network. Reinstallation or replacement of workstations requires tracking the separate network bundles.

Reliability and Compatibility

Most of the entry-level operating systems can be easily crashed or otherwise exhibit incompatibilities of some kind.

PowerLan 10 showed no major incompatibilities.

ELS NetWare sometimes deleted incorrect directories during Xcopy operations run at the server; NetWare also has some minor documented deviations from the DOS handling of filename wild cards.

LANtastic was incapable of completing a few of the tests with caching enabled.

LAN Manager could not complete some tests due to an apparent Ethernet driver incompatibility at DOS workstations; in testing with token-ring adapters, Microsoft LAN Manager performs without similar failures.

Network-OS exhibits incompatibilities with caching at the server.

10Net Plus could not complete several of NSTL's performance tests.

TOPS Network Bundle for DOS was incapable of correctly mounting shared resources from multiple clients at once, could not properly implement the Add Group Name NETBIOS call, and failed to properly run the *Pkunzip* utility from a workstation to a server.

Performance

Performance variations among the entry-level systems are extreme. ELS NetWare and Microsoft LAN Manager are by far the fastest. PowerLan 10's performance is respectable, with particular strengths handling the relatively large transmission packets in the Lotus test and in tests with Lotus traffic. LANtastic performance is only fair, with relative strength in Foxbase tests and traffic with the small transmission packets. Network-OS also performs fairly fast with the handicap of running without server caching. 10Net Plus runs substantially slower than the other MS-Net derivatives; and the margin is greater than expected simply due to 10Net's not having a customized NETBIOS driver for the Ethernet cards.

Summary

No one system is clearly superior for all network uses. ELS NetWare Level II is fast and powerful as an operating system, and it can be upgraded to higher levels of NetWare at a substantial discount. An ELS NetWare server can be used with other NetWare servers in a larger network, but the limitation of eight simultaneous logins can be a severe handicap. More advanced versions of NetWare do not have this restriction. Installation is tedious, and NetWare does not support a peer-to-peer networking model. Nondedicated NetWare servers are restricted to diskette boot and provide access to the server hard disk only via a network connection within the system. ELS NetWare Level II is an excellent entry-level system except for peer-to-peer networking and somewhat large installations (i.e., because of the eight-login limit).

PowerLan 10 offers good performance, fairly good usability, and few problems. PowerLan 10 is recommended for peer-to-peer and server-based networking. It comes with an excellent E-Mail application. LANtastic makes a reasonable choice for a lightly loaded peer-to-peer network. It is very easy to install, fairly easy to use, and performs relatively well particularly with applications generating smaller packet requests such as Foxbase.

Microsoft LAN Manager 2.0 provides very fast performance overall (competitive with ELS NetWare), but poses high server memory and storage requirements to accommodate the operating system and OS/2. The installation and configuration are complex. Adding users requires little more than applying additional user packs. LAN Manager provides features particularly useful with OS/2 workstations, such as remote execution of OS/2 programs at the server or as a platform for SQL server database applications. Microsoft LAN Manager qualifies as an entry-level operating system on the basis of its price for a limited number of users, but it is probably a better choice for more advanced networks.

CBIS Network-OS is fairly easy to use, but the system would benefit from better documentation. Performance results are fair, and with its server caching incompatibility fixed, it will likely perform faster.

10Net Plus provides many good features including a quality E-Mail application, but its performance lags and it displays some compatibility problems.

TOPS Network Bundle for DOS offers some special features, including easy connection with Macintosh workstations, but incompatibilities and a lack of expected features (e.g., server disk caching) handicap TOPS as a DOS network system.

Program Evaluations

Artisoft LANtastic

Strengths

- Easy to install
- Easy to use
- Can force periodic password changes
- Remote running of applications on server

Limitations

- Few drivers bundled
- Little performance monitoring

CBIS Network-OS

Strengths

- Easy to install
- Easy to use
- Remote dial-in
- Remote running of applications on server

Limitations

- Little performance monitoring
- Incompatibilities with caching

DCA 10Net Plus

Strengths

- Easy to install
- Easy to use
- Force periodic password changes
- Restrict logins to specific nodes

Limitations

- Few drivers bundled
- Fails to complete some tests

Microsoft LAN Manager 2.0

Strengths

- Supports OS/2 workstations
- Forces periodic password changes
- Can restrict logins to specific nodes
- Allows printer pooling, priority queue
- Remote dial-in
- Remote servers
- Many connectivity options
- Remote running of applications on server

Limitations

- Difficult to install
- Copious documentation
- Requires server with at least 5M bytes of RAM
- Requires purchase of OS/2 for server

Novell ELS NetWare Level II

Strengths

- Best overall performance
- Easy to use
- Good documentation
- Supports OS/2 and Macintosh workstations
- Supports VAX file server
- Forces periodic password changes
- Can restrict logins to specific nodes
- Allows printer pooling, priority queues
- Remote dial-in
- Remote servers
- Many connectivity options
- Remote running of applications on server

Limitations

- Difficult to install
- No local drive at nondedicated server

Performance Technology PowerLan 10

Strengths

- Easy to install
- Easy to use
- Good performance
- Good documentation
- Supports OS/2 workstations
- Remote dial-in
- Remote servers
- Many connectivity options
- Remote running of applications on server

Limitations

- Little performance monitoring

Sitka TOPS Network Bundle for DOS

Strengths

- Easy to install
- Supports Macintosh files and workstations

Limitations

- Few security options
- Few drivers bundled
- Little performance monitoring
- Not fully DOS compatible

Program Recommendations

Novell ELS NetWare Level II

Novell's ELS NetWare Level II Version 2.15 is fast and robust. Third-party support for Novell products is extensive, Novell offers NetWare bridge (actually internetwork router) software, and an ELS NetWare network can attach to larger Novell networks. It is the best choice for installations using dedicated servers, where peer-to-peer networking is not needed and the eight-login limit is not too restrictive. E-Mail must be purchased as a third-party add-on product. Upgrades to Advanced NetWare 2.15 or SFT NetWare 2.15 are available at a discount.

Performance Technology PowerLan 10

PowerLan 10 provides decent performance with reliability, and it is appropriate for server-based networks with some peer-to-peer networking activity. cc:Mail comes bundled with PowerLan, and extensions (e.g., PowerLan internetwork routing) are available.

Artisoft LANtastic

LANtastic is extremely easy to install, learn, and use. Artisoft's mail implementation is bundled with the operating system, and voice mail hardware is available. Although LANtastic does not show the best performance, its ease of installation recommends it for lightly loaded, primarily peer-to-peer networks.

Rating Summaries

Figure 1.
Artisoft LANtastic

Figure 2.
CBIS Network-OS

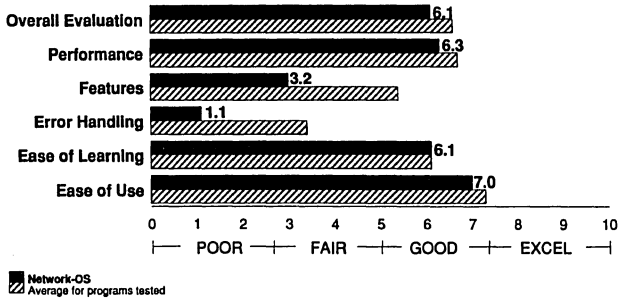


Figure 3.
DCA 10Net Plus

Figure 4.
Microsoft LAN Manager

Figure 5.
Novell ELS NetWare Level II

Figure 6.
Performance Technology PowerLan

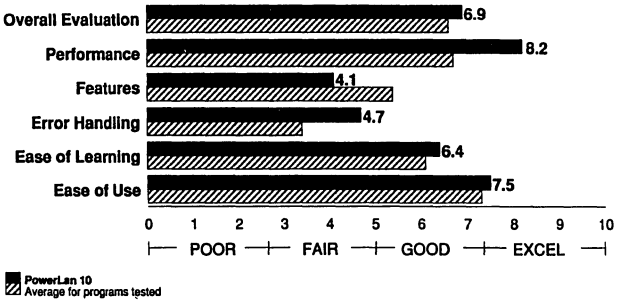
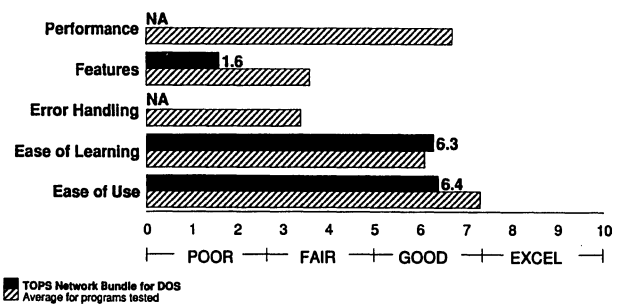


Figure 7.
Sitka TOPS Network Bundle for DOS



Overall Evaluation

ELS NetWare leads the overall evaluation with the only consistently good ratings for performance, features, and usability. Limitations include a maximum of eight simultaneous logins, a tedious installation procedure, and an only fair client side to the nondedicated server configuration.

The other five entry-level programs require some compromise. Microsoft LAN Manager's powerful features and performance rival NetWare's, but installation is tedious and complex, and features are difficult to learn. PowerLan 10 provides consistent—but not spectacular—performance; good usability; and a range of features. LANtastic is easy to install but much less powerful. CBIS' Network-OS performance is handicapped by an incompatibility in server caching, and its features are somewhat limited. Good features and usability fail to compensate for 10Net Plus' very slow performance.

Methodology

The Overall Evaluation is a weighted average of scores for the individual criteria.

Overall Performance Score = (4 x Ease of Learning Score) + (8 x Ease of Use Score) + (4 x Performance Score) + (6 x Features Score) + (Testers' General Evaluation) ÷ 23.

Performance

ELS NetWare Level II dominates the performance evaluation with a fast server operating system obtained at the expense of peer-to-peer capabilities, and excellent server disk caching. Microsoft LAN Manager finishes a close second with its HPFS386 file system at the server and other server-specific adaptations. Although incompatibilities with the Ethernet drivers surfaced during performance testing, tests using token-ring show Microsoft LAN Manager 2.0 to perform on par with more advanced NetWare operating systems.

PowerLan 10 exhibits particular strength with Lotus 1-2-3 tests and with Lotus traffic behind other applications. PowerLan 10 maintains its performance fairly well under network loading.

LANtastic and Network-OS perform at nearly the same level, even though Network-OS is run with no server disk caching because of an incompatibility. Network-OS may show even more strength in revisions that remove this incompatibility.

10Net Plus' slow times are at least partially explained by its lack of a custom Ethernet driver for the Western Digital cards (the other systems supplied custom drivers). 10Net Plus is tested with the Western Digital card's supplied NETBIOS driver, which is somewhat slow. Tests performed on the other systems using the Western Digital NETBIOS driver and custom drivers show no significant advantage in the custom driver (definitely not enough of an advantage to account for the degree of 10Net Plus' slow performance). Reason indicates that 10Net Plus must implement slower disk caching at the server or a slower server operating system kernel.

Methodology

Performance tests measure the network operating systems' speed with applications running with and without background traffic. Overall Performance is a weighted average of the Individual Performance scores.

Performance Score = 5 + 5 x (System Time – Average Time)/(Minimum Time – Average Time)

Features

Microsoft LAN Manager offers more auditing, alerting, and fault tolerant features than the other entry-level systems. ELS NetWare Level II provides the best accounting service and utilities and equally good printing support. 10Net Plus features cover a broad range with no dominance in any one category. The other operating systems are weaker in supervisor utilities and accounting.

Methodology

The Features score is a weighted average of scores based on each operating system's network features. Individual features and their methodology weights are listed in Table 3.

Features Score = (4 x Security Score) + (4 x User Account Permissions Score) + (2 x Accounting Score) + (2 x Auditing Score) + (2 x Alert Service Score) + (Utilities Score) + (2 x Supervisor Utilities Score) + (3 x Performance Monitoring Score) + (Messages/Chatting Score) + (2 x E-Mail

Score) + (3 x Network Printing Score) + (3 x Printing Queues Score) + (2 x Connectivity Score) + (2 x Bridging Score) + (Fault Tolerance Score) + (Application Program Interface Score) + (Bundled Applications Score) ÷ 36.

Error Handling

Many network errors, such as interface card failure, cannot be gracefully recovered by the network operating system; however, even an entry-level operating system can offer features to maintain data integrity and improve fault tolerance. When heavily used file servers are part of the network configurations, error handling features are particularly helpful. In a network intended for only occasional peer-to-peer file sharing, error handling features may be less critical, but data integrity remains an important concern.

Microsoft LAN Manager handles data integrity and error handling well, with disk mirroring or duplexing, drive-full alerts, as well as a range of other features. ELS NetWare Level II offers account locking on multiple failed passwords and an equally good range of other error handling features.

LANtastic provides user-based security, but little other protection, which may encourage its use for peer-to-peer networking rather than client-server environments. TOPS offers no strengths in error handling and is decidedly better for peer-to-peer use.

Methodology

The error handling/data integrity rating represents a weighted average of each network operating system's capability to handle typical network problems and enforce data integrity. Technicians analyze the systems' handling of server hardware failure, security violations, printer errors, power failures, and other criteria. Each program is scored on its error handling and capability to prevent data losses, including security features and problem alerts.

Error Handling Score = (User-Based Security Score) + (Multiple Failed Password Score) + (Unique Password Requirement Score) + (Workstation Restriction Score) + (2 x Drive Full Score) + (Security Check Utility Score) + (2 x Token-Ring Beacon ID Score) + (3 x UPS Monitoring Score) + (2 x Disk Mirroring Score) + (Disk Duplexing Score) + (Read-After-Write Verification Score) + (Hot Fix Score) + (Sector Failure Recovery Score) + (Transaction Logging/Rollback Score) ÷ 19.

Ease of Learning

Except for Microsoft LAN Manager, the entry-level systems install relatively easily. Artisoft's LANtastic is the easiest to install and learn to use; installation requires only one or two disks and takes little time. ELS NetWare's server installation requires a number of disks (some multiple times) and uses some obscure terms and self-modifying menu paths. Network-OS, PowerLan 10, and 10Net Plus all use simple installations with menu setup. TOPS' installation is simple but requires a separate set of 10 disks for each workstation, complicating the installation of groups of workstations.

Microsoft LAN Manager's complex installation requires an initial installation of OS/2 1.2 (or higher, with the correct CSD level). To obtain optimum performance, the OS/2 installation must include the High-Performance File System as the disk file system, which is subsequently replaced by LAN Manager's own HPFS386 version. An additional step designates the (first) file server as a primary domain controller; this step should be smoothly automated by the installation program, but it is left as a separate, manual step.

Network interface card installation and system configuration are similarly easy for most of the systems. Microsoft LAN Manager's *Protocol.ini* file may require direct editing. ELS NetWare restricts the choices of interrupt, DMA channel, and I/O address for adapters, but the available options are usually adequate. TOPS supports only four AT bus cards (TOPS FlashCard, Hercules Network Card Plus for LocalTalk, 3Com EtherLink II, Western Digital EtherCard Plus) and one MCA bus card (3Com 3C523).

ELS NetWare's performance tuning is difficult to learn and perform, but tuning options are few (e.g., number of communication buffers in the server), and NetWare's performance is so good that tuning it is basically unnecessary. Microsoft LAN Manager performance tuning is complex. The documentation does not define some terms, and some parameters (e.g., Server Heuristics bitmap) seem deliberately obscure. Most users accept the defaults on these parameters, which (as with NetWare) should return reasonable performance. Most of the

other systems are easy to tune, but tuning involves trade-offs such as adjusting the time-slicing between local activity at the server and its network services.

Methodology

After studying the manuals and other reference materials supplied with each program, technicians assess how easy it is to learn standard installation, setup, and use of the system's facilities. Ease of learning is a weighted average of scores for the individual criteria.

Ease of Learning Score = (4 x OS Installation Score) + (2 x Card Installation Score) + (2 x Documentation Score) + (Security Administration Score) + (Printer Administration Score) + (Share/Link Score) + (Workstation User Score) + (Performance Tuning Score) + (General Ease of Learning Score) ÷ 14.

Ease of Use

The ELS NetWare documentation is complete and divided into volumes so a user can concentrate on a single portion. LANtastic's user guide comes bound with the technical reference, but the text is well written and clear. Microsoft LAN Manager's documentation is copious but difficult to read; it assumes familiarity with OS/2 concepts and relies on undefined terms. PowerLan 10's documentation is separated into several easy-to-read volumes.

Security administration is very easy in all the systems except NetWare and Microsoft LAN Manager because of the simple structure of MS-Net and DOS security and the systems' relatively few security features. TOPS provides the fewest security features and rates easiest to use. The more extensive security features available in Microsoft LAN Manager and ELS NetWare are more difficult to use, but worth the effort.

Resource sharing and workstation usage are simplest in NetWare, as the default mappings and connections will often be sufficient, with no need to perform explicit allocation of shared or published resources and then mount them from the workstations.

Methodology

After learning each program, technicians install and set it up, tune it, use its security features, and perform other tasks. Ease of use is a weighted average of scores for the individual criteria.

Ease of Use Score = (2 x Documentation Score) + (Security Administration Score) + (Printer Administration Score) + (Share/Link Score) + (Workstation User Score) + (Performance Tuning Score) + (General Ease of Use Score) ÷ 8.

Performance Results

Network performance is the result of a host of factors specific to each of its components. Network-specific factors pertinent to this evaluation include the base operating system software at the server, the network interface card, and driver software and protocols. Among the entry-level LAN operating systems, ELS NetWare uses a specialized proprietary base server operating system, Microsoft LAN Manager is based on OS/2 at the server, and the others use DOS at the server. All the systems except ELS NetWare use some form of NETBIOS protocol in all cases; NetWare uses the Novell-specific IPX protocol. Other important performance factors include the server's file system, disk caching, and file lock arbitration; and the workstation's DOS interception and memory utilization.

NSTL measures network operating system performance running Lotus 1-2-3 Release 3, Microsoft C, Foxbase+/LAN, and the DOS Xcopy operations. Lotus 1-2-3 Release 3, Microsoft C, and Xcopy are run with no traffic and with background traffic generated by Lotus 1-2-3 Release 3 (to produce the performance ratings), Foxbase, cc:Mail, Xcopy, and server traffic. The Foxbase and Xcopy traffic provide additional comparative information.

Test Configuration

LAN operating systems were tested running on a network configured with a Compaq 386/20e server with a 110M-byte hard disk. The network included a Compaq Deskpro 386/25 primary workstation

and five 16MHz Everex 386si secondary workstations. The Everex workstations ran MS-DOS 3.30, and the Compaq systems ran Compaq DOS 3.31. The Compaq systems ran Compaq OS/2 1.21 with Microsoft LAN Manager, and ELS NetWare supplied its own server operating system. A Compaq 386S controller workstation automated the tests. Network connections used Western Digital 8013 Ethernet network interface cards with thin coaxial cabling.

Each network operating system was installed in the server, and all workstations were configured as DOS workstations. Optional services such as messaging and mail pop-ups were omitted. Each operating system was tuned using the default installation parameters or according to the vendor's recommendations and documentation. The server's 9M bytes of RAM were devoted mostly to a disk cache.

Background Traffic

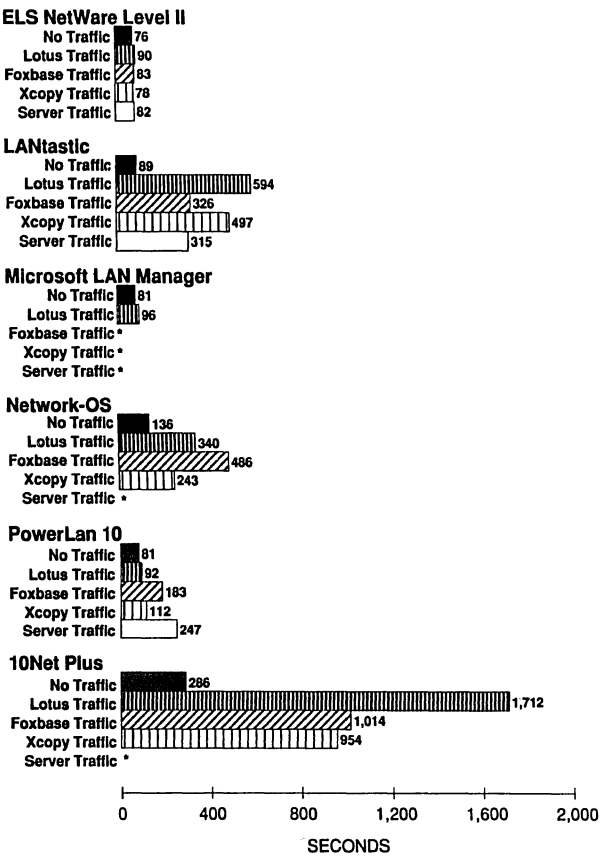
The application benchmarks were timed at the primary workstation with the secondary stations idling and with background ring traffic on five secondary workstations. A transaction processing suite ran on one and four secondary workstations.

Foxbase background traffic consisted of each workstation performing a transaction no more than 30 times a minute; with the systems other than LAN Manager and ELS NetWare, the traffic workstations generally fell behind. The transaction looked up indexed records in three files and locked, updated, and unlocked one record in each file. Lotus traffic consisted of five secondary workstations executing a macro that combines and saves files metered to be active no more than once every 20 seconds on each station. Xcopy traffic copied a 128K-byte directory tree from the server to five workstations no more often than once every 19 seconds. Server traffic used the nondedicated server feature to Xcopy the 128K-byte tree at the server.

Lotus 1-2-3

A Lotus macro loaded and saved a 3M-byte spreadsheet, using the network to move substantial amounts of data. The test was repeated with four traffic applications running concurrently on five secondary workstations and with Xcopy traffic at the server only.

Figure 8.
Lotus 1-2-3



*Would not run on NSTL's test configuration.

Analysis

Loading and saving a file emphasize network-dependent portions of Lotus performance and diminish the contribution of workstation performance to the results.

In all the test iterations, ELS NetWare Level II performs fastest. Probable advantages are a well-tuned NetWare Western Digital Ethernet driver (distributed by Western Digital on the driver disk with the cards) and the NetWare server's excellent disk caching. With no traffic and with Lotus 1-2-3 traffic, Microsoft LAN Manager and PowerLan 10 are nearly as fast as NetWare; both have fairly good server caching and drivers (distributed by Microsoft and Performance Technology, respectively) that seem to provide decent performance. The Microsoft driver may have an incompatibility that prevents completion of some traffic scenarios; with other drivers (e.g., IBM Token-Ring cards), LAN Manager returns quite good performance.

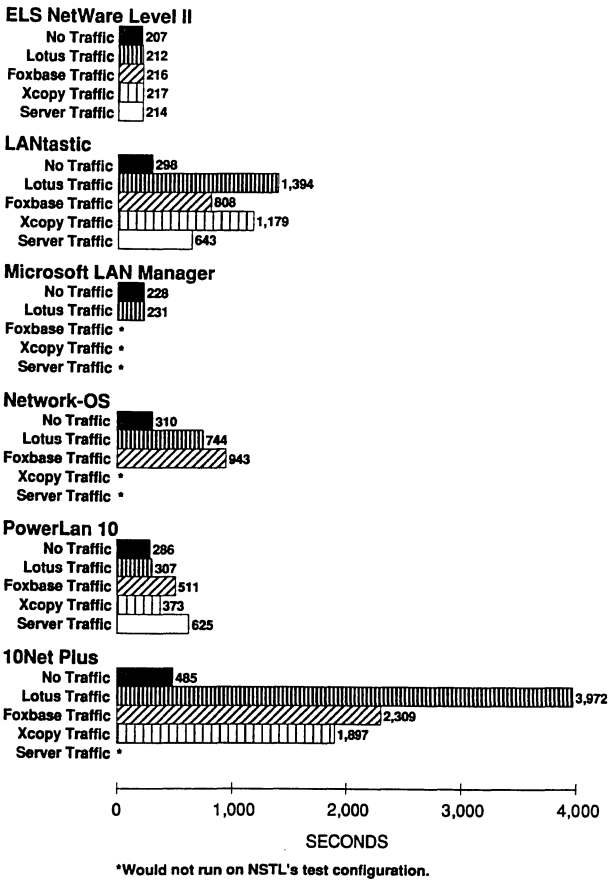
PowerLan 10 provides respectable performance with each type of traffic except the server Xcopy traffic, which has a marked slowing effect.

LANtastic outperforms Network-OS with no traffic and with Foxbase traffic; Network-OS is faster with Lotus and Xcopy traffic. This pattern suggests a faster NETBIOS implementation in Network-OS balanced against LANtastic's running the tests with server disk caching. Server traffic slows LANtastic by a large factor, and 10Net Plus and Network-OS could not complete the test with server traffic.

Microsoft C 5.0

A large ensemble of XLISP 2.0 C source code (10,928 lines totaling 245,222 bytes) was compiled and linked, forming an executable file of 147,228 bytes. The test was repeated with four traffic applications running concurrently on five secondary workstations and with Xcopy traffic at the server only.

Figure 9.
Microsoft C 5.0



The test primarily pumped data from the server to the workstation (i.e., the source code, and loading the compiler) and moved the smaller object modules back, producing mixed uploading and downloading of data. Traffic increased data movement and created a more steady demand on the server.

Analysis

ELS NetWare Level II again benefits from the combined advantages of driver efficiency and server disk caching with excellent performance in all the test iterations. Microsoft LAN Manager performs nearly as well with no traffic and with Lotus traffic.

The natural interruptions in server demand at the primary workstation (during the compiles) give LANtastic, Network-OS, and PowerLan 10 fairly close times with no traffic; 10Net Plus is slower, but not by more than the difference in drivers (10Net uses the Western Digital-supplied NETBIOS) might indicate. The no traffic results simulate a very lightly loaded peer-to-peer network, where the differences in system performance have the least consequence.

In contrast, the traffic scenarios show a strong differentiation among operating systems. With Lotus traffic, Microsoft LAN Manager again performs at a near second to ELS NetWare. PowerLan 10 performs about twice as fast as Network-OS, possibly because of caching; Network-OS performs about twice as fast as LANtastic, and LANtastic about twice as fast as 10Net Plus. With the Foxbase traffic, PowerLan 10 performs half as fast as ELS NetWare, but faster than the others.

To test whether 10Net's slow times result from its not having a customized driver, NSTL tested Network-OS with the Western Digital-supplied driver. Network-OS performs at about the same speed with its custom driver and the Western Digital driver (i.e., three times faster than 10Net Plus) with Foxbase traffic.

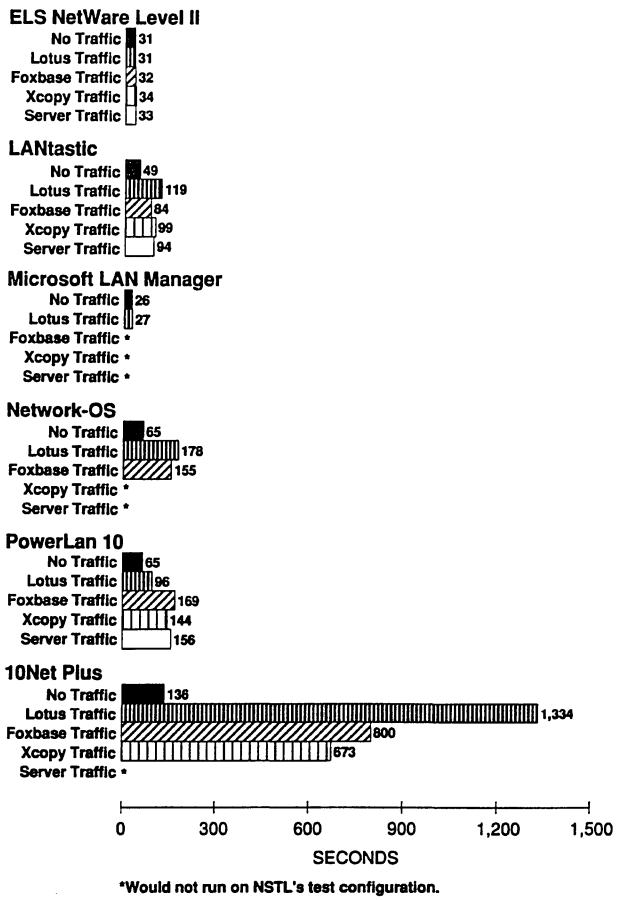
Xcopy to Server

A 5M-byte directory tree (130 files in 13 directories) was copied to the server (command issued with the /s parameter); the source tree was located on the primary workstation's local hard disk (Type 38). The test was repeated with four traffic applications running concurrently on five secondary workstations and with Xcopy traffic at the server only.

Analysis

Microsoft LAN Manager runs slightly faster than ELS NetWare Level II with no traffic and with Lotus traffic. Its superiority in this test is attributable to LAN Manager's NETBIOS implementation more efficiency fulfilling large block requests than Novell's IPX protocol, and the performance characteristics of LAN Manager's HPFS386 version of the OS/2 file system. PowerLan 10's caching and drivers provide fair performance with Lotus traffic, but Network-OS performs better than PowerLan with Foxbase traffic. LANtastic seems particularly strong Xcopying to the server, and it performs well with no traffic and with Foxbase, Xcopy, and server traffic.

Figure 10.
Xcopy to Server



*Would not run on NSTL's test configuration.

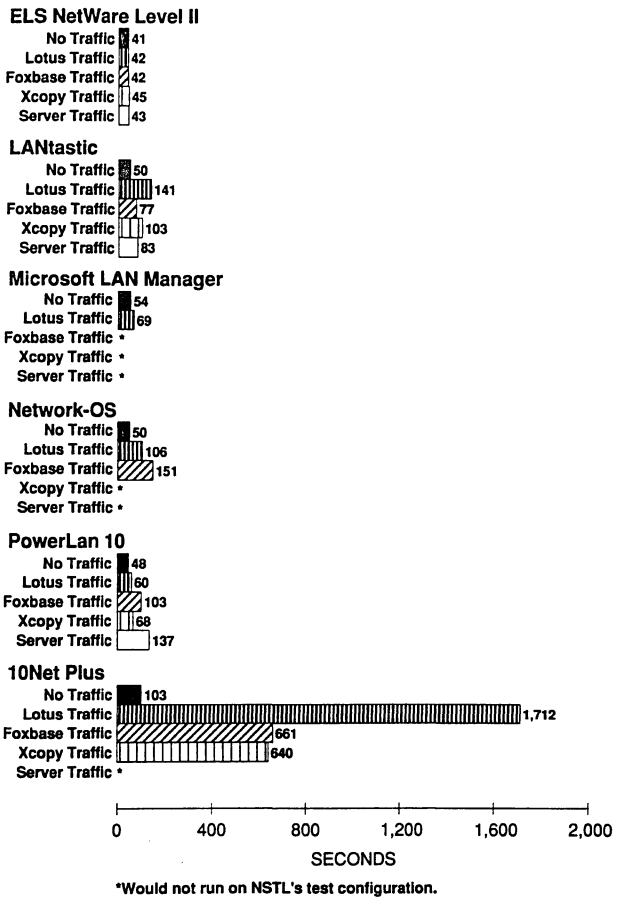
Xcopy from Server

A 5M-byte directory tree (130 files in 13 directories) was copied from the server to the primary workstation (command issued with the /s parameter). The test was repeated with four traffic applications running concurrently on five secondary workstations and with Xcopy traffic at the server only.

Analysis

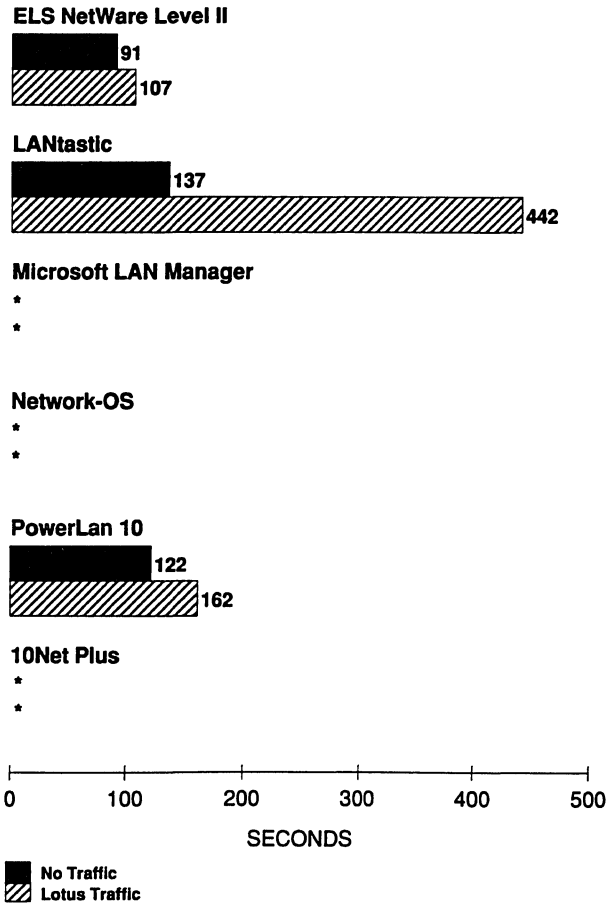
All the operating systems perform noticeably slower than when Xcopying to the server. ELS NetWare Level II maintains its lead, but depending on the type of traffic, PowerLan 10 and LANtastic vie for second place. LANtastic performs noticeably better with server traffic than does PowerLan, and PowerLan exhibits its typical strength with Lotus traffic.

Figure 11.
Xcopy from Server



*Would not run on NSTL's test configuration.

Figure 12.
Xcopy at Server



***Would not run on NSTL's test configuration.**

Xcopy at Server

A 5M-byte directory tree (130 files in 13 directories) was copied from a local area of the server disk to the network (shared) server drive (command issued with the /s parameter). The tree was then copied back. With ELS NetWare, no local (nonshared) area exists on the nondedicated server's disk, so two network areas were used. The test was run with the rest of the network idle and repeated with five workstations executing the Lotus 1-2-3 traffic.

Analysis

For ELS NetWare Level II, LANtastic, and PowerLan 10, the server Xcopy times are longer than the workstation times Xcopying to and from the server. The advantage the server has as a workstation (no need to actually use the Ethernet cable for data transfer) is outweighed by the disadvantage of having to share server processing power between its serving and workstation roles. The results reinforce the suggestion that even entry-level networks benefit from a dedicated server.

A comparison of times obtained with and without traffic shows that ELS NetWare is moderately slowed by traffic, PowerLan 10 is slowed about twice as much, and LANtastic even more relative to the no-traffic times.

Foxbase+/LAN

A suite of 16 tests was run at the primary 386/25 workstation in exclusive mode so that file lock requests did not slow the server.

1. 51,100 were written records to three different files, testing the speed of writing records.
2. The Account (50,000 records), Teller (1,000 records), Transact (1,000 records), and Branch (100 records) files were indexed.
3. The first 3 of every 10 Account records to three temporary files were copied.
4. The records copied in Test 3 were deleted.
5. The temporary files created in Test 3 were appended to the Account file.
6. The Account file was packed and reindexed. The resulting Account file contained the same records as initially, but in a different order.
7. 1,000 transactions were processed, each updating a record in the Account, Teller, and Branch tables. A History record was written for each transaction.
8. Four indexes were created on the 1,000-record History file.
9. Test 7 was repeated; the four History file indexes were updated each time a History record was written.
10. Blocks of 1,000 records were appended to the History file, increasing its size to 10,000 records.
11. Test 9 was repeated; the indexed History file increased to 10,000 records.
12. 1,000 Account records were selected in indexed order and printed to disk.

Table 1a. Foxbase+/LAN Tests

No Traffic (times in seconds)

	ELS NetWare	LANtastic	10Net Plus	PowerLan 10	Network-OS
1	50	52	52	54	72
2	15	18	20	18	35
3	20	23	25	23	59
4	28	31	41	39	119
5	9	11	16	15	49
6	24	29	34	31	80
7	20	26	38	30	56
8	5	7	8	7	24
9	37	40	74	65	239
10	60	68	77	73	202
11	61	97	209	140	357
12	6	7	8	8	12
13	14	16	18	17	39
14	2	2	4	2	4
15	1	2	3	3	4
16	21	25	30	26	35

13. A report was created from 1,000 Account records selected on an unindexed field and printed to disk.
14. The 1,000-record Teller file was grouped and subtotaled, and the report sent to disk.
15. The Teller and Branch files were joined, and the report sent to disk.
16. The History, Branch, Teller, and Account files (1,000, 100, 1,000, and 50,000 records) were joined, and the report sent to disk. The History file was sorted by account ID, date, and time.

Analysis

The Foxbase tests results reveal an overall pattern of ELS NetWare sustaining network loading very well. Without traffic, ELS NetWare is only slightly faster that the next program (geometric mean time of 14.6 seconds compared to LANtastic's 17.9 seconds, PowerLan 10's 20.7 seconds, and Network-OS' 23.8 seconds). With Lotus traffic, ELS NetWare barely shifts to a geometric mean of 15.3 seconds. PowerLan slips to 23 seconds, but LANtastic drops to 60.4. The situation reverses with Foxbase traffic, as ELS NetWare holds at 15.6 seconds, PowerLan drops to 41.3, and LANtastic holds at 37.5. The overall tendency, as with the other tests, is that PowerLan 10's performance remains strong with Lotus 1-2-3, and LANtastic remains strong with Foxbase traffic.

NOTE: *Geometric means for tests 1 through 16 are not provided with the performance results.*

Table 1b. Foxbase+/LAN Tests

Lotus Traffic (times in seconds)

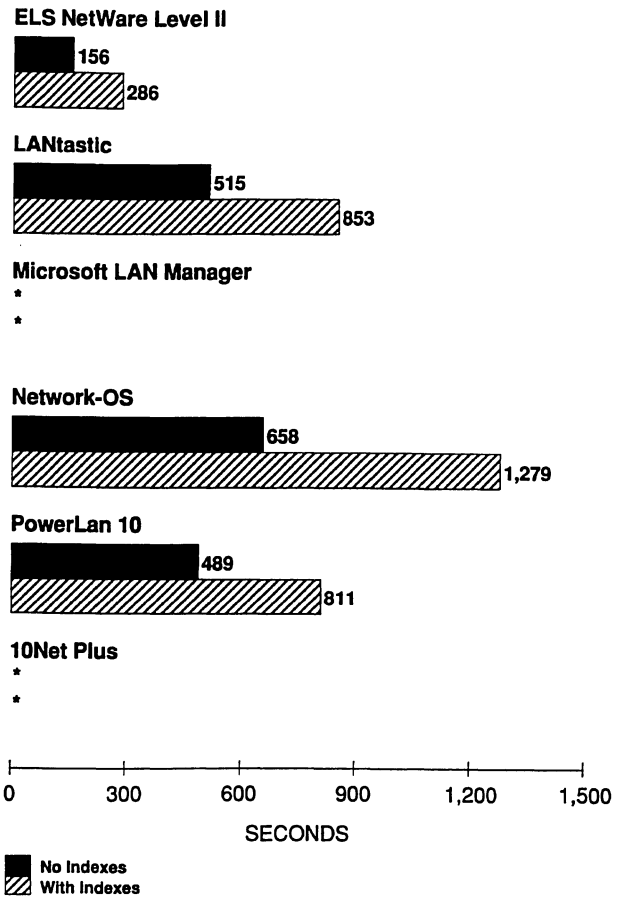
	ELS NetWare	LANtastic	PowerLan 10
1	49	78	59
2	16	49	19
3	20	61	27
4	29	93	43
5	9	49	18
6	24	76	40
7	20	118	32
8	5	29	9
9	36	223	72
10	61	160	86
11	63	677	154
12	6	15	8
13	14	36	19
14	2	11	2
15	2	12	3
16	21	66	28

Table 1c. Foxbase+/LAN Tests

Foxbase Traffic (times in seconds)

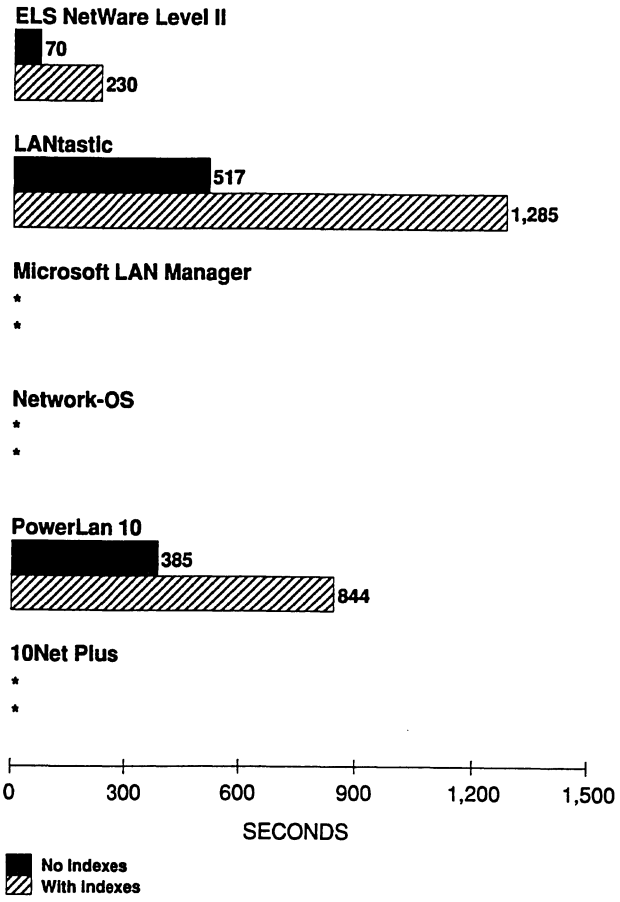
	ELS NetWare	LANtastic	PowerLan 10
1	50	59	76
2	15	30	35
3	20	36	53
4	29	63	91
5	10	28	35
6	24	50	76
7	21	62	55
8	5	16	15
9	38	121	148
10	61	109	144
11	63	426	359
12	7	11	11
13	14	24	32
14	2	6	4
15	2	7	5
16	21	45	47

Figure 13a.
Transaction Processing with One Workstation



***Would not run on NSTL's test configuration.**

Figure 13b.
Transaction Processing with Four Workstations



***Would not run on NSTL's test configuration.**

Transaction Processing

This test simulated a multiuser database transaction processing environment using five database files in Foxbase+/LAN 2.1 (Accounts, Teller, Branch, Transaction, and History files). Each transaction read from the Transaction file; located and locked a record in each of the Accounts, Teller, and Branch files; added a record to the History file with a lock; updated all locked records; and unlocked all records.

The Transaction Processing suite consisted of one secondary Everex workstation processing 960 transactions without indexes and with four indexes on the History file; and four workstations each processing 240 (nonoverlapping) transactions without and with four indexes. Instead of speeding record lookup, the indexes in this scenario slow processing as they increase disk activity and file contention at the server.

The transaction processing benchmark produced the heaviest server loading, barring the server traffic tests. The volume of traffic and file contention produced in this test simulates the loading volume created by many more workstations under typical multiuser database use.

Analysis

Transaction processing results show that while ELS NetWare may be faster than PowerLan and (at least on this test) PowerLan faster than LANtastic, their responses to workstation loading are different. ELS NetWare's times for four workstations are faster than for one workstation, indicating the division of the records among the workstations; however, with more workstations NetWare might lose performance with workstation competition for server resources.

PowerLan performs a bit faster than LANtastic with one workstation transaction processing, but with four workstations, PowerLan maintains almost the same time (a bit less without indexes, a bit more with indexes). LANtastic takes substantially longer with four workstations and indexes than with only one workstation. These results indicate that PowerLan 10 may be a better choice for a network with a server/workstation orientation; the server traffic results in the other tests recommend LANtastic for peer-to-peer networking.

Vendors

Artisoft, Inc.
Artisoft Plaza
575 East River Road
Tucson, AZ 85704 (602) 293-6363

CBIS, Inc.
5875 Peachtree Industrial Boulevard
Norcross, GA 30092 (404) 446-1332

DCA 10Net Communications
7887 Washington Village Drive
Dayton, OH 45479 (513) 433-2238

Microsoft Corp.
One Microsoft Way
Box 97017
Redmond, WA 98073-9717 (206) 882-8080

Novell, Inc.
122 East 1700 South
Provo, UT 84606 (801) 429-5900

Performance Technology
7800 IH 10 West
Suite 800
San Antonio, TX 78230 (512) 349-2000

Sitka Corp.
950 Marina Village Parkway
Alameda, CA 94501 (415) 769-9669

Characteristics

Table 2. LAN Operating System Characteristics

	Requirements	Network Adapters Supported	Supplier Support
Artisoft LANtastic (Version 3.0; released June 1990)	• Drives: hard drive; high- or low-density diskette • Server Memory: 256KB; uses 40KB depending on driver • Workstation Memory: 256KB; uses 12KB depending on driver • Operating System: DOS 3.1 and higher; 3.2 not recommended • Processor: 8088, 80286, 80386, 80486	LANtastic 2M bps, LANtastic AE-2 Ethernet, Ethercard Plus, Arcnet, Xircom Pocket Ethernet, NETBIOS-compatible adapters with available driver	Telephone, fax, and BBS support; upgrades; newsletter available through dealers
CBIS Network-OS (Version 7.0A)	• Drives: 10MB hard drive, 360KB diskette • Server Memory: 640KB RAM; uses 0 to 56KB • Workstation Memory: 640KB; uses 0 to 31KB maximum without print capability; 59KB maximum with print capability • Operating System: IBM PC-DOS/MS-DOS 3.1 and higher • Processor: 8086, 8088, 80286, 80386, 80486, PS/2 compatible	PureData, Thomas-Conrad, Tiara, Standard Microsystems Arcnet; Western Digital, 3Com, Tiara, Gateway Ethernet; IBM Token-Ring	Telephone support, newsletter, technical tips, new product information
DCA 10Net Plus (Version 4.2)	• Drives: 40MB hard drive, diskette drive • Server Memory: 87KB for 10Net; 43KB for NETBIOS • Workstation Memory: 50KB for 10Net; 43KB for NETBIOS • Operating System: DOS 3.x and higher • Processor: 80286 or higher with 2MB RAM	NETBIOS compatibles	Telephone support, newsletter, bulletin board, upgrades
Microsoft LAN Manager (Version 2.0; released August 1990)	• Drives: 20MB hard disk, high-density diskette • Server Memory: 5MB; 16MB maximum • Workstation Memory: DOS—512KB, 640KB recommended; OS/2—2.5MB minimum, 4MB recommended • Operating System: OS/2 1.2 (server); OS/2 1.1 or DOS 3.1 (workstation) • Processor: 80286, 80386, 80486	All cards with NDIS, including IBM Token-Ring; 3Com 501, 503, 523, 505b, 603 Etherlink; Western Digital Etherlink, Interlan	Telephone and electronic service request support, access to Microsoft knowledge base, journal
Novell ELS NetWare Level II (Version 2.15; released May 1989)	• Drives: 2, internal only • Server Memory: 1MB RAM dedicated; 2MB RAM nondedicated • Workstation Memory: drivers require 55KB to 70KB • Operating System: DOS 3.x and higher • Processor: 80286, 80386 (not recommended)	All cards certified with NetWare 2.1x	Available through resellers or supplier at (800) LAN-SWER

Table 2. LAN Operating System Characteristics (Continued)

	Requirements	Network Adapters Supported	Supplier Support
Performance Technology PowerLan 10 (Version 1.3; released February 1990)	• Drives: 20MB server hard disk; 360KB diskette • Server Memory: 120KB • Workstation Memory: OS and NETBIOS use minimum 35KB configurable • Operating System: MS-DOS 3.0 and higher; 3.3 and higher recommended • Processor: 80286, 80386, 80486	NETBIOS, SMC, or compatibles; Nestar and Micro Channel boards; Novell NE1000, NE2000; Western Digital 8003, 8013; 3Com 3C505, 3C503	Telephone support, bulletin board, newsletter
Sitka TOPS Network Bundle for DOS (Version 3.0)	• Drives: Hard disk and diskette drives • Server Memory: 66KB; 215KB conventional memory • Workstation Memory: 65KB to 232KB, client only • Operating System: DOS 3.1, 3.3, 4.01 • Processor: 80286, 80386, 80486, PS/2	3Com 3C503 Etherlink, 3C523 Etherlink MC; Western Digital 8003; all Macintosh Ethernet connections	Telephone support (415) 769-8711, bulletin board

Table 3. LAN Operating System Features

Server parameters (0)	Weight	ELS NetWare	LANtastic	LAN Manager	Network-OS	PowerLan 10	10Net Plus	TOPS
Maximum simultaneous users	1	8	300	1,024	255	255	255	20
Maximum server volume size	1	256MB	5GB	2GB	U	A	A	U
Maximum volumes	1	32	24	24	26	24	A	20
Maximum shared printers	1	5	5	5	5	5	3	3
Maximum simultaneous DOS 3.1 locks	1	M	3,000	U	255	255	255	1,024
Maximum open files	1	1K	5,100	8,192	255	10K	255	100
Memory used, nondedicated server	1	INS	40KB	INS	69K	INS	INS	70-90KB
Remote boot	1	▲	▲	▲	▲	▲	—	—
Security (4)								
User-based security	4	▲	▲	▲	▲	▲	▲	—
MS-Net-type share security	0	—	—	▲	▲	▲	▲	▲
Create security groups	2	▲	▲	▲	▲	—	▲	—
Security equivalences	0	▲	—	—	—	—	▲	—
Set account expiration date	1	▲	▲	▲	—	—	▲	—
Time restrictions	1	▲	▲	▲	—	—	—	—
Lock account after failed passwords	1	▲	—	—	—	—	—	—
Designate intruder-detect threshold	1	▲	—	▲	—	—	—	—
Set login count retention	1	▲	—	—	—	—	—	—

See footnotes on page 326.

Table 3. LAN Operating System Features (Continued)

	Weight	ELS NetWare	LANtastic	LAN Manager	Network-OS	PowerLan 10	10Net Plus	TOPS
Mandatory password change	1	▲	▲	▲	—	—	▲	—
Limit concurrent connections	1	▲	▲	—	▲	—	▲	—
User-set password option	1	▲	—	▲	▲	—	—	—
Set minimum password length	1	▲	—	▲	▲	—	▲	—
Disable/lock accounts	1	▲	▲	▲	—	—	▲	—
Packets/bytes sent and received	1	▲	▲	▲	▲	▲	▲	▲
Packets/bytes per second	1	▲	—	▲	—	—	—	—
Bad packets	1	▲	▲	▲	▲	▲	▲	▲
Open files	1	▲	▲	P	▲	▲	▲	—
Highest number of open files	1	▲	—	▲	—	—	▲	—
Record locks	1	—	—	P	▲	▲	▲	—
Highest number of record locks	1	—	—	▲	—	—	▲	—
Connections	1	▲	▲	▲	▲	▲	▲	▲
Highest number of connections	1	▲	—	▲	—	—	▲	—
Disk blocks read and written	1	▲	—	▲	—	—	▲	—
Disk blocks per second	1	—	—	—	—	—	—	—
Disk utilization	1	—	—	—	—	▲	—	—
Disk demand vs service	1	—	—	—	—	—	—	—
Drive I/O errors	1	▲	—	▲	—	—	▲	—
Packets routed	1	▲	—	—	—	—	—	—
Packets routed per second	1	N	—	—	—	—	—	—
Clear statistics	1	—	—	▲	—	—	▲	—
Identify beacon sender	1	—	—	—	—	—	—	—
Messages/Chatting (1)								
Send messages	1	▲	▲	▲	▲	▲	▲	—
Group messages	1	▲	▲	▲	▲	▲	▲	—
Broadcast message	1	▲	▲	▲	▲	▲	▲	—
Block messages	1	▲	▲	▲	▲	▲	▲	—
Log messages	1	—	▲	▲	▲	▲	—	—
Hot-key to messaging	1	—	▲	—	▲	▲	▲	—
Chatting	1	—	▲	—	▲	▲	▲	—
Maximum chatters	1	0	2	0	2	U	U	0
E-Mail (2)								
Create mail groups	1	—	S	▲	—	Q	▲	▲
Certified mail	1	—	—	▲	—	Q	▲	▲
Forward received mail	1	—	▲	▲	—	Q	▲	▲
Forward with comments	1	—	▲	▲	—	Q	—	▲
cc:lists	1	—	—	▲	—	Q	▲	▲
Edit/save received mail	1	—	▲	▲	—	Q	▲	▲

See footnotes on page 326.

Table 3. LAN Operating System Features (Continued)

	Weight	ELS NetWare	LANtastic	LAN Manager	Network-OS	PowerLan 10	10Net Plus	TOPS
Date/time-stamp	1	—	▲	▲	—	Q	▲	▲
Maximum attached files	1	—	1	1	—	Q	1	0
Import text	1	T	—	—	▲	—	Q	▲
Print E-Mail	1	—	▲	▲	—	Q	▲	▲
Inter-post office mail	1	—	—	▲	—	Q	R	▲
Mail gateways	1	—	—	▲	—	R	R	▲
Hot-key E-Mail	1	—	▲	▲	—	R	▲	—
Encryption	1	—	—	▲	—	Q	▲	▲
Mail folders	1	—	—	▲	—	Q	▲	▲
Sort mail	1	—	—	▲	—	Q	▲	▲
Unsend mail	1	—	▲	▲	—	Q	—	—
Discard mail by receipt date	1	—	—	▲	—	Q	▲	—
Voice mail available	1	—	▲	▲	—	—	—	—
Archival Services (0)								
Backup/restore server disk	1	▲	T	▲	T	T	T	T
Backup/restore selected directories	1	▲	T	▲	T	T	T	T
Backup modified files	1	▲	T	▲	T	T	T	T
Backup system files	1	▲	T	▲	T	T	T	T
On-line backup of account files	1	▲	—	▲	—	—	—	—
Backup skips open files	1	▲	—	▲	V	▲	—	—
Scheduled backups	1	▲	—	▲	V	▲	—	—
Backup to tape	1	R	V	▲	V	▲	—	—
Multiple tape drives	1	▲	V	▲	—	▲	—	—
Backup to diskette	1	▲	▲	▲	▲	▲	▲	▲
Backup Macintosh files on server	1	▲	—	—	—	—	—	▲
Network Printing (3)								
Automatic clear	1	▲	▲	▲	—	—	▲	—
Print banner	1	▲	▲	▲	▲	▲	▲	—
List available printers/queues	1	▲	▲	▲	▲	▲	▲	▲
List current redirections	1	▲	▲	▲	▲	▲	▲	▲
Printer status	1	▲	▲	▲	▲	▲	▲	▲
End spool from within application	1	▲	▲	▲	▲	▲	▲	▲
Time-out for end spool	1	▲	▲	▲	▲	▲	▲	▲
Print to network file	1	▲	▲	▲	▲	▲	▲	—
Select print mode	1	▲	▲	W	▲	—	—	—
Select form type	1	▲	▲	▲	—	—	—	—
PostScript font download	1	▲	▲	▲	▲	—	—	—
LaserJet font download	1	▲	▲	▲	▲	—	—	—
Require unique passwords	1	▲	—	▲	—	—	—	—

See footnotes on page 326.

Table 3. LAN Operating System Features (Continued)

	Weight	ELS NetWare	LANtastic	LAN Manager	Network-OS	PowerLan 10	10Net Plus	TOPS
Restrict user to workstation(s)	1	▲	—	▲	B	B	▲	—
Disconnect after inactive period	1	—	—	▲	—	—	▲	—
Share-Level Permissions (0)								
Read files	1	—	—	▲	▲	▲	▲	C
Write to file	1	—	—	▲	▲	▲	▲	C
Create files	1	—	—	▲	▲	▲	▲	C
Delete files	1	—	—	▲	▲	▲	▲	C
Execute only	1	—	—	▲	—	▲	▲	▲
Share-level password protection	1	—	—	▲	—	▲	▲	▲
User Account Permissions (4)								
Read files	1	▲	▲	▲	▲	▲	D	—
Write to files	1	▲	▲	▲	▲	▲	D	—
Create files	1	▲	▲	▲	▲	▲	—	—
Delete files	1	▲	▲	▲	▲	▲	—	—
Grant permissions	1	▲	—	▲	—	—	D	—
Execute only	1	▲	▲	▲	—	—	D	—
Modify file attributes	1	▲	▲	▲	—	▲	—	—
Limit simultaneous users	1	—	—	▲	—	▲	—	—
Assign permissions to directories	1	▲	▲	▲	—	▲	D	—
Assign permissions to files	1	—	▲	▲	—	▲	D	—
Assign permissions to queues	1	▲	—	▲	—	▲	—	—
Administrator rights on specific directories	1	—	—	▲	—	—	—	—
Inherited permissions	1	▲	▲	▲	▲	▲	▲	▲
Mask inherited rights	1	▲	—	▲	—	—	▲	—
Accounting (2)								
Limit user account space	1	▲	—	▲	—	—	—	—
Track user access time	1	▲	F	▲	—	—	E	—
Track user data reads	1	▲	▲	—	—	—	—	—
Track user data writes	1	▲	▲	—	—	—	—	—
Track user server requests	1	▲	▲	—	—	—	—	—
Track user space usage	1	▲	—	▲	—	—	—	—
Charge users for services	1	▲	—	—	—	—	—	—
Variable service rates	1	▲	—	—	—	—	—	—
Set user account balances	1	▲	—	—	—	—	—	—
Set user credit lines	1	▲	—	—	—	—	—	—
Logout at credit limit	1	▲	—	—	—	—	—	—
Auditing (2)								
Logins	1	▲	▲	▲	—	—	▲	—
Unsuccessful login attempts	1	▲	—	▲	—	—	▲	—
Attempted security violations	1	G	▲	▲	—	—	▲	—

See footnotes on page 326.

Table 3. LAN Operating System Features (Continued)

	Weight	ELS NetWare	LANtastic	LAN Manager	Network-OS	PowerLan 10	10Net Plus	TOPS
Logouts	1	▲	▲	▲	—	—	▲	—
File open	1	▲	▲	▲	—	—	—	—
Selective audit	1	—	▲	▲	—	—	—	—
Audit specific resources	1	—	—	▲	—	—	—	—
Alert Service (2)								
Drive full	1	—	—	▲	—	▲	—	—
Excessive errors	1	—	—	▲	—	—	—	—
Intruder alert	1	—	—	▲	—	—	—	—
Printer problem	1	—	—	▲	—	—	▲	—
Print request complete	1	▲	—	▲	—	—	▲	—
Utilities (1)								
System login script	1	—	▲	▲	▲	▲	—	—
User login scripts	1	▲	▲	▲	▲	—	—	—
Explicit file locking	1	▲	—	—	—	—	—	—
Display logged-in users	1	▲	▲	▲	▲	▲	▲	—
Display network resources	1	▲	—	▲	▲	▲	▲	▲
Display rights	1	▲	▲	H	—	▲	▲	—
Execute server program from workstation	1	J	L	I	▲	—	K	—
Supervisor Utilities (2)								
Forced disconnect	1	▲	—	▲	▲	—	—	▲
Security check utility	1	▲	—	—	—	—	▲	—
List security group access limits	1	▲	—	—	—	—	▲	—
List user access limits	1	▲	▲	—	—	—	▲	—
List user access rights by resource	1	▲	▲	▲	—	—	—	—
Realtime status: files/volumes	1	▲	—	▲	—	—	▲	▲
Performance Monitoring (3)								
Average response time	1	—	—	▲	—	—	—	—
Cache statistics	1	▲	▲	▲	▲	▲	▲	—
Server CPU utilization	1	▲	—	—	—	▲	—	—
Print screen	1	▲	▲	▲	▲	▲	▲	▲
Print notification	1	▲	—	▲	—	—	▲	—
Printing Queues (3)								
Multiple queues on one printer	2	▲	▲	▲	—	—	—	—
Multiple printers on one queue	2	▲	▲	▲	—	—	—	▲
Multiple queues on multiple printers	1	▲	—	▲	—	—	—	—
Restrict queue hours	1	A1	—	▲	—	—	—	—
Queue priority levels	1	▲	—	▲	—	—	—	—
Print preprocessor	1	—	—	▲	—	—	—	▲
Queue status	1	▲	▲	▲	▲	▲	▲	▲
Change queue order	1	▲	▲	▲	▲	—	▲	—

See footnotes on page 326.

Table 3. LAN Operating System Features (Continued)

		Weight	ELS NetWare	LANtastic	LAN Manager	Network-OS	PowerLan 10	10Net Plus	TOPS
Switch queues	1	—	—	—	▲	—	▲	—	
Delete job from queue	1	▲	▲	▲	▲	▲	▲	▲	
Hold/release print job	1	▲	▲	▲	▲	—	▲	—	
Restart job at beginning	1	Y	▲	▲	▲	—	▲	—	
Pause printer	1	Y	▲	H	▲	▲	Z	—	
Pause queue	1	▲	▲	H	—	▲	Z	—	
Close queue	1	▲	▲	H	—	—	—	—	
Connectivity (2)									
OS/2 workstations	2	▲	—	▲	—	▲	—	—	
OS/2 processes with private sessions	1	▲	—	▲	—	—	—	—	
Macintosh file servers	0	—	—	V	—	—	—	C1	
Macintosh workstations	3	▲	V	V	V	—	—	C1	
VAX file servers	0	R	V	V	—	—	—	—	
VAX workstations	0	—	—	V	—	—	—	—	
NFS workstations	0	—	—	—	—	—	—	—	
NFS file servers	0	—	—	—	—	—	—	—	
327x coaxial gateway	0	R	V	V	V	—	R	—	
327x remote gateway	0	R	V	V	V	—	R	—	
327x Token-Ring gateway	0	R	V	V	—	—	R	—	
327x bisynchronous gateway	0	R	V	V	V	—	R	—	
327x terminal emulation	0	R	V	V	V	—	R	—	
Asynchronous gateway	2	E1	V	B1	V	▲	—	—	
Maximum COM ports in asynchronous gateway	1	16	V	8	0	2	0	0	
Queue access to serial devices	1	—	V	B1	—	—	—	—	
Asynchronous terminal emulation	1	R	V	—	—	—	R	—	
Bridging (2)									
Remote workstation	2	▲	K1	▲	▲	▲	R	—	
Remote servers	1	▲	K1	▲	—	▲	R	—	
Maximum adapter types per server	3	1	6	4	2	1	1	1	
Maximum adapter types per external bridge	2	M1	0	4	0	8	4	0	
TCP/IP bridge	1	G1	V	—	G1	—	1	—	
HDLC bridge	1	—	—	V	—	—	—	—	
X.25 point-to-point bridge	1	H1	V	V	—	▲	—	—	
X.25 multipoint packet switched bridge	1	J1	V	V	—	▲	—	—	
Asynchronous bridge	1	▲	V	V	—	▲	R	—	
Scheduled connections	1	—	—	V	—	—	—	—	
Line drop after idle time	1	▲	—	V	—	—	—	—	

See footnotes on page 326.

Table 3. LAN Operating System Features (Continued)

		Weight	ELS NetWare	LANtastic	LAN Manager	Network-OS	PowerLan 10	10Net Plus	TOPS
Fault Tolerance (1)									
UPS monitoring	1	▲	—	▲	—	—	—	—	
Disk mirroring	1	—	—	▲	—	▲	—	—	
Disk duplexing	1	—	—	▲	—	▲	—	—	
Server duplexing	1	—	—	▲	—	▲	—	—	
Split seeks	1	▲	—	▲	—	▲	—	—	
Read verification	1	▲	—	▲	—	▲	—	—	
Hot fix	1	▲	—	▲	—	▲	—	—	
Sector recovery on mirrored drives	1	—	—	▲	—	—	—	—	
Application Program Interfaces (1)									
Named Pipes	1	▲	—	▲	—	—	—	—	
NETBIOS	1	▲	▲	▲	▲	▲	▲	▲	
APPC	1	P1	—	V	—	—	—	—	
E-Mail API	1	▲	▲	▲	—	—	—	▲	
Novell system calls	1	▲	—	—	Q1	▲	—	—	
Accounting API	1	▲	—	▲	—	—	—	—	
Auditing API	1	▲	▲	▲	—	—	—	—	
Indexed file manager	1	▲	—	S1	—	—	—	—	
Transaction logging and rollback	1	—	—	S1	—	—	—	—	
Bundled Applications (1)									
Menu development utilities	1	▲	—	▲	—	—	—	—	
Time management	1	—	—	—	—	—	▲	—	
Disk caching for nonserver	1	—	▲	—	▲	▲	▲	—	
DOS command shell	1	—	—	—	—	—	—	—	

▲—Has feature.
A—Depends on DOS version.
B—Restricts to workstation ID, which can be given from any workstation.
C—Permissions designated by volume.
D—Uses security level rather than permission scheme.
E—Via Auditing feature.
F—Additional application required.
G—Supervisor can view last intruder's node address.
H—Requires Administrator privilege.
I—OS/2 programs only; request must be made from OS/2 workstation.
J—Program written specifically to run on a server can be installed as an operating system extension.
K—Can execute DOS program from server command prompt. Screen output not redirected.
L—With Artisoft's The Network Eye application.
M—Limited by available memory.
N—Peak number of routing buffers used.
P—User must count.
Q—cc:Mail bundled with operating system.
R—Available at additional cost.
S—Using user-name grouping.
T—Uses DOS backup; DOS required, but not provided.
U—Unlimited.
V—With third-party software.
W—Accomplished by setting multiple queues to the same printer.
Y—Requires access to print server console.
Z—Only at server connected to printer.
A1—Individual jobs can be deferred.
B1—For OS/2 workstations only.
C1—TOPS for Macintosh required; additional cost.
E1—Requires NetWare Asynchronous Communication Services: $1,495.
G1—Available from Racal InterLan, Wollongong, Excelan.
H1—NetWare X.25 Point-to-Point bridge: $1,250.
J1—NetWare X.25 Multipoint Bridge, $1,750.
K1—Using Artisoft's LANtastic Z product.
M1—Four with NetWare Asynchronous Remote Bridge: $395.
P1—Announced, but not shipped.
Q1—Novell record-locking calls.
S1—Available with SQL server.
INS—Information not supplied.

Glossary of Terms

Parameters

Maximum simultaneous users: The maximum number of sessions that can be simultaneously active on a single server.

Maximum server volume size: The maximum server hard disk volumes supported by the network operating system.

Maximum volumes: The maximum number of volumes supported by the network on a single hard disk.

Maximum shared printers: The maximum number of shared printers that can be attached to a single file or print server.

Maximum simultaneous DOS 3.1 locks: The maximum locks that can be held by all users on all files on a single server.

Maximum open files: The maximum number of files that can be opened from one server.

Memory used, nondedicated server: The amount of memory (from the 640K bytes of DOS memory) used for nondedicated server applications.

Remote boot: The server supports remote booting of workstations (such as diskless workstations).

Security

User-based security: A network administrator assigns a password and privileges to individual users. Users sign on to the network once and can access all resources available to them.

MS-NET-type share security: Passwords are assigned to individual resources (e.g., network printer, network directory), and any user who can provide a given password can access the corresponding resource. Although less secure than user-based security, this system is adequate when security and administration needs are minimal.

Create security groups: Users with similar access needs can be assigned to security groups, and access restrictions can be set/modified all at once for all users in the group.

Security equivalences: The administrator can assign a new user or group security equivalence to an existing user or group.

Set account expiration date: Accounts can be dated to expire, after which the user can no longer access the network.

Time restrictions: User access can be restricted to certain times of day.

Lock account after failed password: The network can be programmed to shut down a node following a specified number of incorrect password attempts.

Designate intruder-detect threshold: The administrator designates how many failed login attempts will signal an alert or automatically lock the account.

Set login count retention: The administrator can designate a period of time during which failed attempts are logged by the system (i.e., to prevent long-term users from accumulating enough failures to lock their accounts).

Mandatory password changes: Users can be forced to periodically change their passwords in order to gain access.

Limit concurrent connections: The administrator can limit a user account to a specified number of simultaneous logins (i.e., at different stations) to facilitate security and resource administration.

User-set password option: A user's ability to set his or her own password can be limited (e.g., when an account will be used by multiple users).

Set minimum password length: The administrator can set a minimum character length for all passwords; longer passwords are generally more secure.

Disable/lock accounts: The administrator can disable an account without deleting it, so that it can then be quickly reactivated.

Require unique passwords: The administrator can prevent a user from repeating a password he or she has already used; the system maintains at least a password history for each user.

Restrict user to workstation(s): A user's login access can be restricted to one or more specified workstations.

Disconnect after inactive period: Workstations are logged out after a specified period of inactivity.

Share-Level Permissions

Read files: Users can read files in the shared directory.

Write to files: Users can write to existing files in the shared directory.

Create files: Users can create new files in the shared directory.

Delete files: Users can delete files in the shared directory.

Execute only: Users can execute, but not read or write to, files in a shared directory (i.e., prevents illegal copying of software).

Share-level password protection: Password security can be established in shared directories.

User Account Permissions

Read files: Users can read specified files.

Write to files: Users can write to specified files.

Create files: Users can create new files in a secured directory.

Delete files: Users can delete files in a secured directory.

Grant permissions: Users can grant (to other users) access to specified files (i.e., limited hierarchical distribution of administrative tasks).

Execute only: Users can execute, but not read or write to, secured files in a shared directory (i.e., prevents illegal copying of software).

Modify file attributes: Users can modify file attributes such as read-only, hidden, and system attributes.

Limit simultaneous users: Network resources can be limited to some maximum number of users. In conjunction with an execute-only privilege, this restriction would enforce software licensing restrictions.

Assign permissions to directories: Security permissions can be assigned to directories and apply to all files therein.

Assign permissions to files: Security permissions can be assigned to individual files (e.g., an execute-only file in a directory designated as read-write).

Assign permissions to queues: Access to printer queues can be limited for security or resource management purposes.

Administrator rights on specific directories: The system administrator can grant Administrative rights to a user in a specific directory only.

Inherit permissions: Access rights in a directory can be passed to subdirectories.

Mask inherited rights: A subset of the rights in a given directory can be established for its subdirectories.

Accounting

Limit user account space: Users' accounts can be limited to a specified number of disk blocks, after which the user receives a Disk Full message.

Track user access time: The network can monitor user access time (measured from login to logout).

Track user data reads: The network can monitor the number of reads performed by user.

Track user data writes: The network can accrue data writes by user to their accounts.

Track user server requests: The network can accrue server requests by user to their accounts.

Track user space usage: The network can accrue space usage by user on a periodic (e.g., daily, weekly, etc.) basis.

Charge users for services: Costs can be associated with various use measures (e.g., space usage, data read/writes, access time), and these costs can be accrued to each user.

Variable service rates: Network service rates can vary by day and time. Variable rates encourage network use during off-peak hours.

Set user account balances: Users can be assigned balances against which network services costs are charged.

Set user credit line: Users may take account balances to an established credit line.

Logout at credit limit: The system can log out any user who exceeds a credit line. The account remains disabled until the administrator increases the credit line.

Auditing

Logins: The system can record the date, time, and user name for all logins.

Unsuccessful login attempts: The system can record the date, time, and user name for all unsuccessful logins.

Attempted security violations: The network can maintain a record of users who try unsuccessfully to access files.

Logouts: The system can record the date, time, and user name for all logouts.

File open: The system can record the date, time, and user name each time any file is opened on audited resources.

Selective audit: Auditing of resources can be selective (e.g., just the logins and logouts, and not file openings).

Audit specific resources: Auditing can be specified for selected resources to prevent filling the audit file with nonessential information.

Alert Service

Drive full: An alert message can notify the administrator when a network drive fills to capacity.

Excessive errors: An alert message can be sent to the administrator when a designated number of network errors occur (e.g., 100 bad packets received).

Intruder alert: An alert message can notify the administrator when a designated number of failed login attempts have occurred.

Printer problem: An alert message can notify the administrator when a printer problem occurs.

Print request complete: A message can notify a print queue user when his or her print job is completed.

User Utilities

System login script: The administrator can create a single batch file that executes after each user logs in.

User login scripts: The administrator or user can develop files that automatically execute system utilities and/or move the user into an application upon login.

Explicit file locking: Network commands can be used to lock files explicitly specified by a user.

Display logged-in users: Any user can obtain a list of all users currently logged in to the network (useful when sending messages).

Display network resources: Any user can display a list of available network resources.

Display rights: Any user can display a list of his or her access rights for a given resource.

Execute server program from workstation: Users with the appropriate privileges can run programs on a server, making better use of system resources.

Supervisor Utilities

Forced disconnect: Supervisors can disconnect any logged-in user as a security measure or as a means of clearing inactive users.

Security check utility: A system utility examines the security system for loopholes such as accounts without passwords, inappropriate rights, too many supervisors, and others.

List security group access limits: The administrator can request a listing of security groups with descriptions of group privileges.

List user access limits: The network administrator can request a listing of users with descriptions of their privileges.

List user access rights by resource: An administrator can select a resource and request a list of users with access.

Remote server administration: An administrator can control server resources from a workstation other than the server.

Real-time status: files/volumes: An administrator can monitor the status server volumes showing files currently in use and the users accessing them.

Performance Monitoring

Average response time: A server can display an average time needed to service requests made to the server.

Cache statistics: A server can display cache statistics such as hit ratio, cached reads/writes, and others.

Server CPU utilization: A server can show CPU utilization by measuring CPU idle time.

Packets/bytes sent and received: A server can measure amount of information sent and received at the server.

Packets/bytes per second: A server can measure the instantaneous rate of information arrival and departure at the server.

Bad packets: A server can record the number of bad packets received at the server (used to diagnose potential problems).

Open files: A server can show how many files are open files at any time; many servers offer a maximum on open files as a configurable parameter.

Highest number of open files: A server can show the highest number of files open at any one time since the statistics were last cleared.

Record locks: A server can show how many files are open at any time; many servers offer a maximum on record locks as a configurable parameter.

Highest number of record locks: A server can show the highest number of record locks in place at any one time since the statistics were last cleared.

Connections: A server can show how many connections are currently in place; many servers offer a maximum on connections as a configurable parameter.

Highest number of connections: A server can show the highest number of connections at any one time since the statistics were last cleared.

Disk blocks read and written: A server can show the number of disk blocks read and written since the statistics were last cleared.

Disk blocks per second: A server can show the instantaneous rate of disk usage.

Disk utilization: A server can measure disk utilization, or the percentage of time the disk subsystem is active.

Disk demand vs. service: A server can show the ratio of requests for disk service to disks actually serviced. A number greater than 1 shows disk requests being made faster than they can be serviced, indicating overutilization of the server.

Drive I/O errors: A server can show the number of I/O errors occurring on the drive. I/O errors may signify imminent disk failure or a disk controller problem.

Packets routed: A server can show the number of packets rerouted to another server. A large number of rerouted packets may indicate the need for a topology change such as installing a dedicated bridge.

Packets routed per second: A server can show peak routing demand in packets per second.

Clear statistics: The server operator can clear statistics without shutting down the server.

Identify beacon sender: The system works with the token-ring fault-detection system for identifying faulty adapters in the ring.

Messages/Chatting

Send messages: Network users can send short communications to one or more logged-in users (unlike E-Mail, which can communicate with users who are not logged in).

Group messages: Messages can be sent to groups of users (e.g., all users in the programmers group).

Broadcast message: The system can send the same message to every logged-in user (or workstation) with a single command.

Block messages: Users can issue a command that blocks messages (which halt all processes until cleared) to prevent interruption of long, unattended batch operations.

Log messages: Users can log messages to a file (i.e., when blocking messages).

Hot key to messaging: Messages can be sent from within a DOS application (feature provided by OS/2).

Chatting: The system permits an electronic "conference call," whereby users can exchange messages without addressing each one.

Maximum chatters: The maximum number of users that can participate in one chat session and see all comments.

E-Mail

Create mail groups: The E-Mail system can define and save lists of users for frequently used E-Mail group delivery.

Certified mail: The E-Mail system can automatically return a message to the original sender when the message has been read.

Forward received mail: Mail can be forwarded to other users. The forwarded message cannot be changed by the forwarder.

Forward with comments: Mail can be forwarded with comments attached.

cc: lists: Users listed in a carbon copy (CC) list receive copies of messages.

Edit/save received mail: E-Mail files can be edited and saved in standard ASCII (or a word processor) format.

Date/time stamp: All mail is date and time-stamped when sent.

Maximum attached files: This is the maximum number of binary files (e.g., spreadsheets, graphics, etc.) that can be attached to a mail message.

Import text: The mail editor can import text from an ASCII file.

Print E-Mail: Users can make a hard copies of any E-Mail messages using standard network printer commands.

Inter-post office mail: Mail can be addressed for delivery to mailboxes at any remote network post office. Mail is sent between post offices automatically, typically over an asynchronous modem link.

Mail gateways: Gateways can be used to link different mail systems, typically to MCI Mail, Western Union EasyLink, and IBM PROFS.

Hot-key to mail facility: The mail E-Mail program can be used as a memory-resident program in DOS systems such that the user need not exit an application to access mail.

Encryption: Mail can be encrypted using user-provided passwords to secure transmission. Mail can be organized into "folders" (e.g., Unread, Need Response, Personal, etc.).

Sort mail: Mail can be sorted by a variety of keys (e.g., date, priority, sender, etc.).

Unsend mail: Mail that has been sent can be retracted by the sender any time before the recipient reads it.

Discard mail by receipt date: All mail received before a certain date can be deleted to clear space on the mail server.

Voice mail available: The system provides facilities for creation, exchange, and playback of voice mail.

Archival Services

Backup/restore server disk: Backup utilities can be used to back up the entire server hard disk including hidden files and system files.

Backup/restore selected directories: Backup utilities can be used to back up user-specified directories only.

Backup modified files: Backup utilities can be used to back up files that have been modified since the last backup.

Backup system files: Backup utilities can be used to back up system files on the server without disrupting routine network activities.

On-line backup of account files: Backup utilities can be used to back up server system files (account databases) without disrupting routine network activities.

Backup skips open files: Open files do not halt a backup operation. Files open for update are bypassed, and files open for read/only purposes can be opened and backed up normally.

Scheduled backups: Network backups can be scheduled for off-peak hours.

Backup to tape: The network backup utilities can be used with tape backup systems.

Multiple tape drives: Multiple tape drives are supported such that backup and restore operations progress from one drive to the next as the tapes fill.

Backup to diskette: Diskette drives can be used as archival devices.

Backup Macintosh files on server: A supplied utility backs up Macintosh files (resource and data fork) stored on the server.

Network Printing

Automatic clear: The printer queue can be set up such that the appropriate escape codes reset the printer at the start of each print job.

Print banner: The printer queue can be set up to insert a user banner or separator page between jobs.

List available printers/queues: Workstation users can display the status (i.e., availability) of network printers.

List current redirections: Users can request a list of network printers attached to local device names (e.g., Laser—1 attached to LPT1).

Printer status: Users with the appropriate privilege can display the status of the network printers.

End spool from within application: Spooling files can be closed with a keystroke; the closed file is submitted to a printer queue, and a new file opened.

Time-out for end spool: Spooling files can be set to close automatically after a designated period during which no characters are received from the workstation.

Print to network file: Files can be sent to a network file instead of a printer, and the network file can be sent to a print queue.

Select print mode: Users can select a print mode (e.g., portrait, landscape, letter quality, etc.) and the appropriate escape codes are automatically sent to the printer.

Select form type: Print jobs can be submitted with a specified form type (e.g., green bar, micro perf). When the form type is loaded, all queued jobs specified for that form type are printed.

PostScript font download: The print spooler automatically downloads PostScript fonts to a printer as needed.

LaserJet font download: The print spooler automatically downloads fonts to a LaserJet (or compatible) printer as needed.

Print screen: Shift-PrtSc can be set to print to a network printer.

Print notification: Users are notified (by message) when their print jobs have completed printing.

Printing Queues

Multiple queues on one printer: Multiple queues can be directed to a single printer. Queues may be set to print during different times or with different priorities.

Multiple printers on one queue: A queue can be set to print to the first available network printer.

Multiple queues on multiple printers: Multiple queues can be set to print to the first available network printer.

Restrict queue hours: Queues can be set to print only during designated hours. An overnight queue might accept jobs all day and print only from 8 p.m. to 6 a.m.

Queue priority levels: Queues can be assigned priority levels.

Print preprocessor: A supplied filter program can process submitted jobs before printing (e.g., convert plotter files for a laser printer).

Queue status: Users can view the status of at least their own jobs in the printer queue.

Change queue order: Users can reorder their own jobs in the print queue. The queue operator or administrator can reorder all jobs in the queue.

Switch queues: A user can move printing jobs from one queue to another.

Delete job from queue: A user can delete jobs submitted to the queue.

Hold/release print job: Users can place their print jobs on hold. Jobs on hold remain in the queue but are not printed until they are released.

Restart job at beginning: A current job can be restarted printing from the beginning (e.g., when printer problems lose part of the job).

Pause printer: The printer can be set to pause such that no jobs are printed on it from any queue.

Pause queue: A single queue can be paused; other queues (possibly attached to the same printer) can be used normally.

Close queue: A queue can be closed such that it does not accept jobs, but continues printing any jobs already in the queue.

Connectivity

OS/2 workstations: Workstations running OS/2 are supported as network nodes.

OS/2 processes with private sessions: Each OS/2 process can have its own unique set of drive mappings.

Macintosh workstations: Macintosh systems are supported as network nodes.

Macintosh file server: Macintosh systems are supported as file servers.

VAX file server: VAX architecture systems are supported as file servers.

VAX workstations: VAX architecture systems are supported as network nodes.

NFS workstations: Network File System-based (NFS) workstations can be used as full network nodes.

NFS file servers: A Network File System (NFS) gateway provides access to NFS file servers from workstations.

327x coaxial gateway: A gateway allows workstations to act as 3270 series terminals. The gateway attaches to a cluster controller via a coaxial connection.

327x remote gateway: A gateway allows workstations to act as 3270 series terminals. The gateway attaches to a cluster controller via a synchronous modem connection.

327x token-ring gateway: A gateway allows workstations to act as 3270 series terminals. The gateway attaches to a cluster controller via a token-ring connection.

327x bisynchronous gateway: A gateway allows workstations to act as 3270 series terminals. The gateway attaches to a cluster controller via a bisynchronous connection.

327x terminal emulation: Network software enables workstations to emulate 3270 series terminals.

Asynchronous gateway: Asynchronous communication services permit workstations to share asynchronous connections such as modem pooling and connections to a VAX.

Maximum COM ports, asynchronous gateway: The maximum number of COM ports that can be shared in an asynchronous gateway. Specialized hardware is needed to share more than two COM ports in PC-compatible systems.

Queue access to serial devices: When all available asynchronous connections are busy, workstations requesting asynchronous services are queued and serviced in order of receipt.

Asynchronous terminal emulation: Network software enables workstations to emulate terminals attached through the asynchronous gateway.

Bridging

Remote workstation: Network software supports workstations connected through modems.

Remote servers: Network software supports connection of other network servers through modems.

Maximum adapter types per server: The maximum number of different network adapter types (e.g., token-ring, Ethernet, Arcnet, Starlan) that can be operated simultaneously in one server (often called internal bridging).

Maximum adapter types per external bridge: The maximum number of different network adapter types that can be operated simultaneously in one external bridge.

TCP/IP bridge: A bridge provides TCP/IP services to workstations on the network. TCP/IP is a standard set of file sharing protocols widely supported on UNIX workstations, minicomputers, and mainframes.

HDLC bridge: Two networks can be bridged using a synchronous high-density data link connection over dial-up or dedicated lines.

X.25 point-to-point bridge: Two networks can be bridged using a synchronous X.25 connection over a dial-up or dedicated lines.

X.25 multipoint packet switched bridge: Multiple networks can be bridged using X.25 connections to a packet switched network. These networks are available as value-added networks (VANs) from companies such as Tymnet and Telenet.

Asynchronous bridge: Two networks can be bridged using an asynchronous connection over dial-up lines.

Scheduled connections: Scheduled connections are automatically made and broken.

Line drop after idle time: Bridge connections can be broken automatically after a designated period of inactivity.

Fault Tolerance

UPS monitoring: The network software supports a hardware interface to an uninterruptable power supply. The UPS signals the server when it is operating on battery power; the server then initiates shutdown procedures to be completed before the UPS runs out of power.

Disk mirroring: Mirrored disks are maintained as exact duplicates. In the event that one disk fails, the system software immediately switches to using the other.

Disk duplexing: Duplexed disks are mirrored disks that use separate controllers. Read requests are sent to whichever disk is not occupied; write requests go to both disks to maintain mirroring. Duplexing improves throughput as well as fault tolerance.

Server duplexing: Servers can be maintained as exact duplicates. When one server fails, the mirrored server immediately takes over.

Split seeks: Read requests are sent to whichever disk subsystem is not occupied in a duplexed disk system; write requests go to both disks to maintain mirroring.

Read verification: The system software verifies the readability of sectors before flushing the sector buffer.

Hot fix: When read verification fails, the sector is relocated and the bad sector marked.

Sector recovery on mirrored drives: When mirrored disks cease mirroring after a sector failure, the sectors are read from the good disk and relocated on the bad disk. Mirroring can then continue.

Application Program Interfaces

Named pipes: The network supports the named pipes interface adopted by Microsoft to simplify programming network connections. Named pipes is similar to interprocess pipes, but the processes are on different network workstations.

NETBIOS: The network supports the network interface invented by IBM for personal computer networking.

APPC: The network supports IBM's APPC interface for advanced peer-to-peer communication among all varieties of computers from micros to mainframes.

E-Mail API: The network system defines an application program interface (API) to the network mail system (e.g., for programs that automatically send mail or for developing mail gateways).

Novell system calls: The network interprets Novell system calls, allowing applications written for NetWare networks to be executed.

Accounting API: The network operating system defines an application program interface (API) to the network accounting system (e.g., for programs that automatically capture accounting information or for spreadsheet manipulation).

Auditing API: The network system defines an API to the network auditing system (e.g., for programs that automatically capture information for centralized network management, such as IBM's NetView).

Indexed file manager: The network system defines a programming interface to an indexed file manager (e.g., for programs that manipulate a database).

Transaction logging and rollback: The network system defines a programming interface for fault-tolerant applications. Transactions are groups of related updates that are either made completely or not made at all.

Bundled Applications

Menu development utilities: The network software includes utilities that assist the administrator in preparing menus.

Time management: The network software includes utilities to manage appointments, group meetings, and other activities.

Disk caching for nonservers: The network supplies a disk caching implementation for DOS systems not acting as servers.

DOS command shell: The network software includes a DOS shell with menus to make DOS easier to use.

Software Prices

		Price ($)
Entry-Level LAN Operating Systems		
	Artisoft LANtastic	
	Per Server	495
	6 Users	795
	CBIS Network-OS	
	Up to 8 Users	1,520
	9 to 80 Users	1,988
	DCA 10Net Plus	
	10 Users	895
	Microsoft LAN Manager	
	5 Users	995
	10 Users	1,990
	Novell ELS NetWare Level II	
	8 Users	1,895
	Performance Technology PowerLan 10	
	10 Users	1,495
	Sitka TOPS Network Bundle for DOS	
		1,992

UNIX
File Server Programs

A Report from NSTL

In this report:

Synopsis

Focus
NSTL evaluated three ported NetWare and LAN Manager file server implementations running under UNIX on 486-based systems. The products' features, performance, and usability were compared and rated.

Programs Tested

StarGroup LAN Manager
AT&T

Ported NetWare
Interactive Systems Corp.

NetWare/X
NCR Corp.

Program Recommendation

- AT&T StarGroup LAN Manager

Source
Based on data generated by tests designed and conducted by National Software Testing Laboratories, Inc. (NSTL), a division of Datapro Information Services Group, Plymouth Meeting, PA 19462. Telephone (800) 223-7093.

Ratings Key
(On a scale of 0 to 10)
Ratings
● 7.0 - 10.0
○ 5.0 - 6.9
▨ under 5.0
★Recommended

Overall Evaluation	Product Name	Version Tested	Performance	Versatility	Ease of Learning	Ease of Use	Price
8.0	AT&T StarGroup LAN Mgr.	3.4	●	○	●	●	$3,795 ★
8.0	NCR NetWare/X	1.5	●	●	●	●	$10,000
7.3	Interactive Ported Netware	3.0	○	●	●	●	$4,995

Overview

Evaluation Criteria

NSTL examined three early-offering file servers running as UNIX applications. NCR NetWare/X, the market veteran, is already in its second major release. NCR supports NetWare on its own line of Motorola and Intel architecture machines. Interactive Systems recently released its Ported NetWare for 386/486 compatibles running Interactive UNIX System V.3. AT&T pushes its StarGroup LAN Manager on its own StarServer S and StarServer E systems, but the product supports some third-party systems as well (notably Compaq). AT&T has licensed its LAN Manager implementation for UNIX to several other system manufacturers including NCR.

NSTL decided to test ported NetWare and LAN Manager implementations running under UNIX on 486 systems. Although many companies have announced such products, most are not quite ready to ship. Prominent among these suppliers is the Santa Cruz Operation (SCO), the dominant player in Intel-architecture UNIX. SCO LAN Manager/X will be based on the Hewlett-Packard port of LAN Manager.

Why UNIX File Servers?

The main attraction of UNIX file servers is the capability to run applications on the UNIX system along with file service. SQL database servers, accounting packages, and a wide variety of vertical applications are readily available for UNIX. While client/server software is only now emerging for NetWare and OS/2 servers, a rich variety of multiuser packages is already available for UNIX. Dumb terminals are supported on the same system mixed with PCs emulating terminals.

Running applications on the server is increasingly attractive, since faster and faster processors are spending more and more time doing nothing at all. CPU utilization on file servers is typically very low, often lower than 20%. CPU utilization drops even further when using bus master network and drive adapters. Running applications on the server can utilize a lot of CPU processing power that would otherwise be wasted.

UNIX file servers offer vast potential for scalability. UNIX implementations are available today for multiprocessing. UNIX runs on very fast RISC systems that will not run native NetWare or OS/2. Although this extra processing power is unlikely to speed up file server response time, it is very worthwhile for client/server applications such as database servers.

Why Not UNIX File Servers?

The biggest strike against UNIX file servers is their currently poor performance. Ported NetWare in particular is far slower than the native implementation. LAN Manager does not seem to suffer as much in translation, probably because it simply trades a layer of OS/2 for a layer of UNIX. UNIX adds an extra layer encumbering NetWare.

Slower performance is not easily compensated by using faster processors or more processors because file servers typically have very low CPU utilization anyway. Rather, file servers are extremely sensitive to path lengths; that is, how efficiently a request can be processed and a response generated. Native NetWare has always excelled in this regard, but ported NetWare does not.

UNIX file servers are difficult to administer. The inherent complexities of networking are multiplied by the infamous complexity of UNIX and further compounded by the relative immaturity of the products. All the test products failed in some fairly serious fashion during the course of the testing. UNIX file servers are not for the faintheartedand require a fair amount of attention from a UNIX-experienced staff person.

Third-party support requires another trade-off. Each of the test products supports only a handful of network adapters in the file server. All the products tested are seriously limited in this respect.

Installation and Setup

None of the programs are particularly difficult to install and get running, even for a UNIX novice. If a business already has a server running native NetWare, most of the work is done for portable NetWare; the workstation shell remains unchanged. AT&T LAN Manager uses a different protocol stack than Microsoft LAN Manager, so the administrator has to install AT&T stacks even if LAN Manager is currently in use.

NetWare has always been easier to configure and manage than LAN Manager, and to an extent that carries over to the UNIX versions. Managing user groups, security, accounting, printers, and various routine administrative tasks is easier in NetWare xConsole programs than in their LAN Manager counterparts. The gap is narrowed, however; ported NetWare is far less palatable than native NetWare, particularly Interactive's implementation. AT&T LAN Manager, on the other hand, is in many respects easier than Microsoft's version.

Tuning Parameters

Portable NetWare provides an assortment of "magic" tuning parameters. Many of these tuning parameters are at once confusing and crucial. Spawn-ahead processes, clients per process, and shared memory configuration (to name a few) are new and subtle concepts to the experienced NetWare or UNIX administrator. Changing these parameters can affect performance dramatically (NSTL saw 200% differences), but the effect on network reliability is even more dramatic. Both the Interactive and NCR products crashed with their default settings for clients per process; NCR NetWare/X had to be reinstalled. Decreasing the number of clients per process made the benchmarks run, but adversely affected performance.

It is not always obvious where the magic numbers are hidden, particularly when several related numbers exist in different places. For example, Interactive Ported NetWare requires edits to a UNIX text file in order to use files larger than 2M bytes. Without the edit, the workstation returns no error, but the file is truncated. Cryptic messages like "bad NCB packet" appear in various places on the SCONSOLE screen, obliterating the display, but the messages offer little help in determining that ULIMIT is too low. In a similar instance, the Interactive installation instructions suggest changing several UNIX kernel parameters; this must be done manually and the kernel rebuilt. Attempting to shut down and restart the network software often produces unexplained error messages, requiring shutting down and rebooting the entire system (a time-consuming task in UNIX). Other unexplained error messages do not stop processing but often overwrite the menuing system, making it unreadable.

Portable NetWare can be configured to use more than one UNIX process, increasing the proportion of a process' resources available to each workstation. NCR NetWare/X defaults to four workstations per process on installation, and this configuration is adequate for most situations. Interactive defaults to one process shared by all workstations. As workstations are added, the system runs out of resources; the added workstations are unable to connect, and connected workstations receive erroneous "file not found" messages. Increasing the number of processes involves shutting down and restarting the server. NCR's default settings are less likely to cause resource problems, but when such problems do occur, the affected workstations are unable to use the server, even after rebooting, until the server is shut down and restarted.

AT&T wisely rid its system of the many indecipherable parameters found in Microsoft's LAN Manager. Most notably, server heuristics are no longer supported. The workstation tweaks are similar to Microsoft's; it can take weeks of trial-and-error tuning to discover that tuning changes actually decreased performance. AT&T has also done a somewhat better job than either NCR or Interactive at integrating the tasks of UNIX and network administration.

With AT&T, NSTL encountered other problems. During lengthy workstation processing operations, files and subdirectories in shared directories suddenly seem to disappear. The files and directories are still present on the server and visible to other workstations. The workaround is to drop and reuse the shared device, but even such a simple solution can be very inconvenient in the middle of lengthy operations.

Administrator Utilities

Both ported NetWare and LAN Manager have administration utilities that run only as UNIX applications. AT&T LAN Manager's UNIX application is considerably easier than NCR or Interactive's, and it can be run remotely using the supplied Kermit terminal emulator.

The UNIX administration program (SCONSOLE) can be run remotely on NCR and Interactive systems only if the user has a network-compatible terminal emulation program (e.g., Crosstalk Mark IV). Interactive's SCONSOLE is particularly poor. Error messages are cryptic and sometimes vanish in a flash. Several pieces of the administration software use old-style menus that scroll by, rather than the easier dialog style. Portions of the software that have been adapted to the dialog style are amazingly slow even on a 33MHz 486 system. NCR's SCONSOLE is not state-of-the-art user interface material either.

Security/Auditing

NetWare offers a number of features to make the endless chore of maintaining security a bit easier, and consequently, more likely to be maintained. NetWare accounts can be set up to expire after a given period—a perfect solution for temporary employees. NetWare can also force users to change their passwords periodically to decrease the likelihood of lost or stolen passwords and minimize the potential damage.

LAN Manager has a slight advantage in auditing capability. It records information that may be useful in tracking the activities of intruders, such as unsuccessful login attempts and file opens.

Accounting

Depending on the corporate attitude toward profit centers, accounting features may be either vital or useless. NetWare's accounting feature lets businesses bill network use, in a very flexible and detailed fashion, to departments and individuals. LAN Manager has no comparable feature, but most companies view the network as basic infrastructure overhead and do not bill for it.

Performance Monitoring

Much of the performance monitoring in the test systems is done through a UNIX utility. Overall, very little separates the three systems in terms of the statistics they gather, but it can be more than a little difficult to figure out what to do based on the information collected, particularly in Interactive Ported NetWare. UNIX tuning has always been a bit of an art, and tuning UNIX file servers even more so.

Connectivity

Part of the appeal of UNIX file servers is that one system connects all. Although in many ways these UNIX versions offer connectivity options unavailable in their predecessors, some gaping holes will still hamper companies wanting to standardize on them.

The most attractive connectivity feature of these products is the way they meld DOS and UNIX networks. With all the products, a DOS client can access a published RFS volume on the network, not just volumes on the UNIX server. DOS clients can also act as terminals, potentially on any UNIX server in the network. Add, say, an X terminal emulator, and the connectivity possibilities are endless.

Of course, connectivity is not that easy. The biggest obstacle is the small number of network interface cards supported in the server. NCR currently supports a single interface adapter model in its 486 server, and the others support only a handful of adapters. Interactive NetWare supports the largest variety of adapters, but unlike native NetWare, it allows only one adapter in the server. The

only workaround is an external bridge PC. AT&T LAN Manager also allows only a single adapter in the server, and it provides no bridge software.

Only AT&T LAN Manager supports Macintosh clients without a separate bridge. NCR and Interactive support Macintosh workstations through the standard Novell VAP running in a bridge PC. LAN Manager is also the only one of the products to ship with terminal emulation software that enables DOS clients to act as terminals on the UNIX host. The NetWare programs support this type of connection using a third-party terminal emulator. AT&T's supplied emulator is rather basic, so users may do well to get a third-party package or AT&T's more extensive terminal emulator option.

Printing

NetWare is somewhat more capable than LAN Manager in the area of shared printer management, although LAN Manager has some unique and useful features. Among the NetWare implementations, NCR has a big advantage in printing because Interactive does not support print servers. Print servers allow DOS clients to share printers with the network and provide convenient features such as print notification. LAN Manager can share printers attached to DOS clients, but it lacks some of NetWare's forms management features, which are particularly useful with laser printers.

NCR NetWare/X versus Interactive Ported NetWare

In comparing the NetWare products, the primary consideration is price versus polish. NCR NetWare/X is more reliable and somewhat faster and provides a richer subset of NetWare 3.11 functionality. NCR has clearly done more to enhance the basic Novell package, whereas Interactive seems to have done a more straightforward port. A glaring weakness in NCR's offering is its support for a single server adapter: a rather plain-performing Western Digital Ethernet card. Using an external bridge adds costs and taxes performance.

Interactive NetWare supports adapters from a handful of companies. It does not yet support the IBM Token-Ring Network products or any 32-bit EISA adapters in the server. Interactive Systems is clearly the most aggressive of the three in supporting third-party hardware, and it plans to increase its support soon. NCR announced support for the Proteon token-ring adapter in Version 1.6 of NetWare/X.

Both NetWare products share the same fundamental strength: easy and seamless integration into Novell NetWare networks. NCR NetWare/X is the better implementation, and Interactive the budget choice.

Ported NetWare versus AT&T LAN Manager

Comparing ported NetWare to AT&T LAN Manager boils down to a choice between a super idea poorly implemented and a dull idea well implemented. The idea behind ported NetWare is to provide NetWare 3.11 (with customary NetWare performance, usability, and reliability) with access to standard UNIX client/server applications rather than proprietary NLMs, all with seamless integration into existing NetWare networks. As the saying goes, something has been lost in the translation. Performance is disappointing, the server is easily crashed, and the server is far more difficult to administer and maintain.

LAN Manager for UNIX evokes little interest initially (the OS/2 version has hardly been a stunning success), but AT&T LAN Manager is good enough to cause some second thoughts. Macintosh support on the server, support for token-ring and Ethernet (but not at the same time) adapters, symmetric multiprocessing, a generally sound implementation, and aggressive pricing add up to a winner.

Still, AT&T is fighting an uphill battle. As good as AT&T's LAN Manager is, it cannot compete with the speed and usability of native NetWare 3.11. Where there is room for portable and native NetWare to complement each other, AT&T has a tough marketing job pitching LAN Manager over NetWare. AT&T has chosen even to bypass Microsoft's diminutive coattails by implementing its own network stack.

Summary

None of the UNIX file server programs are likely to dominate the market in their current form. Each represents a promising step in the right direction—universal connectivity of different platforms.

AT&T LAN Manager is the classiest program of the bunch. It is the fastest and easiest to keep up and running. Its aggressive pricing makes it an attractive alternative to Microsoft LAN Manager in client/server-oriented applications. Its flaws are as numerous as its strengths, however, as it shares the traditional weaknesses of its LAN Manager predecessors. Its client software requires twice the memory required by NetWare. Its general administration is clumsy. No internal bridging is allowed, and no external bridge software is provided. Performance using non-client/server network databases such as Foxbase is poor.

NCR is clearly committed to enhancing NetWare, not just porting it. The current release of NCR NetWare/X is a solid implementation. It is easy to use, and its performance is decent. Ported NetWare cannot yet compete head-to-head with native NetWare; it must be relegated to a complementary role, which it fills well, integrating easily and seamlessly into an overall NetWare environment. NCR NetWare/X needs broader hardware support and another performance boost. The price is hard to swallow at $10,000.

Interactive has not enhanced the basic functionality of NetWare at all; instead it concentrates on supporting a wide variety of third-party hardware. Among the three test programs, Interactive supports the widest range of server interface cards. Combined with NetWare external bridging, Interactive Ported NetWare can adapt to almost any environment with ease. Interactive now needs to concentrate hard on the fundamentals of better reliability, availability, and performance. Although more expensive than AT&T LAN Manager, Interactive's price point of $5,000 is half the price of NCR NetWare/X and less than native Novell NetWare 3.11.

Program Evaluations

AT&T StarGroup LAN Manager

Strengths

- Best performance overall
- Best interface on UNIX software
- Macintosh support on the server (no bridge needed)
- Shares workstation printers
- Includes Kermit terminal emulation for executing UNIX sessions from DOS clients
- Best client/UNIX interface utilities
- Strong auditing capabilities

Limitations

- Server does not support multiple adapters
- Limited server interface adapter support
- No bridge software provided
- Workstation software requires more memory than NetWare

Interactive Ported NetWare

Strengths

- Low price
- Broadest support for server network adapters
- Easy to administer users/groups
- Seamless integration into NetWare networks
- Supports user sessions on UNIX host using third-party terminal emulation products
- Strong accounting features

Limitations

- Server does not support multiple adapters
- Lackluster performance overall
- Cannot execute commands or time-share on UNIX host from workstations
- Poor user interface on UNIX software
- Many important parameters require editing kernel definition and regenerating kernel

NCR NetWare/X

Strengths

- Easy to administer users/groups
- Shares workstation printers
- Excellent performance with client-based database applications
- Easier to configure and manage than Interactive Ported NetWare
- Easier troubleshooting than in Interactive Ported NetWare
- Seamless integration into NetWare networks
- Supports user sessions on UNIX host using third-party terminal emulation products
- Up to four network adapters in server
- Recovers deleted files
- Strong accounting features
- Shares workstation printers

Limitations

- Supports single network adapter
- Twice the cost of competing products
- Lackluster performance overall
- Cannot execute commands or time-share on UNIX host from workstations

Program Recommendation

AT&T StarGroup LAN Manager

AT&T LAN Manager proves to be faster and more stable than its NetWare competitors and provides a more complete, polished package at a lower cost (far less than Microsoft LAN Manager). With just a slight performance upgrade and a bit more polish, AT&T LAN Manager could go beyond its UNIX connectivity niche and become a serious competitor in the broader DOS server market.

Rating Summaries

Figure 1.
AT&T StarGroup LAN Manager Ratings

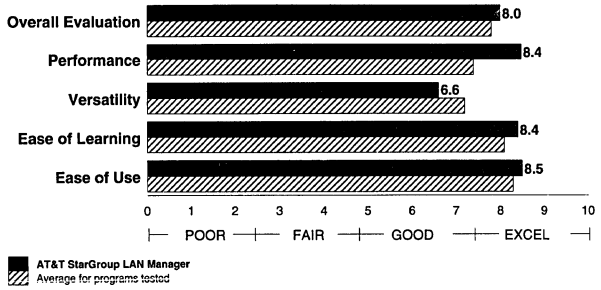


Figure 2.
Interactive Ported NetWare Ratings

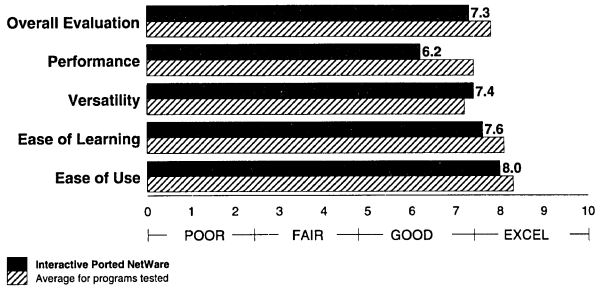


Figure 3.
NCR NetWare/X Ratings

Overall Evaluation

The two top programs have very different characters. NCR NetWare/X is a good choice for predominantly DOS LANs with a moderate need for UNIX connectivity. Its seamless integration is a big plus in companies with large NetWare installations. AT&T LAN Manager is probably the better choice for a predominantly UNIX environment. It performs better, has better UNIX integration, and costs less than half the price of NCR NetWare/X.

Interactive Ported NetWare is another good choice for predominantly DOS LANs with moderate UNIX connectivity needs. It costs half the price of NCR NetWare/X and works on a fairly broad base of hardware. Ported NetWare is not for the UNIX novice and needs some development before it is ready for mission-critical applications.

Methodology

The Overall Evaluation is a weighted average of scores for the individual criteria.

Overall Evaluation Score = (5 x Performance Score) + (5 x Versatility Score) + (3 x Ease of Learning Score) + (6 x Ease of Use Score) ÷ 19.

Performance

AT&T LAN Manager consistently produces the best performance, and Interactive Ported NetWare just as consistently produces the worst. Wide swings in performance caused by seemingly minor tuning adjustments make definitive performance statements difficult, however. AT&T LAN Manager undoubtedly benefits considerably from its support for a fast network adapter. NSTL has consistently found the server adapter to be a key factor in network performance. Some of LAN Manager's lead will surely evaporate when the competitors write drivers for 32-bit adapters. For now, AT&T's adapter gives it a considerable edge.

Strengths and weaknesses of both products parallel those in native NetWare and OS/2 LAN Manager. LAN Manager excels in large block transfer activities, such as Xcopy, and NetWare performs small packet database activity better. As with its predecessors, LAN Manager's client software is embarrassingly large. NCR and AT&T supply memory extender software for network drivers.

LAN Manager users will have to use extended memory for the driver, as many popular applications will not run otherwise.

Both AT&T LAN Manager and Interactive Ported NetWare are slower than their respective OS/2 and native versions, Ported NetWare more so because NetWare has always derived its excellent performance from running without the interference of an operating system. Microsoft has moved LAN Manager in the same direction: using monolithic rather than layered drivers, and adding more kernel/device driver code rather than pay the cost of running as an application. It seems AT&T LAN Manager and the NetWare products will have to move in this direction to attain competitive performance.

Methodology

The Performance rating is a weighted average of scores recorded for the individual tests. The weights listed here apply to each individual test within a series; for example, Microsoft C with no traffic and with each type of traffic (four separate tests) each received a weight of 4.

Performance Score = (4 x Lotus 1-2-3 Series) + (4 x Microsoft C Series) + (4 x Xcopy to Server Series) + (4 x Xcopy from Server Series) + (1 x Foxbase Series) + (4 x Transaction Processing Series, 4 Stations) + (4 x Transaction Processing Series, 8 Stations) + (4 x Transaction Processing Series, 16 Stations) ÷ 29.

Versatility

LAN Manager and NetWare each have unique features in addition to a substantial body of common features. NetWare offers more features in several areas, including security administration, accounting, and printing.

NCR NetWare/X is largely a superset of Interactive Ported NetWare's features. NetWare/X has several useful and important capabilities that Ported NetWare currently lacks, including internal bridging and DOS client printer sharing. Interactive Ported NetWare enjoys a substantial advantage over NCR NetWare/X in support for server interface cards. NCR currently supports only one network adapter.

Although AT&T LAN Manager finishes third overall, it provides many important features left out of the two NetWares: notably, terminal emulation, UNIX/DOS file transfer and translation, and DOS batch-level control of UNIX processes at the server. LAN Manager supports Macintosh clients without an external bridge.

Methodology

The Methodology rating is a weighted average of scores for the individual features. Features and their methodology weights appear in Table 3.

Ease of Learning

The Interactive and NCR manuals look different on the outside, but in organization and content they are virtually identical. Both are poorly indexed and make it difficult to find information unless the user knows what command is needed. In contrast, the AT&T manuals present clear, step-by-step instructions for administrative and user tasks.

All three products provide menu interfaces for setting up and tuning the server. Interactive provides the best on-line Help, but Ported NetWare requires the most fine-tuning for server efficiency. Only Ported NetWare requires tuning beyond the scope of the menu system, and these facets are poorly documented. The manuals describe installation procedures in which the user is prompted for UNIX kernel parameter values, but the prompted procedures are never actually executed; the user must tune the UNIX kernel manually. Simply accepting default values during the NCR and AT&T installations will be adequate for most situations.

For setting up and using workstations, AT&T LAN Manager requires more learning time than the other products. The NetWare products require generation of a few start-up files for the particular network board being used. AT&T does provide a menu-driven workstation setup program, and the documentation is thorough and well organized.

Methodology

The Ease of Learning rating is a weighted average of the scores for the individual criteria.

Ease of Learning Score = (Network Setup Score) + (User Account Administration Score) + (System Tuning Score) + (Printer Management Score) + (Workstation Use Score) ÷ 5.

Ease of Use

Once installed, server start-up and workstation attachment are easy in all the products. The AT&T installation produces a workstation start-up script that executes all necessary procedures automatically. Interactive Ported NetWare and NCR NetWare/X require only three commands. Mapping to shared directories involves a simple command in all the products. AT&T's workstation program requires considerably more memory than the other products' and may need some fine-tuning of resources to run large programs.

All the products offer menu-based interfaces for administration from the server and workstations. Interactive's server interface is the most visually appealing and easiest to navigate. At a workstation, AT&T provides a single administration facility with menu options for all administrative tasks; Interactive and NCR users must move between a number of menu programs and utilities.

Server tuning is generally done during installation of the network software or within the administration menu system. Interactive Ported NetWare deviates from this practice in some instances. The administrator must edit a text file in UNIX to enable the use of files larger than 2M bytes. Furthermore, the installation instructions suggest changing several UNIX kernel parameters, which must be done manually and the kernel rebuilt. Attempting to shut down and restart the network software often produces unexplained error messages, requiring shutting down and rebooting the entire system (a time-consuming task in UNIX). Other unexplained error messages do not stop processing but often overwrite the menuing system and make it unreadable.

Ported NetWare can be configured to use more than one UNIX process, increasing the proportion of a process' resources available to each workstation. Ported NetWare defaults to one process shared by all workstations. As workstations are added, the system runs out of resources, resulting in the added workstations not being able to connect and erroneous "file not found" messages on connected workstations. Increasing the number of processes involves shutting down and restarting the server.

NCR NetWare/X defaults to four workstations per process at installation, and this configuration is adequate for most environments. The system is less likely to run out of resources with NCR's default settings, but when it does, the affected workstations are unable to use the server (even after rebooting) until the server is shut down and restarted.

During testing, AT&T workstations processing lengthy operations often encountered problems in which files and subdirectories in shared directories suddenly seemed to disappear. The files and directories are still present on the server and visible to other workstations. Users can easily overcome the problem by dropping and reusing the shared device, but the workaround can be very inconvenient during lengthy operations.

Methodology

The Ease of Use rating is a weighted average of scores for the individual criteria.

Ease of Use Score = (User Account Administration Score) + (System Tuning Score) + (Printer Management Score) + (Workstation Use Score) ÷ 4.

Performance Results

Network Configuration

NSTL tested the UNIX operating systems on a network consisting of Everex 16MHz 80386SX and PC Kraft 33MHz 80386DX workstations and a 33MHz 80486 server with a level 2 cache. Server configurations vary because the products do not support a common platform. NCR NetWare/X was tested on an NCR MC/33 (Micro Channel bus), Interactive on a Dell (EISA bus), and AT&T on an AT&T StarServer S (EISA bus). The servers were equipped with 8M bytes of memory and a single 320M-byte hard disk drive.

The server systems themselves provide very comparable performance, but differences in the programs' supported interface adapters upset the balance. NCR and Interactive were tested with 16-bit adapters because neither currently supports 32-bit Ethernet adapters. NCR uses a Western Digital 8003/MC adapter and Interactive a Novell NE2000. AT&T LAN Manager receives a considerable performance advantage using AT&T's 32-bit EISA adapter. The difference in interface card support raises a very real consideration, in that most installations would configure the server with a 32-bit network adapter given the option.

Background Traffic

Most of the benchmarks were run without network traffic and with background traffic on five secondary workstations generated by Lotus 1-2-3, LAN, and Xcopy. Foxbase background traffic consisted of each workstation performing a transaction up to 30 times a minute. The transaction looks up indexed records in three files and locks, updates, and unlocks one record in each file. Lotus traffic consisted of five secondary workstations executing a macro that combines and saves files metered to be active no more than once every 20 seconds on each station. Xcopy traffic copied a 128K-byte directory tree from the server to five workstations no more often than once every 19 seconds. Server traffic used the nondedicated server feature to Xcopy the 128K-byte tree at the server.

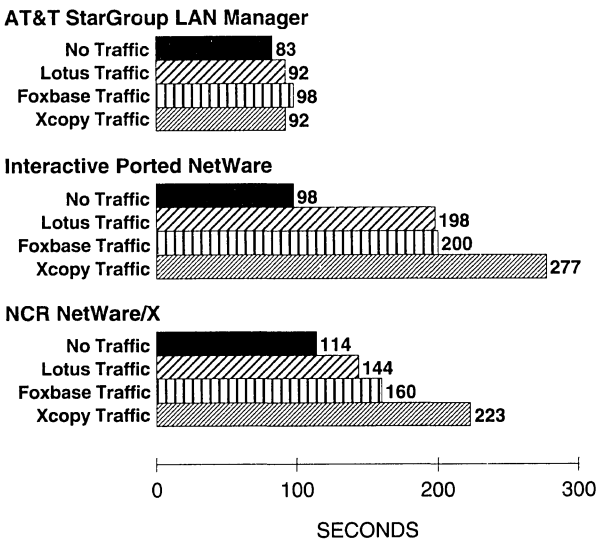
Lotus 1-2-3

A Lotus macro loaded and saved a 3M-byte spreadsheet, using the network to move substantial amounts of data. The test was repeated with concurrent traffic on five secondary workstations.

Analysis

This test emphasizes the network-dependent portions of Lotus performance (loading and saving a file) to diminish the contribution of workstation performance to the results. With no traffic, the results mirror the relative performance of Microsoft LAN Manager and Novell NetWare. AT&T LAN Manager, like the Microsoft product on which it is based, benefits from its fast transmission of large packets, but unlike the Microsoft version, which falls behind NetWare when traffic is added, the AT&T implementation pulls ahead, mostly because of the 32-bit network adapter. Foxbase traffic has the greatest impact on AT&T LAN Manager's performance. Foxbase traffic transmits small packets, adding system overhead that reduces the significance of the faster network interface card. Even so, LAN Manager is still considerably faster than its competitors.

Figure 4.
Lotus 1-2-3



Interactive Ported NetWare is faster than NCR NetWare/X without traffic, but it falls behind when traffic is added, possibly because NCR distributes the traffic over several processes.

Microsoft C 5.0

A large ensemble of XLISP 2.0 C source code (10,928 lines totaling 245,222 bytes) was compiled and linked, forming an executable file of 147,228 bytes. The test was repeated with concurrent traffic on five secondary workstations.

The test primarily pumps data from the server to the workstation (i.e., the source code, and loading the compiler) and moves the smaller object modules back, producing mixed uploading and downloading of data. Traffic increases data movement and creates a steadier demand on the server.

Analysis

As with the Lotus test, AT&T LAN Manager is the fastest product with no traffic and widens its lead when traffic is added. The gap between NCR NetWare/X and Interactive Ported NetWare also widens as traffic is added.

Figure 5.
Microsoft C 5.0

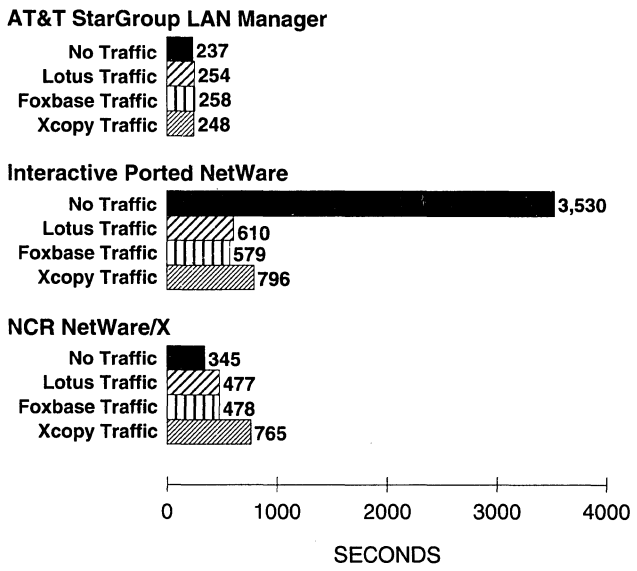
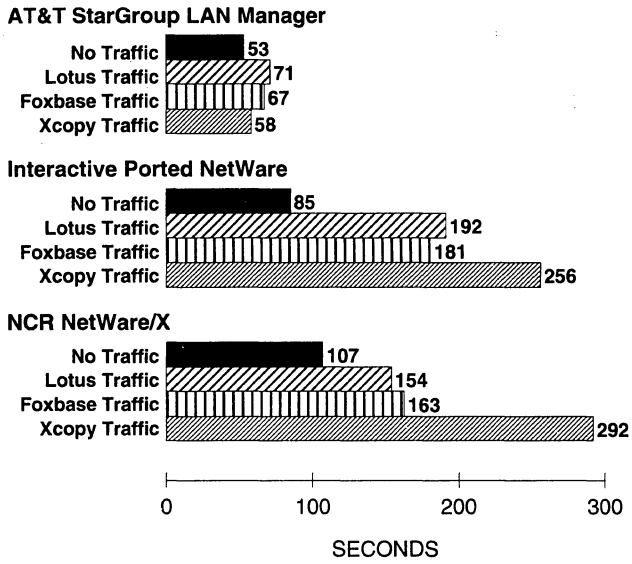


Figure 6.
Xcopy to Server



Xcopy to Server

A 5M-byte directory tree (130 files in 13 directories) was copied to the server (command issued with the /s parameter); the source tree was located on the primary workstation's local hard disk (Type 38). The test was repeated with concurrent traffic on five secondary workstations.

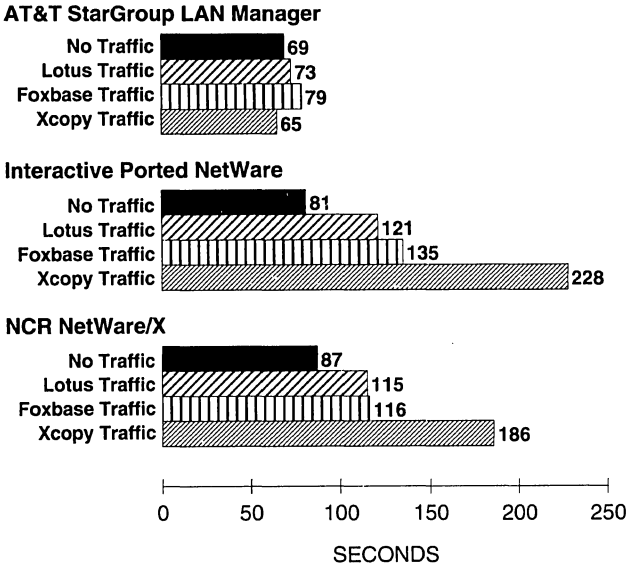
Analysis

The Xcopy benchmark consists almost exclusively of disk I/O operations. AT&T LAN Manager's performance with Xcopy traffic is only slightly slower than with no traffic, indicating very efficient handling of large volumes of disk I/O. By contrast, both the Interactive and NCR NetWare ports are slowed more by Xcopy traffic than by other types of traffic, indicating a difficulty handling large-volume disk I/O operations.

Xcopy from Server

A 5M-byte directory tree (130 files in 13 directories) was copied from the server to the primary workstation (command issued with the /s parameter). The test was repeated with concurrent traffic on five secondary workstations.

Figure 7.
Xcopy from Server



Analysis

Results are comparable to those recorded in the Xcopy to Server benchmark, except for AT&T LAN Manager, which becomes slightly slower while the others are slightly faster.

Foxbase+/LAN

A suite of 16 tests ran at the primary 386/25 workstation in exclusive mode so that file lock requests did not slow the server.

1. 51,100 records were written to three different files, testing the speed of writing records.
2. The Account (50,000 records), Teller (1,000 records), Transact (1,000 records), and Branch (100 records) files were indexed.
3. The first 3 of every 10 Account records were copied to three temporary files.
4. The records copied in Test 3 were deleted.
5. The temporary files created in Test 3 were appended to the Account file.
6. The Account file was packed and reindexed. The resulting Account file contained the same records as initially, but in a different order.
7. 1,000 transactions were processed, each updating a record in the Account, Teller, and Branch tables. A History record was written for each transaction.
8. Four indexes were created on the 1,000-record History file.
9. Test 7 was repeated; the four History file indexes were updated each time a History record was written.
10. Blocks of 1,000 records were appended to the History file, increasing its size to 10,000 records.
11. Test 9 was repeated; the indexed History file was increased to 10,000 records.
12. 1,000 Account records were selected in indexed order and printed to disk.

Table 1. Foxbase+/LAN Tests (times in seconds)

	StarGroup LAN Manager	Ported NetWare	NetWare/X
1	48	50	48
2	17	21	19
3	26	36	27
4	34	51	40
5	14	22	13
6	30	40	35
7	25	26	20
8	7	10	8
9	60	48	36
10	66	83	75
11	88	102	62
12	6	8	6
13	16	20	19
14	23	27	24

13. A report was created from 1,000 Account records selected on an unindexed field and printed to disk.
14. The History, Branch, Teller, and Account files (1,000, 100, 1,000, and 50,000 records) were joined, and the report sent to disk. The History file was sorted by account ID, date, and time.

Analysis

Transaction processing Tests 7, 9, and 11 are the most complex in the series. All involve finding and updating records based on indexes. Test 9 also updates small indexes when a record is added, and Test 11 updates large indexes. On all three tests, NCR NetWare/X outperforms AT&T LAN Manager. Interactive Ported NetWare also outperforms AT&T LAN Manager on Test 9. LAN Manager is fastest on the simpler tests of writing to disk and creating new indexes. The results are consistent with the performance of Microsoft LAN Manager and Novell NetWare: Microsoft LAN Manager is generally slower than Novell NetWare in complex transaction processing.

Transaction Processing

NSTL simulates a multiuser, database transaction processing environment using five database files in Foxbase+/LAN 2.1 (Account, Teller, Branch, Transaction, and History files). Each transaction reads from the Transaction file; locates and locks a record in each of the Account, Teller, and Branch files; adds a record to the History file with a lock; updates all locked records; and unlocks all records.

The Transaction Processing suite consists of a total of 960 transactions divided equally among the workstations. The test is run with 4, 8, and 16 workstations without indexes and with 4 indexes on the History file. Instead of speeding record lookup, the indexes in this scenario slow processing as they increase disk activity and file contention at the server.

The transaction processing benchmark produces the heaviest server load. The volume of traffic and file contention produced in this test simulates the loading volume created by many more workstations under typical multiuser database use.

Figure 8a.
Transaction Processing, 4 Workstation

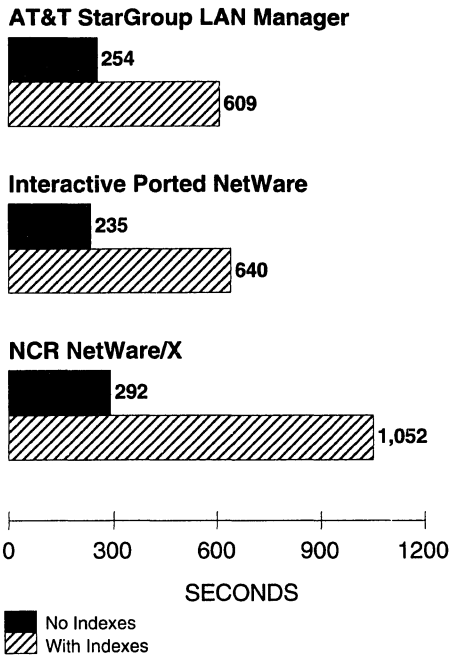
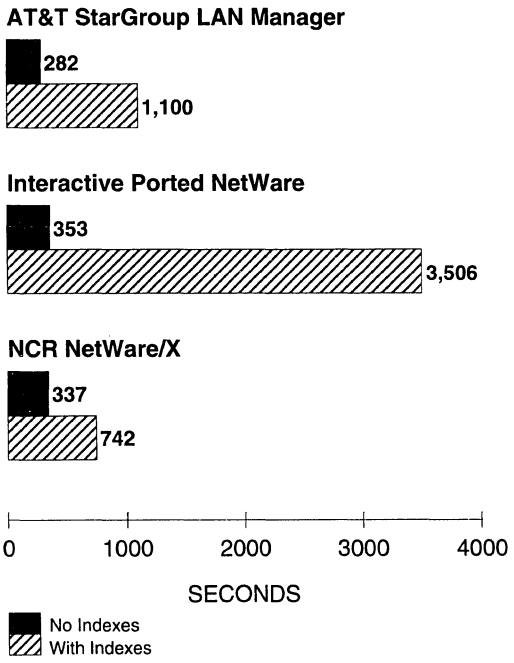


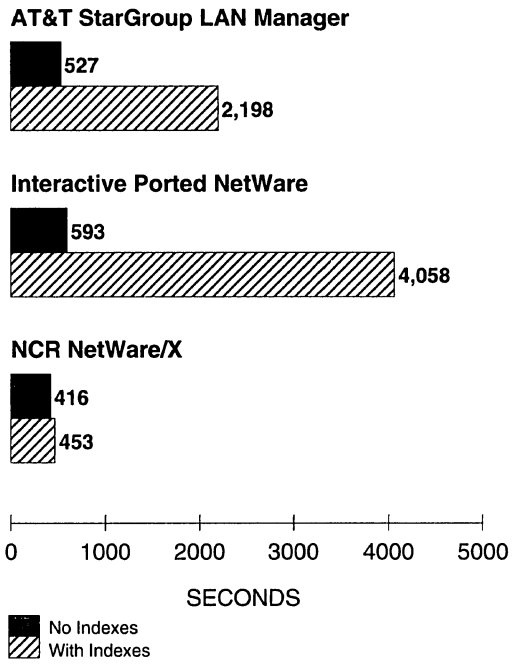
Figure 8b.
Transaction Processing, 8 Workstations



Analysis

AT&T LAN Manager shows little performance degradation as load increases moderately, while its competitors degrade considerably with moderate loads. At the heaviest loads (i.e., indexed transac-

Figure 8c.
Transaction Processing, 16 Workstations



tions with 8 and 16 users), LAN Manager's performance drops off dramatically.

NCR NetWare/X and Interactive Ported NetWare were tested using their default installation configurations. For Interactive NetWare, this includes a single UNIX process allocated to NetWare; NCR distributes the load across five processes. NCR NetWare/X performs the slowest with four users, where several processes compete for resources, while Interactive NetWare does very well with a single process handling this relatively moderate load. With eight users, Interactive NetWare's single process runs out of resources and is unable to complete the test. With additional processes, Interactive NetWare completes the tests, but contention between processes for resources degrades its performance to unacceptable levels on the indexed tests. NCR NetWare/X maintains consistent performance as the load per process increases.

Vendors

AT&T
1 Speedwell Avenue
Morristown, NJ 07960 (800) 247-1212

Interactive Systems Corp.
2401 Colorado Avenue
Santa Monica, CA 90404 (213) 453-8649

NCR Corp.
1700 S. Patterson Boulevard
Dayton, OH 45479 (513) 445-5000

Characteristics

Table 2. UNIX File Server Program Characteristics

	Requirements	Network Adapter Support	Supplier Support
AT&T StarGroup LAN Manager (Server Version 3.4; released January 1991)	• Drives: 60MB hard disk • Server Memory: 8MB • Workstation Memory: software uses 45-170KB • Operating System: UNIX, DOS, OS/2, Macintosh • Processor: 80386	• Server: AT&T Starlan 10 PC NAU, Fiber NAU, EISA NAU; Starlan PC NAU; IBM Token-Ring 16/4 • Workstation: AT&T Starlan 10 PC NAU, Fiber NAU, EISA NAU; Starlan PC NAU; IBM Token-Ring 16/4, Token-Ring I, II, III; Proteon p1347, p1390; 3Com EtherLink I, II; Racal Interlan NS210; others with NDIS drivers	Telephone support (90 days); magazine; 1-year upgrade/update plan; installation and maintenance programs; training programs
Interactive Ported NetWare (Version 3.0; released December 1990)	• Drives: not specified • Server Memory: 4MB; 6MB • Workstation Memory: software uses 55-70KB • Operating System: UNIX • Processor: 80386	• Server: Western Digital, Racal Interlan, 3Com lines; Novell NE2000, PC-NIC • Workstation: all NetWare-supported adapters	Telephone support, bulletin board
NCR NetWare/X (Version 1.5; released April 1991)	• Drives: 100MB hard disk • Server Memory: 9MB; 16MB recommended • Workstation Memory: software uses 70KB • Operating System: UNIX, DOS, OS/2, Macintosh • Processor: 80486 Micro Channel	• Server: Western Digital Ethernet/MC • Workstation: Western Digital Ethernet/MC and Novell compatibles	Software Service ($150 per month) includes telephone support, software updates and releases, bulletin board service; training programs available

Table 3. UNIX File Server Program Features

	Weights	AT&T StarGroup LAN Manager	Interactive Ported NetWare	NCR NetWare/X
Server parameters	0			
Maximum Simultaneous Users	1	254	250	255
Maximum Server Volume Size (GB)	1	1.2	3.0	3.0
Maximum Volumes	1	24	50	50
Maximum Shared Printers	1	U	16	16
Maximum Open Files	1	U	100K	100K
Multiple Servers	1			
Global Naming of Users and Groups	1	—	—	—
Global Naming of All Objects	1	—	—	—
Link Security	1	—	—	—
Remote Server Administration	1	▲	▲	▲
Remote Administration of Multiple Servers	1	▲	▲	▲

See footnotes on Page 422.

Table 3. UNIX File Server Program Features (Continued)

	Weights	AT&T StarGroup LAN Manager	Interactive Ported NetWare	NCR NetWare/X
Security	4			
User-Password Security	4	▲	▲	▲
Shared-Password Security	0	▲	—	—
Security Groups	2	▲	▲	▲
Security Equivalences	1	—	▲	▲
Account Expiration Date	1	—	▲	▲
Time Restrictions	1	—	▲	▲
Lock Account after Failed Passwords	1	—	▲	▲
Set Intruder-Detect Threshold	1	▲	▲	▲
Set Login Count Retention	1	—	▲	▲
Mandatory Password Change	1	—	▲	▲
Limit Concurrent Connections	1	—	▲	▲
User-Set Password Option	1	B	▲	▲
Set Minimum Password Length	1	▲	▲	▲
Disable/Lock Accounts	1	—	▲	▲
Require Unique Passwords	1	—	▲	▲
Restrict User to Workstation(s)	1	—	▲	▲
Disconnect after Inactive Period	1	—	—	—
User Account Permissions	4			
Read Files	1	▲	▲	▲
Write to Files	1	▲	▲	▲
Create Files	1	▲	▲	▲
Delete Files	1	▲	▲	▲
Grant Permissions	1	▲	▲	▲
Execute Only	1	▲	F	F
Modify File Attributes	1	▲	▲	▲
Limit Simultaneous Users	1	▲	—	—
Assign Permissions to Directories	1	▲	▲	▲
Assign Permissions to Files	2	▲	▲	▲
Assign Permissions to Queues	1	▲	▲	▲
Administrator Rights on Specific Directories	1	—	▲	▲
Inherited Permissions	1	▲	▲	▲
Mask Inherited Rights	1	—	▲	▲

See footnotes on Page 422.

Table 3. UNIX File Server Program Features (Continued)

	Weights	AT&T StarGroup LAN Manager	Interactive Ported NetWare	NCR NetWare/X
Accounting	2			
Restrict User Account Space	1	—	—	—
Track User Access Time	1	▲	▲	▲
Track User Data Reads	1	—	▲	▲
Track User Data Writes	1	—	▲	▲
Track User Server Requests	1	—	▲	▲
Track User Space Usage	1	—	▲	▲
Charge Users for Services	1	—	▲	▲
Variable Service Rates	1	—	▲	▲
Set User Account Balances	1	—	▲	▲
Set User Credit Lines	1	—	▲	▲
Logout at Credit Limit	1	—	▲	▲
Auditing	2			
Logins	1	▲	▲	▲
Unsuccessful Login Attempts	1	▲	—	—
Last Successful Login Attempt	1	▲	▲	▲
Attempted Security Violations	1	▲	▲	▲
Logouts	1	▲	▲	▲
File Open	1	▲	—	—
Selective Audit	1	—	—	—
Audit Specific Resources	1	▲	—	—
Alert Service	1			
Drive Full	1	▲	▲	▲
Excessive Errors	1	▲	—	—
Intruder Alert	1	▲	▲	▲
Printer Problem	1	▲	▲	▲
Print Request Complete	1	▲	—	▲
User Utilities	1			
System Login Script	1	—	▲	▲
User Login Scripts	1	▲	▲	▲
Explicit File Locking	1	—	▲	▲
Display Logged-In Users	1	A	▲	▲
Display Network Resources	1	▲	—	—
Display Rights	1	A	▲	▲
Execute Server Program from Workstation	3	▲	—	—
Unload Shell/Stack	1	—	—	▲
Recover Deleted Files	1	—	—	▲

See footnotes on Page 422.

Table 3. UNIX File Server Program Features (Continued)

	Weights	AT&T StarGroup LAN Manager	Interactive Ported NetWare	NCR NetWare/X
Supervisor Utilities	2			
Forced Disconnect	1	▲	▲	▲
Security Check Utility	1	—	▲	▲
List Security Group Access Limits	1	▲	▲	▲
List User Access Limits	1	—	▲	▲
List User Access Rights by Resource	1	▲	▲	▲
Realtime Status: Files/ Volumes	1	▲	—	—
Automatic Update of Workstation Shell	1	—	—	—
Performance Monitoring	3			
Average Response Time	1	▲	—	—
Cache Statistics	1	▲	▲	▲
Server CPU Utilization	1	▲	▲	▲
Packets/Bytes Sent and Received	1	▲	▲	▲
Packets/Bytes per Second	1	—	—	—
Bad Packets	1	▲	▲	▲
Open Files	1	▲	▲	▲
Peak Files Open	1	—	▲	▲
Record Locks	1	▲	▲	▲
Peak Record Locks	1	—	▲	▲
Connections	1	▲	▲	▲
Peak Connections	1	—	▲	▲
Disk Blocks Read and Written	1	▲	▲	▲
Disk Blocks per Second	1	▲	▲	▲
Disk Utilization	1	▲	▲	▲
Disk Demand vs. Service	1	▲	▲	▲
Drive I/O Errors	1	▲	—	—
Packets Routed	1	—	—	—
Packets Routed per Second	1	—	—	—
Clear Statistics	1	—	—	—
Identify Token-Ring Beacon Sender	1	—	—	—
Messages/Chatting	1			
Send Messages	2	▲	▲	▲
Group Messages	2	▲	▲	▲
Broadcast Message	2	▲	▲	▲
Block Messages	2	▲	▲	▲
Log Messages	1	▲	—	—
Hot Key to Messaging	1	C	—	—
Chatting	0	—	—	—
Maximum Chatters	0	—	—	—

See footnotes on Page 422.

Table 3. UNIX File Server Program Features (Continued)

	Weights	AT&T StarGroup LAN Manager	Interactive Ported NetWare	NCR NetWare/X
Archival Services	1			
Back Up/Restore Server Disk	1	UNIX	UNIX	▲
Back Up/Restore Selected Directories	1	UNIX	UNIX	▲
Back Up Modified Only	1	UNIX	UNIX	UNIX
Back Up System Files	1	UNIX	UNIX	UNIX
On-line Back Up of Account Files	1	UNIX	UNIX	UNIX
Back Up Skips Open Files	1	—	—	▲
Scheduled Back Ups	1	UNIX	UNIX	UNIX
Back Up to Tape	1	UNIX	UNIX	▲
Multiple Tape Drives	1	—	—	—
Back Up to Diskette	1	▲	UNIX	UNIX
Back Up Macintosh Files on Server	1	UNIX	—	▲
Network Printing	3			
Automatic Clear	1	▲	▲	▲
Print Banner	1	▲	▲	▲
List Available Printers/Queues	1	▲	▲	▲
List Current Redirections	1	▲	▲	▲
Printer Status	1	▲	▲	▲
End Spool from Application	1	C	—	—
Time-Out for End Spool	1	—	▲	▲
Print to Network File	1	—	▲	▲
Select Print Mode	1	—	▲	▲
Select Form Type	1	—	▲	▲
PostScript Font Download	0	—	—	—
LaserJet Font Download	0	—	—	—
Print Screen	1	▲	▲	▲
Print Notification	1	▲	—	▲
Multiple Printer Configurations	1	▲	▲	▲
Printing Queues	1			
Multiple Queues on One Printer	2	▲	▲	▲
Multiple Printers on One Queue	2	▲	▲	▲
Multiple Queues on Multiple Printers	1	▲	▲	▲
Restrict Queue Hours	1	▲	—	—
Queue Priority Levels	1	▲	▲	▲
Print Preprocessor	1	▲	—	—
Queue Status	1	▲	▲	▲

See footnotes on Page 422.

Table 3. UNIX File Server Program Features (Continued)

	Weights	AT&T StarGroup LAN Manager	Interactive Ported NetWare	NCR NetWare/X
Change Queue Order	1	▲	▲	▲
Switch Queues	1	A	—	—
Insert File into Queue	1	A	▲	▲
Delete Active Print Job	1	A	▲	▲
Delete Job from Queue	1	▲	▲	▲
Hold/Release Print Job	1	—	▲	▲
Restart Job at Beginning	1	▲	—	—
Pause Printer	1	▲	▲	▲
Pause Queue	1	▲	▲	▲
Close Queue	1	▲	▲	▲
Connectivity	2			
OS/2 Workstations	2	▲	▲	▲
OS/2 Processes with Private Sessions	1	—	▲	▲
Macintosh Workstations	3	E	D	D
NFS Workstations	2	▲	▲	▲
Asynchronous Gateway	2	▲	▲	▲
Terminal Emulation Access to UNIX	1	▲	—	—
INT14 Access for Terminal Emulators	2	▲	▲	▲
Ethernet	1	▲	▲	▲
Arcnet	1	—	D	D
Token-Ring (16M bps)	1	▲	D	D
Token-Ring (4M bps)	1	▲	▲	D
AppleTalk	1	—	D	D
Bridge Software Included	1	—	▲	▲
NFS Volumes Available to Clients	1	▲	▲	▲
Diskless Workstations	1	I	—	▲
Fault Tolerance	0			
UPS Monitoring	1	G	—	—
Disk Mirroring	1	G	—	—
Disk Duplexing	1	G	—	—
Server Duplexing	1	—	—	—
Split Seeks	1	G	—	—
Read Verification	1	G	—	—
Hot Fix	1	G	—	—
Sector Failure Recovery on Mirrored Drives	1	G	—	—
Application Program Interfaces	0			
Named Pipes	2	▲	H	H
NETBIOS	3	▲	▲	▲
APPC	0	—	—	—

See footnotes on Page 422.

Table 3. UNIX File Server Program Features (Continued)

	Weights	AT&T StarGroup LAN Manager	Interactive Ported NetWare	NCR NetWare/X
E-Mail API	0	—	—	—
Accounting API	1	▲	▲	▲
Auditing API	1	▲	—	—
Indexed File Manager	0	—	—	—
Transaction Logging and Rollback	0	—	—	—
IPX/SPX	3	—	▲	▲
Peer Resource Sharing	1			
Share Hard Disk	1	—	—	—
Share Printers	1	▲	—	▲
Share Modem	1	—	—	—

▲—*Yes, has feature.*
A—Administrator only.
B—For guest account only.
C—DOS clients only.
D—Via a bridge.
E—Separate product.
F—File attribute only.
G—Available via add-on product.
H—Clients only.
I—Requires special boot adapter.
U—Unlimited.
UNIX—Using UNIX facilities.

Software Prices

		Price ($)
UNIX File Server Programs		
	AT&T StarGroup LAN Manager Per server; unlimited users	3,795
	Interactive Ported NetWare Per server; unlimited users	4,995
	NCR NetWare/X 255 users	10,000

Glossary of Terms

Server Parameters

Maximum Simultaneous Users: The maximum number of sessions that can be simultaneously active on a single server.

Maximum Server Volume Size: The maximum server hard disk volume supported by the network operating system.

Maximum Volumes: The maximum number of volumes supported by the network on a single hard disk.

Maximum Shared Printers: The maximum number of shared printers that can be attached to a single file or print server.

Maximum Open Files: The maximum number of files that can be opened from one server.

Multiple Servers

Global Naming of Users and Groups: Users and groups can be accessed using symbolic names independent of server assignments.

Global Naming of All Objects: All network objects (users, print queues, file services, etc.) can be accessed using symbolic names independent of server assignments.

Link Security: The system controls the ability to send data to linked servers or to use their resources on a server-by-server basis.

Remote Server Administration: An administrator can control server resources from workstations other than the server.

Remote Administration of Multiple Servers: An administrator can control multiple servers from workstations.

Security

User-Password Security: A network administrator assigns a password and privileges to individual users. Users sign on to the network once and can subsequently access all network resources available to them.

Shared-Password Security: Passwords are assigned to individual resources (e.g., network printer, network directory), and any user who can provide a given password can access the corresponding resource. Shared passwords are less secure than user-password security, but they are adequate for applications where security and administration needs are minimal.

Security Groups: The administrator can assign users with similar access needs to security groups, and access restrictions for all users in the group can be set and/or modified all at once.

Security Equivalences: The administrator can assign a new user or group security equivalence to an existing user or group. The new user has the same access rights as the equivalent.

Account Expiration Date: Accounts can be dated to expire after some period of time. After the expiration date, the account user can no longer access the network.

Time Restrictions: The network supports restricting access of specified users to certain times of day.

Lock Account after Failed Passwords: The network can be programmed to shut down or close a node following a specified number of incorrect user password attempts.

Set Intruder-Detect Threshold: The administrator designates how many failed login attempts signal an alert or automatically lock an account. A series of consecutive failed login attempts generally signifies an attempted security breach.

Set Login Count Retention: The administrator can designate a period of time over which failed attempts are "remembered" by the system. This prevents longtime users from eventually accumulating enough failures to lock their accounts.

Mandatory Password Change: The administrator can require that all users periodically change their passwords. The software periodically forces the user to choose a new password in order to gain access.

Limit Concurrent Connections: The administrator can limit a user account to a specified number of simultaneous logins to facilitate security and resource administration.

User-Set Password Option: The administrator can permit users to change their own passwords, but the privilege can be limited (e.g., when an account, such as a guest account, will be used by multiple users).

Set Minimum Password Length: The administrator can require a minimum character length for all passwords. Long passwords are generally more secure than short passwords.

Disable/Lock Accounts: The administrator can disable an account without deleting it (the account can then be quickly reactivated).

Require Unique Passwords: The administrator can prevent a a user from repeating a password that he or she has used in the past. Password histories are maintained for each user for multiple past passwords.

Restrict User to Workstation(s): A user's login access can be restricted to one or more specified workstations. On a network that permits remote access, this type of restriction limits access to sensitive information.

Disconnect after Inactive Period: Workstations are logged out after a specified period of inactivity.

User Account Permissions

Read Files: The user can read specified files.

Write to Files: The user can write to specified files.

Create Files: The user can create new files in a secured directory.

Delete Files: The user can delete files in a secured directory.

Grant Permissions: The user can grant (to other users) access to specified secured files. The ability to grant permissions permits limited hierarchical distribution of administrative tasks.

Execute Only: The user can execute, but not read or write to, secured files in a shared directory (prevents illegal copying of programs).

Modify File Attributes: The user can modify file attributes such as read-only, hidden, and system attributes.

Limit Simultaneous Users: Resources can be limited to some maximum number of users. In conjunction with an execute-only privilege, this type of restriction can enforce software license restrictions.

Assign Permissions to Directories: Security permissions can be assigned to directories, applying to all files in the directory.

Assign Permissions to Files: Security permissions can be granted to individual files (e.g., one file can be designated as execute only, even though the directory is designated read-write).

Assign permissions to Queues: Access to printer queues can be limited for security or resource management purposes. Only authorized users can submit jobs to secured printer queues.

Administrator Rights on Specific Directories: The system administrator can grant administrator-level rights to a user in a specific directory only.

Inherited Permissions: Access rights in a directory can be passed to subdirectories.

Mask Inherited Rights: A subset of the rights in a given directory can be established for its subdirectories.

Accounting

Restrict User Account Space: User accounts can be limited to a specified number of disk blocks per account. Users who exceed the quota receive a Disk Full message.

Track User Access Time: The network can be set up to monitor user access time (measured from login to logout) for accounting and management purposes.

Track User Data Reads: The network can be set up to monitor the number of reads performed by a user.

Track User Data Writes: The network can be set up to accrue data writes by user to their accounts.

Track User Server Requests: The network can be set up to accrue server requests by user to their accounts.

Track User Space Usage: The network can be set up to accrue space usage by user on a periodic basis (e.g., daily, weekly, etc.).

Charge Users for Services: Costs can be associated with various use measures (e.g., space usage, data read/writes, access time) and these costs accrued to each user (typically to account for network costs in multiple budgets).

Variable Service Rates: Network service rates can vary by day and time. Variable rates encourage network use during off-peak hours.

User Account Balances: Users can be assigned balances against which network service costs are charged.

User Credit Lines: Users may take account balances to an established credit line.

Logout at Credit Limit: The system can log out any user who exceeds a credit line. The account remains disabled until the administrator increases the account balance or credit line.

Auditing

Logins: The system can record the date, time, and username for all logins.

Unsuccessful Login Attempts: The system can record the date, time, and username for all unsuccessful logins.

Last Successful Login Attempt: The system can record the last time a user successfully logged in to the system.

Attempted Security Violations: The network can maintain a record of users who try unsuccessfully to access files.

Logouts: The system can record the date, time, and username for all logouts.

File Open: The system can record the date, time, and username each time any file is opened on audited resources.

Selective Audit: Auditing of resources can be selective (e.g., logins and logouts, but not file openings).

Audit Specific Resources: Auditing can be specified for selected resources (e.g., a critical accounting file or directory) to prevent filling the audit file with nonessential information.

Alert Service

Drive Full: An alert message can notify the administrator when a network drive fills to capacity.

Excessive Errors: An alert message can notify the administrator when some designated number of network errors occurs (e.g., 100 bad packets received). The administrator can then diagnose the problem and reduce the network errors.

Intruder Alert: An alert message can notify the administrator when a designated number of failed login attempts have occurred. The administrator can then identify the intruder or disable the besieged account.

Printer Problem: An alert message can notify the administrator when printer problems occur (e.g., out of paper).

Print Request Complete: A message can notify a print queue user when his or her print job is completed.

User Utilities

System Login Script: The administrator can create a single batch file that executes after each user logs in.

User Login Scripts: An administrator or user can develop files that automatically execute system utilities and/or move the user into an application upon login.

Explicit File Locking: Network commands can be used to lock files explicitly specified by a user.

Display Logged-In Users: Any user can obtain a list of all users currently logged in to the network (useful when sending messages).

Display Network Resources: Any user can display a list of available network resources.

Display Rights: Any user can display a list of his or her access rights for a given resource; for example, a user unsuccessfully trying to write to file may have read-only rights to that directory.

Execute Server Program from Workstation: Users with the appropriate privileges can run programs on a server, making better use of system resources.

Unload Shell/Stack: Users can unload the network shell software.

Recover Deleted Files: Users have access to a utility that recovers deleted files.

Supervisor Utilities

Forced Disconnect: Supervisors can disconnect any logged-in user as a security measure or to clear an inactive user.

Security Check Utility: A supplied utility can examine the security system for loopholes such as accounts without passwords, inappropriate rights to sensitive directories, too many supervisors, and others.

List Security Group Access Limits: The administrator can request a listing of security groups with descriptions of each group's system privileges.

List User Access Limits: The administrator can request a listing of users with descriptions of their system privileges.

List User Access Rights by Resource: An administrator can select a resource and request a list of users with access.

Realtime Status: Files/Volumes: An administrator can monitor disk access status to show server volumes and/or files currently in use and by what users.

Automatic Update of Workstation Shell: When a user logs in, the network operating system checks that the workstation is running the most recent version of the

appropriate shell software and offers the user the option of updating the workstation software if necessary.

Performance Monitoring

Average Response Time: A server can display the average time needed to service requests made to the server.

Cache Statistics: A server can display cache-specific statistics such as cache hit ratio, number of cache reads, number of cached writes, and others.

Server CPU Utilization: A server can show CPU utilization by measuring CPU idle time.

Packets/Bytes Sent and Received: A server can measure the amount of information sent and received at the server.

Packets/Bytes per Second: A server can measure the instantaneous rate of information arrival and departure at the server.

Bad Packets: A server can record the number of bad packets received at the server (for diagnosing potential problems).

Open Files: A server can show the number of open files at any given time; many servers offer a maximum on open files as a configurable parameter.

Peak Files Open: A server can show the highest number of files open at any one time since the statistics have last been cleared.

Record Locks: A server can show the number of record locks in place at any given time; many servers offer a maximum on record locks as a configurable parameter.

Peak Record Locks: A server can show the highest number of record locks in place at any one time since the statistics were last cleared.

Connections: A server can show how many connections are currently in place; many servers offer a maximum on connections as a configurable parameter.

Peak Connections: A server can show the highest number of connections at any one time since the statistics were last cleared.

Disk Blocks Read and Written: A server can show the number of disk blocks read and written since the statistics were last cleared.

Disk Blocks per Second: A server can show the instantaneous rate of disk usage.

Disk Utilization: A server can measure disk utilization, or the percentage of time the disk subsystem is active.

Disk Demand versus Service: A server can show the ratio of requests for disk service to the number of disks actually serviced. A number greater than 1 shows disk requests being made faster than they can be serviced; a number close to 1 or greater than 1 indicates overutilization of the server.

Drive I/O Errors: A server can show the number of I/O errors occurring on the drive. I/O errors may signify imminent disk failure or a disk controller problem.

Packets Routed: A server can show the number of packets rerouted to another server. A large number of rerouted packets may indicate the need for a topology change such as installing a dedicated bridge.

Peak Packets Routed per Second: A server can show peak routing demand in packets per second.

Clear Statistics: The server operator can clear statistics without shutting down the server.

Identify Token-Ring Beacon Sender: The system works with the token-ring fault-detection system for identifying faulty adapters in the ring.

Messages/Chatting

Send Messages: Network users can send short communications to one or more logged-in users.

Group Messages: Messages can be sent to groups of users (e.g., to all users in the programmer's group).

Broadcast Message: The system can send the same message to every logged-in user (or workstation) with a single command.

Block Messages: A user can issue a command that blocks messages (which halt processes until the message is cleared) to prevent interruption of long, unattended batch operations.

Log Messages: Users can optionally log messages to a file (e.g., when blocking messages).

Hot Key to Messaging: Messages can be sent from within a DOS application (feature provided by OS/2).

Chatting: The system permits an electronic "conference call," whereby users can exchange messages back and forth without addressing each message.

Maximum Chatters: This is the maximum number of users that can take part in one chat session (all participants see all comments).

Archival Services

Back Up/Restore Server Disk: Backup utilities can be used to back up the entire server hard disk including hidden files and system files.

Back Up/Restore Selected Directories: Back Up utilities can be used to back up user-specified directories only.

Back Up Modified Files: Back up utilities can be used to back up files that have been modified since the last backup.

Back Up System Files: Backup utilities can be used to back up system files on the server without disrupting routine network activities.

On-line Backup of Account Files: Backup utilities can be used to back up server system files (account databases) without disrupting routine network activities.

Back Up Skips Open Files: Open files do not halt a backup operation. Files open for update are bypassed, and files open for read-only purposes can be opened and backed up normally.

Scheduled Backups: Network backups can be scheduled for off-peak hours.

Back Up to Tape: The network backup utilities can be used with tape backup systems.

Multiple Tape Drives: Multiple tape drives are supported such that backup and restore operations progress from one drive to the next as the tapes fill.

Back Up to Diskette: Diskette drives can be used as archival devices.

Back Up Macintosh Files on Server: A supplied utility backs up Macintosh files (resource and data fork) stored on the server.

Network Printing

Automatic Clear: The printer queue can be set up such that the appropriate escape codes reset the printer at the start of each print job.

Print Banner: The printer queue can be set up to insert a banner or separator page between jobs to identify users submitting the jobs.

List Available Printers/Queues: Workstation users can display the status (i.e., availability) of network printers.

List Current Redirections: Users can request a list of network printers attached to local device names (e.g., Laser_1 is attached to LPT1).

Printer Status: Users with the appropriate privilege can display the status of the network printers (e.g., printing, idle, out of paper, etc.).

End Spool from Application: Spooling files can be closed with a keystroke (e.g., Ctrl-Alt-PrtSc). The closed file is submitted to a printer queue, and a new file is opened.

Time-Out for End Spool: Spooling files can be set to close automatically after a designated time during which no characters are received from the workstation.

Print to Network File: Spool files can be created and sent to a network file instead of a printer. The network file can subsequently be sent to a print queue.

Select Print Mode: Users can select a print mode (e.g., portrait, landscape, letter quality), and the appropriate escape codes are automatically sent to the printer.

Select Form Type: Print jobs can be submitted for a specified form (e.g., green bar, micro perf, letterhead), and the job remains in the queue until the designated form is loaded. When the operator changes the form, jobs specified for that form type are selected from the queue.

PostScript Font Download: The print spooler automatically downloads PostScript fonts to the printer as needed.

LaserJet Font Download: The print spooler automatically downloads fonts to a LaserJet (or compatible) printer as needed.

Print Screen: Shift-PrtSc can be set to print to a network printer.

Print Notification: Users are notified (by message) when print jobs have completed printing.

Multiple Printer Configurations: More than one printer definition can be set up for a network printer (e.g., specifying different paper types, fonts, orientation.).

Printing Queues

Multiple Queues on One Printer: Multiple queues can be directed to a single printer. Queues may be set to print during different times or with different priorities.

Multiple Printers on One Queue: A queue can be set to print to the first available network printer.

Multiple Queues on Multiple Printers: Multiple queues can be set to print to the first available network printer.

Restrict Queue Hours: Queues can be set to print only during designated hours. An overnight queue might accept jobs all day and print only from 8p.m. to 6a.m.

Queue Priority Levels: Queues can be assigned priority levels. When multiple queues are attached to one or more printers, jobs in the higher priority queue will always print first.

Print Preprocessor: A filter program can process submitted jobs before printing (e.g., convert plotter files for a laser printer).

Queue Status: Users can view the status of at least their own jobs in the printer queue. Some systems let users view the status of all jobs in the queue.

Change Queue Order: Users can reorder their own jobs in the print queue. The queue operator or administrator can reorder all jobs in the queue.

Switch Queues: The user can move a print job from one queue to another.

Insert File into Queue: A queue monitoring utility can insert files directly into print queues.

Delete Active Print Job: A user can delete a current print job submitted to the queue.

Delete Job from Queue: A user can delete jobs submitted to the queue.

Hold/Release Print Job: Users can place their print own jobs on hold. Jobs on hold remain in the queue, but are not printed until they are released.

Restart Job at Beginning: A current job can be restarted printing from the beginning (e.g., when printer problems lose part of the job).

Pause Printer: The printer can be set to pause such that no jobs are printed on it from any queue.

Pause Queue: A single queue can be paused; other queues (possibly attached to the same printer) can be used normally.

Close Queue: A queue can be closed such that it does not accept jobs but continues printing any jobs already in the queue.

Connectivity

OS/2 Workstations: Workstations running OS/2 are supported as network nodes.

OS/2 Processes with Private Sessions: Each OS/2 process can have its own unique set of drive mappings.

Macintosh Workstations: Macintosh systems are supported as network nodes.

NFS Workstations: Network File System (NFS) workstations can be used as full network nodes.

Asynchronous Gateway: Asynchronous communication services permit workstations to share asynchronous connections (e.g., modem pooling, connections to a VAX, etc.).

Terminal Emulation Access to UNIX: The network software enables terminals emulating workstations to access UNIX.

INT14 Access for Terminal Emulators: The network software supports INT14 access from terminal emulating workstations.

Ethernet: The network software supports Ethernet connections.

Arcnet: The network software supports Arcnet connections.

Token-Ring (16M bps): The network software supports 16M bps token-ring connections.

Token-Ring (4M bps): The network software supports 4M bps token-ring connections.

AppleTalk: The network software supports AppleTalk connections.

Bridge Software Included: The network system includes the necessary software to set up a bridge between two networks.

NFS Volumes Available to Clients: Workstation clients can access NFS volumes.

Diskless Workstations: The network software supports diskless workstations.

Fault Tolerance

UPS Monitoring: Networking software supports a hardware interface to an uninterruptible power supply (UPS) that signals the server when it is operating on battery power. The server can then initiate shutdown procedures (notifying all logged-in users) to be completed before the UPS runs out of power.

Disk Mirroring: The system can maintain duplicate hard disks. In the event that one disk fails, the system software immediately switches to using the other.

Disk Duplexing: The system supports mirrored disks with separate controllers. Read requests are sent to

whichever disk subsystem is not occupied; write requests go to both disks to maintain mirroring. Duplexing improves throughput as well as fault tolerance.

Server Duplexing: Servers can be maintained as exact duplicates. When one server fails, the mirrored server immediately takes over.

Split Seeks: Read requests are sent to whichever disk subsystem is not occupied in a duplexed disk system; write requests go to both disks to maintain mirroring.

Read Verification: The system software verifies the readability of sectors after they are written before flushing the sector buffer.

Hot Fix: When read verification fails, the sector is relocated to another position and the bad sector marked.

Sector Failure Recovery on Mirrored Drives: When mirrored disks cease mirroring after a sector failure, the sectors are read from the good disk and relocated on the bad disk. Mirroring can then continue.

Application Program Interfaces

Named Pipes: The network supports the Named Pipes interface adopted by Microsoft to simplify programming network connections. Named Pipes is similar to interprocess pipes, but the processes are on different workstations.

NETBIOS: The network supports the NETBIOS network interface invented by IBM for personal computer networking.

APPC: The network supports IBM's APPC interface for advanced peer-to-peer communication (APPC) among all varieties of computers.

E-mail API: The network system defines an application interface to the network mail system (e.g., for programs that automatically send mail or for developing mail gateways).

Accounting API: The network system defines an application interface to the network accounting system (e.g., for programs that automatically capture accounting information or for spreadsheet manipulation).

Auditing API: The network system defines an application interface to the network auditing system (e.g., for programs that automatically capture information for centralized network management, such as IBM's NetView system).

Indexed File Manager: The network system defines a programming interface to an indexed file manager (e.g., for programs that manipulate a database).

Transaction Logging and Rollback: The network system defines a programming interface for fault-tolerant applications. (Transactions are groups of related updates that are either made completely or not made at all.)

IPX/SPX: The network system defines a programming interface for the IPX and SPX protocols.

Peer Resource Sharing

Share Hard Disk: The user can define a local hard disk as a network device.

Share Printers: The user can define a local printer as a network device.

Share Modem: The user can define a local modem as a network device.

■