National Software Testing Laboratories, Inc.

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NSTL publishes test results in Software Digest Ratings Report, Software Digest Macintosh Ratings Report, PC Digest Ratings Report, and LAN Reporter Ratings Report. The publications carry no advertising.

Recognizing the need for local area network testing, NSTL created a LAN laboratory for testing local area network hardware and software. The LAN laboratory includes two, 16-workstation test beds that can test network throughput, equipment compatibility, and product performance on a comparative basis.

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To meet the information needs of *Datapro Reports on PC Communications'* current and future subscribers, Datapro will provide reports generated from NSTL's LAN laboratory in this volume every month.

Token-Ring Network Adapters

A Report from NSTL

In this report:

Synopsis

Focus

This report highlights the factors that influence purchase decisions for token-ring adapters and compares the features, performance, and overall suitability for specific network environments of 13 products.

Products Tested

TRA 4/16 ISA Plus
Andrew Corp.

TRA 4/16 MCA Plus
Andrew Corp.

16/4 Token-Ring Adapter
IBM

16/4 Token-Ring Adapter/A
IBM

Cypress/3-16
Lantana Technology

Cypress/2-16
Lantana Technology

Smart 16/4 AT Ringnode
Madge Networks, Inc.

Smart 16/4 MC Ringnode
Madge Networks, Inc.

OC-3114 ISA 16/4
Olicom USA

OC-3128 MC 16/4
Olicom USA

M8113 16/4 ISA
Racore Computer Products, Inc.

M8114 16/4 MCA
Racore Computer Products, Inc.

TC4045 16/4 AT
Thomas-Conrad Corp.

Product Recommendations

- Andrew TRA 4/16 ISA Plus
- Andrew TRA 4/16 MCA Plus
- Madge Smart 16/4 AT Ringnode
- Madge Smart 16/4 MC Ringnode
- Olicom OC-3114 ISA 16/4
- Olicom OC-3128 MC 16/4

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	Performance	Features	Usability	Price
	ISA Adapters				
8.8	Madge Smart 16/4 AT Ringnode	●	●	●	$995★
8.4	Andrew TRA 4/16 ISA Plus	●	●	●	$895★
8.4	Olicom OC-3114 ISA 16/4	●	●	●	$895★
7.8	Thomas-Conrad TC4045 16/4 AT	●	●	●	$849
7.4	Racore M8113 16/4 ISA	○	●	●	$845
7.0	Lantana Cypress/3-16	○	●	●	$895
6.4	IBM 16/4 Token-Ring Adapter	◎	●	●	$845
	MCA Adapters				
8.8	Madge Smart 16/4 MC Ringnode	●	●	●	$1,025★
8.5	Andrew TRA 4/16 MCA Plus	●	●	●	$925★
8.5	Olicom OC-3128 MC 16/4	●	●	●	$925★
7.7	Racore M8114 16/4 MCA	●	●	●	$845
7.4	IBM 16/4 Token-Ring Adapter/A	○	●	●	$895
7.2	Lantana Cypress/2-16	○	●	○	$895

Overview

Since the introduction of the 4M bps IBM Token-Ring Network Adapter in 1985, IBM has evolved a token-ring network technology with wide acceptance. IBM's initial offering supported a single ring with 260 IBM/PC stations covering a limited distance. Token-ring networks now support mainframe, System/36, and PS/2 systems and use 16M bps adapters.

IBM has aggressively promoted token-ring network technology as the standard of choice and has advanced proposed enhancements to token-ring network technology. Recommendation 802.5F, covering 16M bps operation, and Recommendation 802.5I, covering early token release, are significant enhancements. Early token release lets a station release the token at the end of a frame transmission without waiting for its header to return. In fact, given the hardware and software differences between earlier adapter versions, performance improvements since NSTL's last token-ring adapter evaluation must be attributed to these technology enhancements. Not covered in this evaluation, Recommendation 802.5D provides for multiple ring networks, or IBM source routing. Some proposed enhancements (such as Recommendations 802.5F and 802.5I) have been implemented in advance of their official acceptance as ratified standards.

The original token-ring standard defining a 4M bps token-passing ring topology eventually became the American National Standards Institute (ANSI) and Institute of Electronic and Electrical Engineers (IEEE) 802.5 Token-Ring Standard. More recently, token-ring has been expanded to include a 16-bit adapter interface and 16M bps bandwidth. A number of vendors produce boards compatible with the IBM and IEEE standards supporting both 4M and 16M bps transmissions.

Evaluation Criteria

NSTL evaluated 13 token-ring adapters: 7 ISA adapters and 6 Micro Channel adapters that maintain BIOS-level compatibility with the IBM Token-Ring Network Adapter products. The Olicom and Andrew cards are identical (often referred to here as Andrew/Olicom), but the products are evaluated individually because of marketing and support considerations. Olicom, an OEM supplier to Andrew, does not sell directly to end users. The test products maintain strict compatibility with the IEEE 802.5 standard and sufficient IBM compatibility to run IBM hardware-specific programs (e.g., IBM 3270 emulation and OS/2 Extended Edition communications). All the test adapters support 4M and 16M bps transfer rates (all tests are conducted in 16M bps transfer mode) and can coexist on a ring with IBM 16/4 cards set at the same transfer rate.

Other vendors, such as Proteon and PureData, declined participation in the evaluation, claiming the 16M bps interface specification is not sufficiently standardized, and because new products were not available in time for testing. Western Digital was in the process of selling its network adapter business to Standard Microsystems. 3Com, Ungermann-Bass, Hewlett-Packard, NCR, Tiara, CNet, and other vendors did not have 16M bps products available in time for testing; NCR, Hewlett-Packard, and CNet plan to release 16M bps cards in the second half of 1991. LLC drivers necessary for the low-level throughput tests were not available for IBM's new 24-bit Token-Ring Network 16/4 Busmaster Server Adapter/A.

Token-Ring Basics

Token-ring is logically and physically a ring structure. (In contrast, the Arcnet token-passing architecture is physically a bus and logically a ring.) Under token-ring, workstations or nodes capture a token to send data. A node attaches data and a node address to the captured token (in a token frame) and changes the token's status to indicate that it is "busy." As the token passes from node to node around the ring, each node checks the address and retransmits the token until it reaches the receiving (addressee) node, which reads the frame. After reading the frame, the node flips a receive bit and retransmits the token. When the originating station receives the returned frame with the receive bit flipped, it generates a new token to reestablish network traffic.

If one node transmits constantly or if the token is lost, the network is effectively disabled. To prevent these problems, one node serves as an active monitor, waiting for the token and generating a free token if no token is received after a period of time. The active monitor marks a recurrently busy token with a monitor bit and subsequently frees the token for network traffic. If the active monitor fails, another node automatically takes over as active monitor.

Token-ring stations link to the network through a Multistation Access Unit (MAU), where nodes can be removed or added without breaking the ring. All adapters in a single ring must maintain the same ring speed, but 16M bps and 4M bps cards installed in a single file server can be used by two rings with different speeds. All the test adapters support both 16M and 4M bps ring transmission speeds.

Texas Instruments, Ungermann-Bass, Toshiba, and IBM manufacture compatible chipsets for token-ring adapters. The IBM cards use the IBM chipset. All the others use the Texas Instruments chipset and a version of the Texas Instruments driver, except Madge, which uses its own driver. The IBM and Texas Instruments chipsets are distinguished primarily by their memory management schemes: IBM uses a shared memory interface, and the Texas Instruments chip uses direct memory access (DMA) for data transfer between the adapter and the CPU's RAM area.

Performance

Token-ring performance can be reduced to four primary factors: the adapter's bus interface width and type (8, 16, or 32 bits; ISA, EISA, or MCA), chipset, adapter-to-host data transfer method, and network driver. A 16-bit data path is twice as wide as an 8-bit path, and a wider path should pass a given amount of data twice as fast. Ring speed is less a factor because application software does not yet fully exploit the 4M bps bandwidth, but a 16M bps ring (four times the 4M bps bandwidth) gives applications the potential to transfer larger quantities of data at the faster speed.

The Andrew/Olicom ISA and MCA cards and the Madge AT and MC Ringnode cards consistently deliver the fastest performance. The IBM ISA and MCA adapters use a shared memory interface for adapter-to-host data transfer (the others use bus master DMA data transfer

Bus Mastering

Bus mastering is a technique used by some system components and special expansion adapters to gain control of the system's I/O bus. When a bus master gains control of the bus, it takes responsibility for the manipulation of the data, address, and control signals on the bus. With this control, the bus master can dedicate the bus bandwidth to data throughput, relieving the system's microprocessor from this task and maximizing the efficiency of the bus.

ISA Bus Mastering

DMA channels were the first microcomputer devices (other than the system's microprocessor) to provide bus master capabilities. In ISA bus systems, DMA channels interact with the microprocessor via a set of dedicated control signals. In order to become a bus master, the adapter makes a DMA request (DRQ) and on receiving the corresponding DMA acknowledge (-DACK), the adapter activates the -MASTER signal to indicate to the microprocessor that the I/O bus is in use. Effectively, the I/O bus becomes an extension of the processor's bus. To prevent the microprocessor from attempting to use the bus while the bus master has control, the bus master must perform the time-critical functions normally performed by the microprocessor, including refreshing memory and responding to critical interrupts such as parity errors. These constraints limit the throughput gains of ISA bus mastering.

MCA Bus Mastering

Micro Channel Architecture completely altered the concept of the I/O bus as an extension of the microprocessor bus. The I/O bus is now conceptually a system resource to be competed for, rather than the exclusive property of the microprocessor. A new set of control signals, ARB0 through ARB3, has been introduced to facilitate arbitration among contending devices. Any device with the appropriate intelligence, including the microprocessor and DMA channels, can compete for control of the I/O bus. A Central Arbiter detects when the bus is free and uses the ARB/-GNT signal to initiate contention for the bus. Up to 16 bus masters can compete for the bus with relative priorities assigned through values associated with the ARB signals. Memory refresh and critical interrupt handling have higher priorities than those attainable by other devices, relieving bus masters on the Micro Channel bus from attending to these time-critical functions. After acquiring use of the bus, the bus master focuses solely on the transfer of data between source and destination.

Burst Mode and Streaming Mode

In Burst Mode, a bus master device can transfer a block of data rather than a single transfer before releasing the bus for another round of arbitration.Streaming Mode transfers a data block more efficiently by minimizing the amount of address signaling during the transfer before releasing the bus for another round of arbitration.

A bus master in Burst or Streaming Mode is effectively a "bus hog," and other devices temporarily locked out may develop an urgent need for use of the bus. For example, a network adapter receiving data into its buffer could approach an overrun condition because it is unable to transfer its buffer to memory. In such a time-critical situation, the adapter requiring use of the bus can suspend the bus master's Burst or Streaming Mode by activating a -PREEMPT signal. The -PREEMPT signal begins a new arbitration cycle, allowing another requesting device to acquire control of the bus. A fairness feature prevents a preempted bus master from preempting the device that suspended its burst operation.

schemes), and the IBM ISA adapter is further hampered by an 8-bit bus interface. Filtering out the effects of these two factors, performance differences among the test cards would be significant only in high-traffic, transaction-oriented application environments where driver efficiencies become more discriminating factors. The Madge and Andrew/Olicom cards come with efficient server and workstation drivers. A good ring combination would be a Madge or Andrew/Olicom card in the server and any of the other 16-bit cards in the workstations.

Operating System Drivers

Network adapters come with drivers for one or more network operating systems, and a high-performance driver can enhance transmission speed by using the larger frames supported by 16M bps cards. In tests using different drivers, throughput with IBM's NETBIOS LAN protocol is almost four times greater than with a Novell IPX driver. NETBIOS with a limited number of conversations (i.e., direct connections between nodes) produces network traffic saturation to 94% of the bandwidth at 16M bps. Novell's NETBIOS Emulator (which allows NETBIOS calls to be encapsulated by the IPX driver and transmitted by Novell) barely permits 25% saturation of the available bandwidth.

Packet Size

The ability to move larger packets of data is essential to improving token-ring performance. The Thomas-Conrad, Racore M8113/8114, and IBM 16/4 Adapter and Adapter/A at 16M bps handle packets over 8K bytes, but performance gains level as packet size increases beyond 6K bytes. A number of the cards cannot handle packet sizes over 4K bytes at 16M bps.

Chipset

Given the inherent performance advantages of 16-bit cards over 8-bit cards and bus master DMA transfer over programmed I/O and shared memory, the influence of chipset and drivers should be easy to delineate. Unfortunately, it is difficult to determine the effects of each factor with any degree of certainty because all the cards except the IBM use the same Texas Instruments chipset, and only the IBM cards use shared memory. Performance gains attributable purely to bus mastering further complicate the isolation of the chipset as a performance factor.

Micro Channel Architecture

The Micro Channel Architecture was originally designed to eliminate or minimize critical performance bottlenecks in microcomputer systems (the peripheral expansion bus

channel and the peripheral device's throughput capacity) using peer-to-peer sharing of bus subsystem control by the CPU and intelligent peripheral devices with bus mastering capability. Bus master peripheral devices such as network adapters are built around microprocessors dedicated to I/O transfers between a device's buffer memory and the host's main memory. The adapter's microprocessor frees the main CPU from I/O tasks, and through a bus arbitration scheme with preemption and a fairness algorithm in bus sharing, the adapter can directly exchange data with the host system's main memory and with peer devices. Refer to the sidebar for differences between ISA and MCA bus mastering approaches.

NSTL evaluated adapters in both environments. For the ISA adapters, AST Premium 386/25 systems (25MHz, 0 wait state 386 systems with an 8MHz, 1 wait state bus) were used as the server and primary workstation; for the MCA adapters, IBM PS/2 Model 80 systems were used as the server (20MHz, 1 wait state, 10MHz DMA channel) and primary workstation (16MHz, 1 wait state, 8MHz DMA channel). Everex Step 386iS secondary workstations ran background traffic for both configurations (16MHz, 0 wait state system with an 8MHz, 1 wait state bus). Processor test results show the AST systems have a processing speed advantage.

Token-Ring Features

Memory Management

Except for the IBM Adapter and Adapter/A (which use shared memory), the test token-ring cards use a bus-mastered DMA memory management scheme. Shared memory adapters use memory directly addressable by an 8086 processor in real mode; that is, memory between 640K bytes and 1M byte (A000 to FFFF). Within that range, the adapter requires up to 16K bytes in a contiguous block. Adapters that use direct memory access (DMA) bypass the CPU. DMA controllers (in the standard AT architecture) provide four 8-bit and four 16-bit paths to memory (one 16-bit path is reserved for the system board).

Address conflicts that occur when multiple devices attempt to use the same memory address, I/O address, or DMA channel can lock the system, requiring a hard boot. With shared memory, a number of devices may need to reserve overlapping portions of the 384K-byte block above 1M byte. VGA and EGA adapters require the range starting at A000; super high-resolution video adapters may require all memory to CFFF; EMS 4.0 and EEMS adapters require a 64K-byte block between A000 and E000; and the AT extended BIOS may occupy the range from E000 to EFFF. DMA conflicts not only lock the system; they can prevent use of the device or corrupt the data used by standard devices such as the hard disk and diskette.

Standard DMA controllers generally run at 4MHz, and DMA transfers also take place at that speed; so shared memory should provide faster performance than direct memory access, except when the DMA channel is used by bus master cards. AT bus masters are not governed strictly by the speed of the DMA controller and can implement other methods of improving performance. Bus masters use DMA channels without the disadvantage of the slow DMA controllers. AT bus master cards must use DMA because it takes control of system resources without using the CPU.

Configuration Settings

For use in systems with the standard AT architecture, an adapter's switches or jumpers generally must be configured to prevent conflicts with other system resources. A few ISA network adapters (like EISA and MCA adapters) are entirely software configured, requiring no jumper or switch settings. Lantana Technology and PureData implement software configuration in their products; among the test products, only the Lantana is software configured (media selection and ring speed, which still use jumpers).

Multiple setting options on an ISA adapter enhance setup flexibility, but changing settings can be complicated. The IBM ISA adapter uses an exemplary single 12-switch block (mounted on the trailing edge of the half-length card) that permits easy reconfiguration without removing the card from the system. The IBM documentation clearly describes the procedures for changing the shared memory location and other configuration settings. RJ-11/45 jack support for unshielded twisted-pair wiring is a jumper setting. RJ-11/45 support, included on the Madge, Lantana, Racore, and Thomas-Conrad cards, permits an inexpensive network wiring option.

Operating System Support

For compatibility with a given operating system, a network adapter must be supplied with the appropriate network drivers. IBM enjoys an advantage in that all major network operating systems include IBM-specific drivers. The test cards support Novell SFT NetWare 286 and NetWare 386 and IBM PC LAN Program. All but the Lantana support Microsoft LAN Manager. Not all support 3Com 3+Open and IBM LAN Server, which requires OS/2. The Lantana, Racore, and Thomas-Conrad cards do not support Banyan VINES, and the Andrew/Olicom cards provide only workstation support for VINES.

Summary

Fast, expensive cards such as the Madge Ringnodes may not be appropriate for all network installations. Less expensive, slower cards such as the Racore are adequate for many applications. Performance differences among the cards are not highly significant in typical, small-scale network installations. In high-demand networks with intensive transaction processing applications and large numbers of connections, performance differences become more delineated. In the server, the Madge and Andrew/Olicom are the preferred choices; otherwise, the optimum network configuration may include a variety of cards, each filling a niche dictated by cost and other considerations.

Although a 16M bps adapter provides a wider bandwidth and is clearly the best choice for a token-ring network backbone, its advantages for routine operations are less obvious. With current applications, the performance gain with 16M bps is marginal at best (low-level throughput test results indicate the potential for over 100% improvement with more appropriate applications). Similarly, although MCA architectures are the clear choice for bus master network adapters, downward compatibility problems with ISA devices and cost considerations may preclude their wholesale adoption. Again, their use may be justifiable only in high-demand network environments.

Product Evaluations

Andrew TRA 4/16 ISA Plus

Product Summary

- Bus master DMA (programmed I/O optional)
- 16-bit ISA bus interface
- 4M and 16M bps operation
- 128K bytes on-board RAM
- No RJ-11/45 interface
- Very good server performance
- No server support for VINES networks (workstations only)

Andrew TRA 4/16 MCA Plus

Product Summary

- Uses bus master DMA
- 24-bit MCA bus interface
- 4M and 16M bps operation
- 128K bytes on-board RAM
- RJ-11/45 interface
- Fastest Micro Channel adapter
- No server support for VINES networks (workstations only)

IBM 16/4 Token-Ring Adapter

Product Summary

- Uses shared memory
- 8-bit ISA bus interface
- 64K bytes on-board RAM
- 4M and 16M bps operation
- Below-average performance
- Excellent documentation
- Excellent features
- Wide range of operating system support

IBM 16/4 Token-Ring Adapter/A

Product Summary

- Uses shared memory
- 16-bit MCA bus interface
- 64K bytes on-board RAM
- 4M and 16M bps operation
- Below-average performance
- Excellent documentation
- Excellent features
- Wide range of operating system support

Lantana Cypress/3-16

Product Summary

- Uses bus master DMA (programmed I/O optional)
- 16-bit ISA bus interface
- 4M and 16M bps operation
- 128K bytes on-board RAM
- RJ-11/45 interface
- Below-average performance
- Limited operating system support

Lantana Cypress/2-16

Product Summary

- Uses bus master DMA
- 16-bit MCA bus interface
- 4M and 16M bps operation
- 128K bytes on-board RAM
- RJ-11/45 interface
- Below-average performance
- Limited operating system support

Madge Smart 16/4 AT Ringnode

Product Summary

- Uses bus master DMA (programmed I/O optional)
- 16-bit AT bus interface
- 4M and 16M bps operation
- 128K bytes on-board RAM
- RJ-11/45 interface
- Excellent features and usability
- Best server performance
- Wide range of operating system support

Madge Smart 16/4 MC Ringnode

Product Summary

- Uses bus master DMA
- 32-bit MCA bus interface
- 4M and 16M bps operation
- 128K bytes on-board RAM
- RJ-11/45 interface
- Excellent features and usability
- Good performance
- Wide range of operating system support

Olicom OC-3114 ISA 16/4

Product Summary

- Uses bus master DMA (programmed I/O optional)
- 16-bit ISA bus interface
- 4M and 16M bps operation
- 128K bytes on-board RAM

- No RJ-11/45 interface
- Very good server performance
- No server support for VINES networks (workstations only)

Olicom OC-3128 MC 16/4

Product Summary

- Uses bus master DMA
- 24-bit MCA bus interface
- 4M and 16M bps operation
- 128K bytes on-board RAM
- Fastest MCA adapter
- No RJ-11/45 interface
- No server support for VINES networks (workstations only)

Racore M8113 16/4 ISA

Product Summary

- Uses bus master DMA (programmed I/O optional)
- 16-bit ISA bus interface
- 4M and 16M bps operation
- 128K bytes on-board RAM
- RJ-11/45 interface
- Below-average performance
- Limited operating system support

Racore M8114 16/4 MCA

Product Summary

- Uses bus master DMA
- 16-bit MCA bus interface
- 4M and 16M bps operation
- 128K bytes on-board RAM
- RJ-11/45 interface
- Good server performance
- Limited operating system support

Thomas-Conrad TC4045 16/4 AT

Product Summary

- Uses bus master DMA (programmed I/O optional)
- 16-bit ISA bus interface
- 4M and 16M bps operation
- 128K bytes on-board RAM (upgrade to 2M bytes)
- RJ-11/45 interface
- Good overall performance
- Limited operating system support

Product Recommendations

- Madge Smart 16/4 AT Ringnode
- Madge Smart 16/4 MC Ringnode

The Madge AT and MCA Ringnode products' high overall evaluations recommend the MCA version for server applications and the AT version for either server or workstation use. Excellent performance, features, and usability justify their somewhat high price for many organizations.

- Andrew TRA 4/16 ISA Plus
- Andrew TRA 4/16 MCA Plus
- Olicom OC-3114 ISA 16/4
- Olicom OC-3128 MCA 16/4

Excellent performance and competitive pricing make the Andrew and Olicom adapters good choices for server or workstation installations. At present, none of these adapters support the Banyan VINES network environment in the server.

Rating Summaries

Figure 1.
Andrew TRA 4/16 ISA Plus Ratings

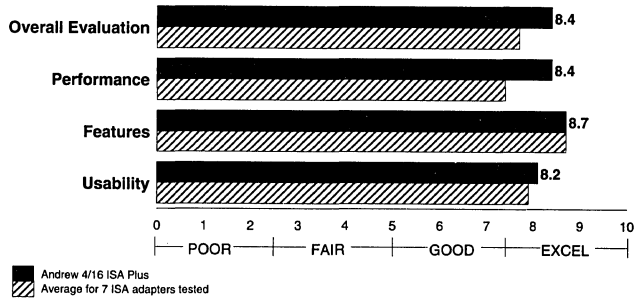


Figure 2.
Andrew TRA 4/16 MCA Plus Ratings

Figure 3.
IBM 16/4 Token-Ring Adapter Ratings

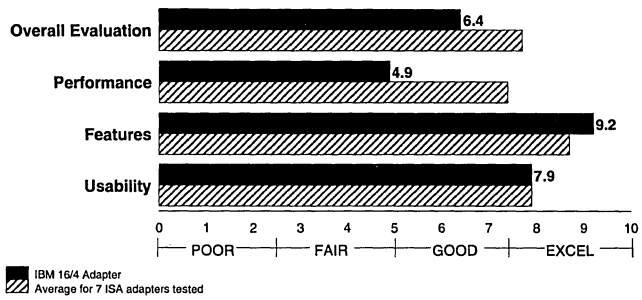


Figure 4.
IBM 16/4 Token-Ring Adapter/A Ratings

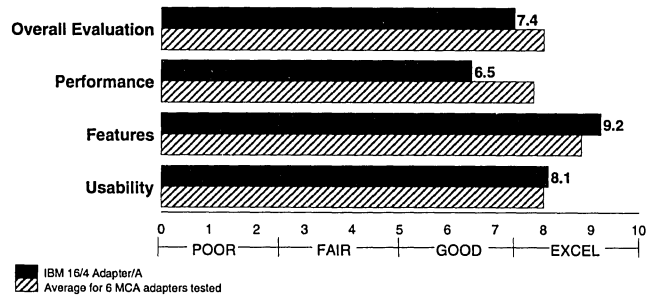


Figure 5.
Lantana Cypress/3-16 Ratings

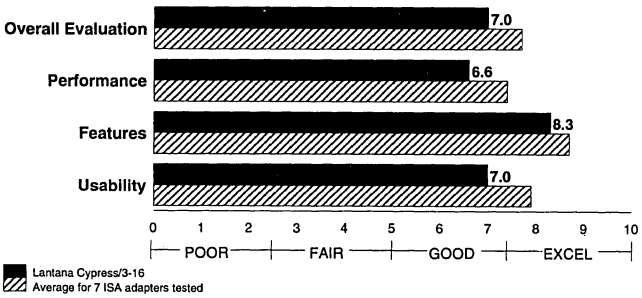


Figure 6.
Lantana Cypress/2-16 Ratings

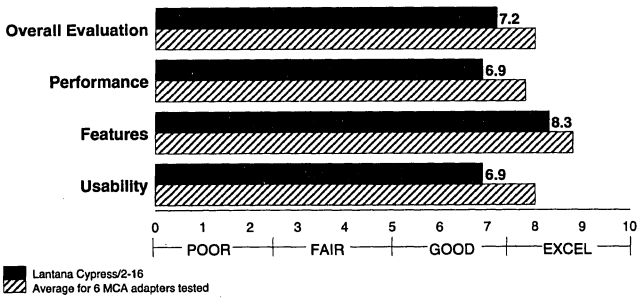


Figure 7.
Madge Smart 16/4 AT Ringnode Ratings

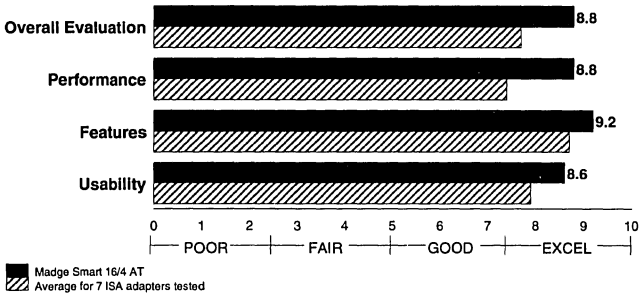


Figure 8.
Madge Smart 16/4 MC Ringnode Ratings

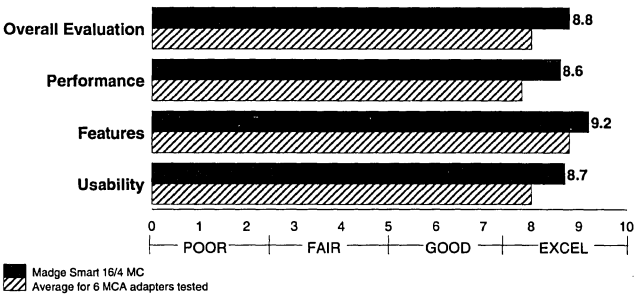


Figure 9.
Olicom OC-3114 ISA 16/4 Ratings

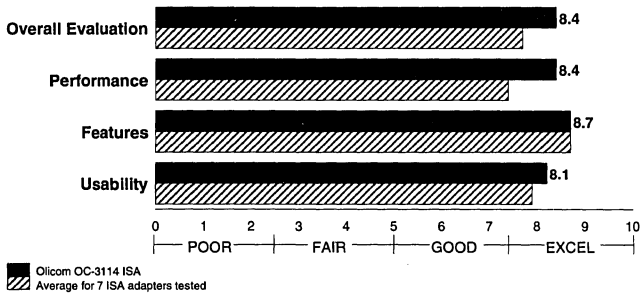


Figure 10.
Olicom OC-3128 MC 16/4 Ratings

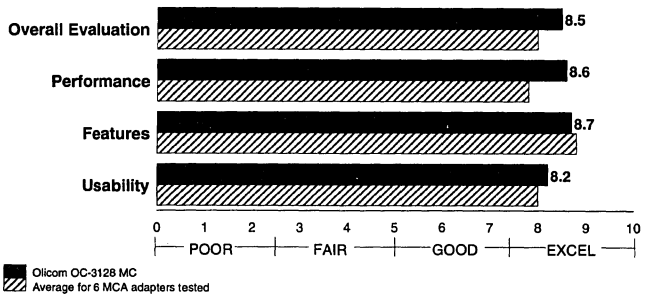


Figure 11.
Racore M8113 16/4 ISA Ratings

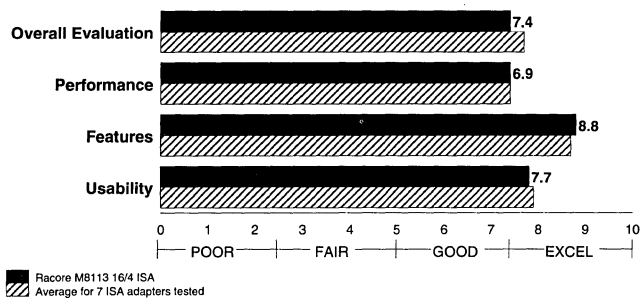


Figure 12.
Racore M8114 16/4 MCA Ratings

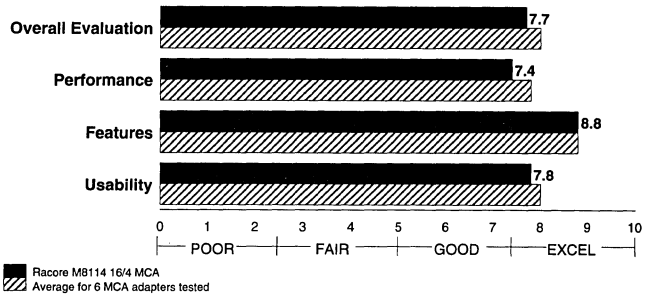
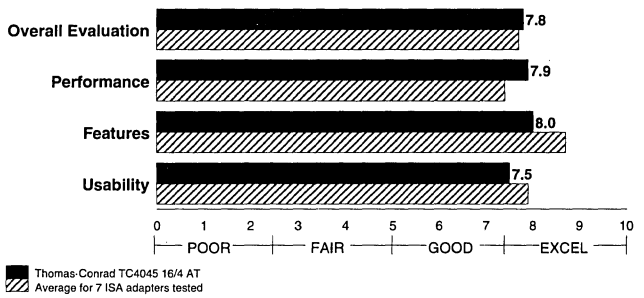


Figure 13.
Thomas-Conrad TC4045 16/4 AT Ratings



Overall Evaluation

The ISA and MCA versions of the Madge, Andrew, and Olicom adapters achieve high rankings with excellent performance, well-rounded features, and good usability. The Andrew and Olicom MCA adapters slightly outperform the Madge MCA adapter. The otherwise sluggish 8-bit IBM ISA adapter closes in on the 16-bit bus master cards in the low-level NETBIOS tests. Considering its somewhat inefficient shared memory data transfer method and 8-bit bus width, the IBM performs competitively against the 16-bit cards overall. The IBM 16/4 works well with almost all the popular network operating systems, supplies a good range of features, and is very easy to configure and install.

The Madge cards, especially the ISA version, excel with heavy throughput and perform impressively in the file server. The well-written NetWare IPX and server drivers contribute to the Madge cards' strong performance. The Madge Smart AT is the fastest ISA card by a significant margin (some 30% faster than the 8-bit IBM 16/4 Adapter and 12% faster than the slowest 16-bit ISA bus master card); it provides good network operating system support, a good mix of features, very good documentation, and excellent diagnostic and configuration utilities.

The Andrew and Olicom cards perform similarly well and support a number of interface standards and network operating systems (no server support for VINES networks). All come with good documentation.

The Thomas-Conrad ISA card returns somewhat inconsistent performance and offers limited operating system support and less than adequate usability. It performs well in the low-level throughput tests and excels with selected high-level applications (Lotus 1-2-3 with no traffic, Xcopy to server with Foxbase traffic, Xcopy from server with mail traffic). Its performance overall falls only 10% short of the top-rated Madge.

The Racore and Lantana cards offer neither strong performance nor good usability. Their average documentation features less than adequate organization. Although the Lantana cards come with excellent configuration utilities and software-based configuration, the documentation is inadequate for complex network operating environments. It provides insufficient information on software installation and setup. The Lantana cards' operating system and standards support are limited.

Methodology

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

Overall Evaluation Score = (6 x Performance Score) + (2 x Features Score) + (1.5 x Usability Score) + (0.5 x Testers' Overall Evaluation) ÷ 10.

Performance

In this evaluation, the definitive performance determinants seem to be the adapter's bus width and the chipset used to provide IEEE 802.5 compatibility. Other determinants include on-board firmware, adapter-to-host interface method (bus master DMA or shared memory), bus type, and network driver software. A token-ring adapter with a 32-bit EISA bus interface and bus mastering might exhibit somewhat different performance results than ISA or MCA versions of the same adapter. For this evaluation, all the test systems use either the 8- or 16-bit ISA bus or a 16-, 24-, or 32-bit MCA bus. Ring speed is not a comparative factor because all the cards were tested at 16M bps. The adapter's device driver or IPX driver may be another significant performance factor. Madge's custom Novell IPX driver seems to improve the Smart Ringnode's performance appreciably.

Bus master adapters (ISA and MCA) consistently outperform both IBM 16/4 shared memory adapters. Sixteen-bit bus master cards are uniformly faster than the 8-bit IBM ISA card. Likewise, the 16-bit MCA bus master cards are uniformly faster than the 16-bit IBM Adapter/A, again showing a decided advantage in bus mastering over shared memory in adapter-to-host data transfers.

Methodology

Performance ratings are based on performance indexes for the high-level application and transaction processing tests and for the low-level throughput tests. A product's score for a single benchmark is (Methodology Weight) ÷ (Best

Time). The overall Performance rating is a weighted average of scores for the individual benchmarks.

Performance Score = (5 x Lotus 1-2-3 Benchmark) + (5 x Microsoft C Benchmark) + (5 x Xcopy to Server Benchmark) + (5 x Xcopy from Server Benchmark) + (24 x Foxbase+/LAN Benchmark) + (8 x Transaction Processing Benchmark) + (13 x Low-Level Throughput Benchmark) ÷ 65.

Features

Features that enhance compatibility and performance are the most heavily weighted in NSTL's evaluation. The Andrew, IBM, Olicom, and Madge cards provide good support for multiple operating systems and configuration options.

The IBM cards set the de facto standard for token-ring network interface cards (and the basis for the IEEE 802.5 standard). With the 16/4 adapters, IBM improves on the standard with more configuration options and support for enhancements such as early token release and 16M bps data transfers with correspondingly larger ring bandwidths.

Cards with lower ratings lack configuration options and support for one or more operating systems and interface standards. The Racore, Thomas-Conrad, and Lantana cards do not support Banyan VINES 4.0 (the Andrew and Olicom cards provide workstation support only) or IBM OS/2 LAN Server, and the Thomas-Conrad and Lantana cards do not support Microsoft LAN Manager.

Methodology

Features ratings are based on a comparison of each interface card against a comprehensive list of features and specifications compiled by NSTL. NSTL verified each product's support for the listed features during testing. The Features rating is a weighted avarage of scores for the individual features (listed with their methodology weights in Table 4).

Usability

Usability ratings are based on tests of the products' installation and configuration procedures and installation of device drivers that interface with the network operating system. Configuration is often determined by the presence of other adapters in the host system and by available memory locations, I/O addresses, and DMA channels. Conflicts in MCA systems are more easily resolved because MCA adapters are configured entirely via software. (The Lantana Cypress/3-16 is the only ISA bus adapter with an entirely software-based configuration and setup.)

Most of the installations require similar levels of effort, and the configurations require minimal alterations to the factory-set switch and/or jumper values. Except for the Racore and Lantana cards, the products' documentation is uniformly good. The Racore documentation lacks clarity and is not well organized; the Lantana documentation lacks comprehensiveness and organization.

The Madge AT Ringnode and Racore M8113 come with descriptions of switch settings printed on the card surface, eliminating the need to consult a manual. The Madge configuration uses several clearly identified switches. The Racore, Andrew, and Olicom ISA adapters use a single switch block for configuration settings and a jumper (a sliding switch on the Andrew/Olicom) for 4M or 16M bps speed selection. The IBM ISA adapter uses a single switch block at its top edge for all configuration settings and speed selection. All these cards can be reconfigured while installed in the host system.

The Thomas-Conrad comes with multiple jumpers and switches scattered across the board, and the manual is definitely required for configuration. The Lantana ISA adapter uses an MCA-style software-based configuration; ring speed and media type are selected via jumpers on the Lantana ISA and MCA cards.

Methodology

Usability ratings are based on evaluations of the products' installation (setup, configuration, settings, and ease of physical insertion into the PC expansion slot), the availability of diagnostic and configuration utilities, and the quality of the documentation. The Usability rating is a weighted average of scores for the individual criteria.

Usability Score = (4 x Manual Score) + (2 x Hardware Installation and Setup Score) + (2 x Software Installation, Diagnostics, and Error Messages Score) ÷ 8.

Performance Results

Token-ring adapter performance is influenced by a number of factors relating to its hardware design and software interface to the network operating system. For this evaluation, the performance factors can be narrowed to the chipset, on-board firmware, adapter-to-host interface method (bus master DMA or shared memory), bus type (ISA or MCA) and interface width, and the driver software loaded to support the board. A token-ring adapter with a 32-bit EISA bus interface and bus mastering might exhibit somewhat different performance results than an ISA or MCA version. The test systems use an 8- or 16-bit ISA bus or a 16- or 24-bit MCA bus. Ring speed is not a comparative factor because all the adapters are tested at 16M bps.

NSTL evaluated token-ring card performance with four applications: Lotus 1-2-3 Release 3, Microsoft C, Foxbase+/LAN, and DOS Xcopy. The application tests were timed on the primary workstation with the secondary stations idling. The tests were then repeated with background ring traffic generated by Lotus 1-2-3, Foxbase, DOS Xcopy, and cc:Mail on five secondary workstations with test cards installed. A suite of 16 Foxbase+/LAN database tests ran on one, three, five, and eight workstations with and without indexes (one, three, and five workstations contained test cards). The cards were also tested running Foxbase transaction processing and low-level throughput tests.

Background Traffic

Foxbase background traffic consisted of each workstation performing a transaction no more than 30 times a minute. The transaction looks up indexed records in three files and locks, updates, and unlocks one record in each file. In Lotus, each secondary workstation executes a macro that combines and saves files metered to be active no more than every 20 seconds on each station. cc:Mail background traffic consisted of the five workstations submitting a

Figure 14a.
Lotus 1-2-3, ISA Adapters

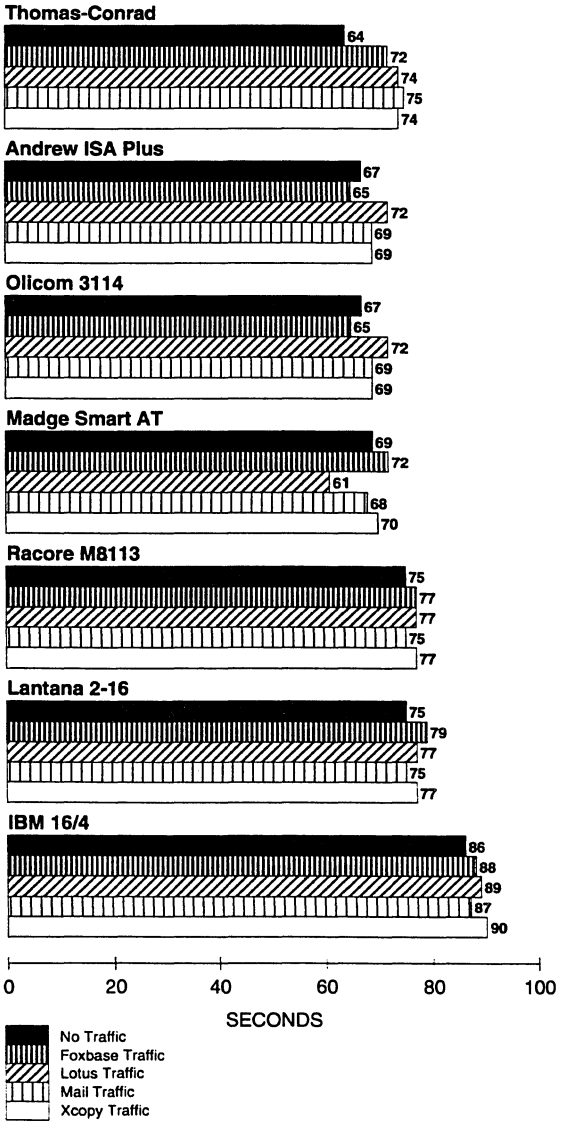
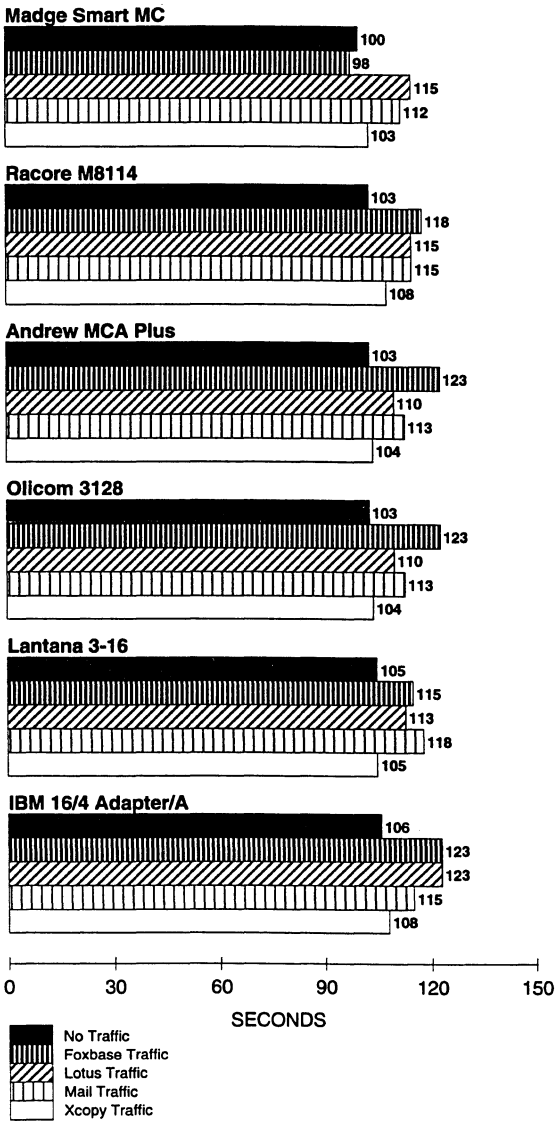


Figure 14b.
Lotus 1-2-3, MCA Adapters



100K-byte file every 44 seconds. Xcopy traffic copies a 128K-byte directory tree from the server to the five background traffic workstations once every 19 seconds.

Network Configuration

Server: AST Premium 386/25 (for ISA adapters) or IBM PS/2 Model 8580-111 (for MCA adapters) running Novell NetWare/386 3.1.

Primary Workstation: AST Premium 386/25 (ISA) or IBM PS/2 Model 8580-041 (MCA).

Secondary Workstations: Eight Everex Step 386iS systems.

Controller Workstation: AST Bravo/286 automated the tests.

The network was connected using IBM 8228 Multiple Access Units (MAUs) and Type 1 shielded twisted-pair (STP) cable. For all the tests, the controller workstation and three secondary workstations used IBM Token-Ring 16/4 Adapters.

According to standard procedure for NSTL LAN product evaluations, all test data, scripts, application programs, and custom program files were restored to the controller station (from a Maynard MaynStream 1300 DAT archive). Data, scripts, and programs were created and/or modified according to the current test methodology. A batch program run on the control workstation uploaded the application programs and custom automation program files to the server.

For testing each product, the appropriate NetWare/386 server driver (NetWare Loadable Module, or NLM) supplied by the vendor was loaded on the server (Novell supplies server NLM and workstation driver files for the IBM

Figure 15a.
Microsoft C 5.0, ISA Adapters

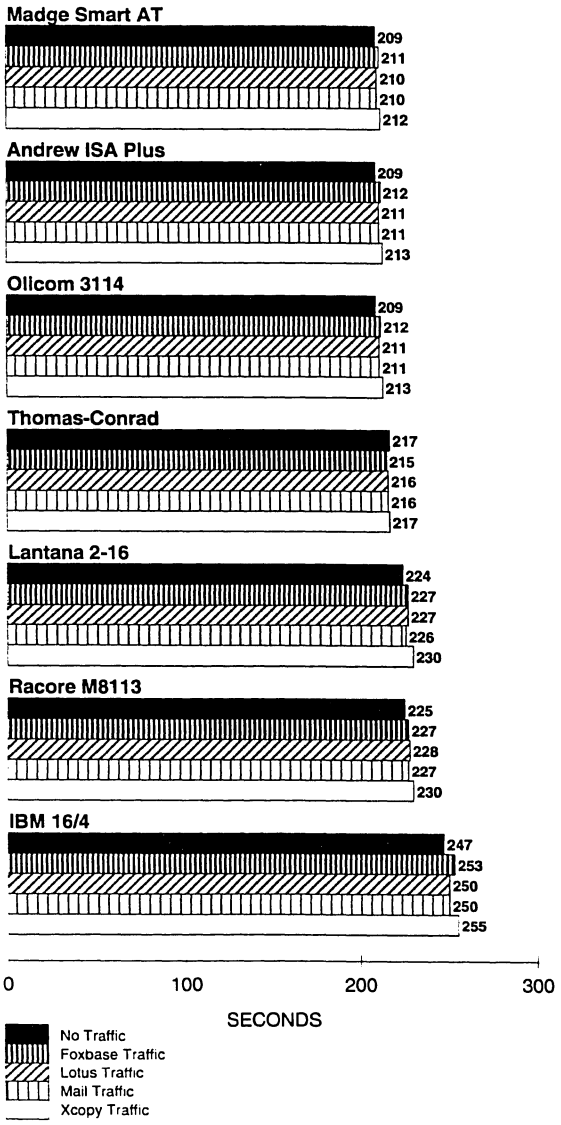
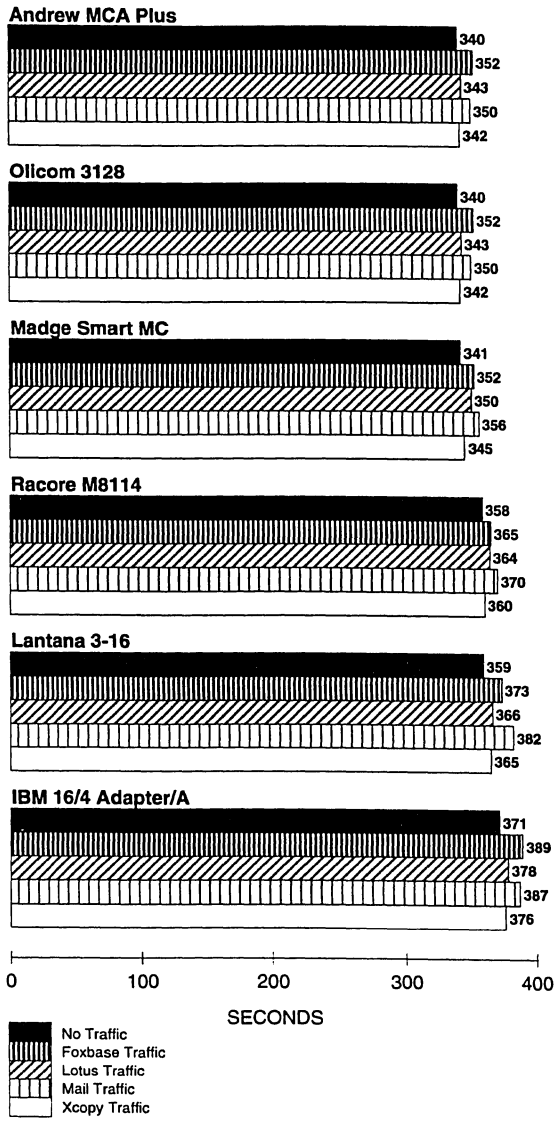


Figure 15b.
Microsoft C 5.0, MCA Adapters



cards). The primary workstation and five secondary workstations with test cards were set up with the appropriate IPX drivers and matching shell files. The workstation IPX and NETx shell or redirector drivers were generated on the server from vendor-supplied files, except for the Madge card, which comes with a preconfigured SMART IPX workstation driver. Stations with nontest cards (IBM Token-Ring 16/4 Adapters) kept the same cards and drivers throughout the tests.

Lotus 1-2-3

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

Analysis

With and without traffic, the 16-bit cards outperform the 8-bit IBM ISA adapter by a large margin. Among the 16-bit cards, those with 24-bit (Andrew and Olicom) and 32-bit addressing (Madge) outperform those with 16-bit addressing in the MCA bus architecture. In both bus architectures, bus-mastered DMA cards are faster than the shared memory IBM cards, which struggle under the heavy data load, especially at the server.

The Madge MC Ringnode exhibits the fastest performance overall, followed by the Andrew, Olicom, Lantana, and Racore MCA cards. Similarly, the Madge AT Ringnode performs fastest in the ISA architecture, followed by the Andrew, Olicom, and Thomas-Conrad cards. The Thomas-Conrad slows under traffic loading, probably because of server driver inefficiency. Well-written drivers give the Madge and Andrew/Olicom cards distinct performance advantages overall.

Figure 16a.
Xcopy to Server, ISA Adapters

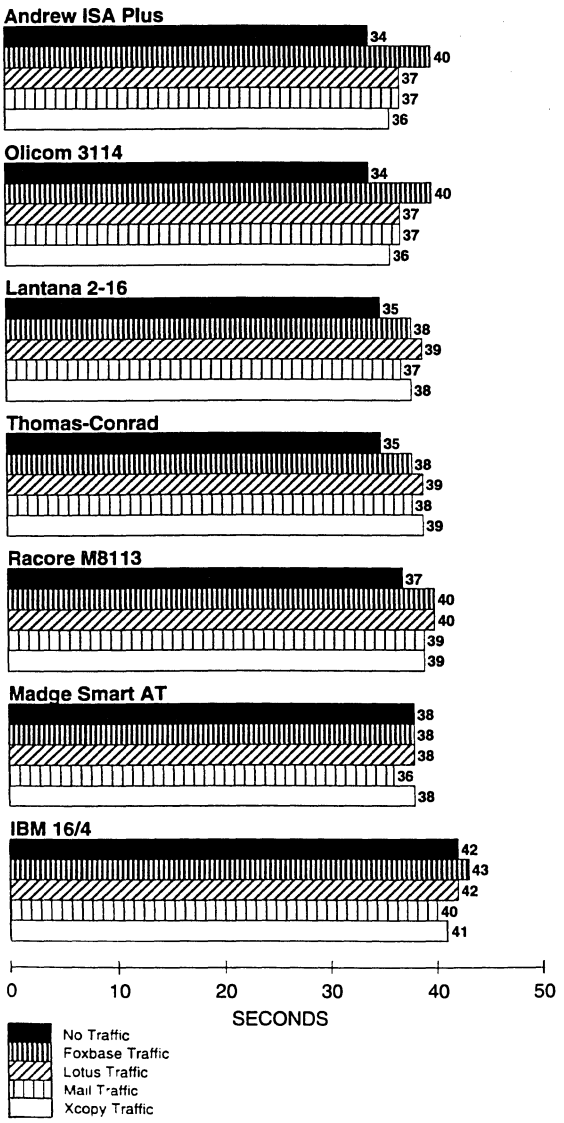
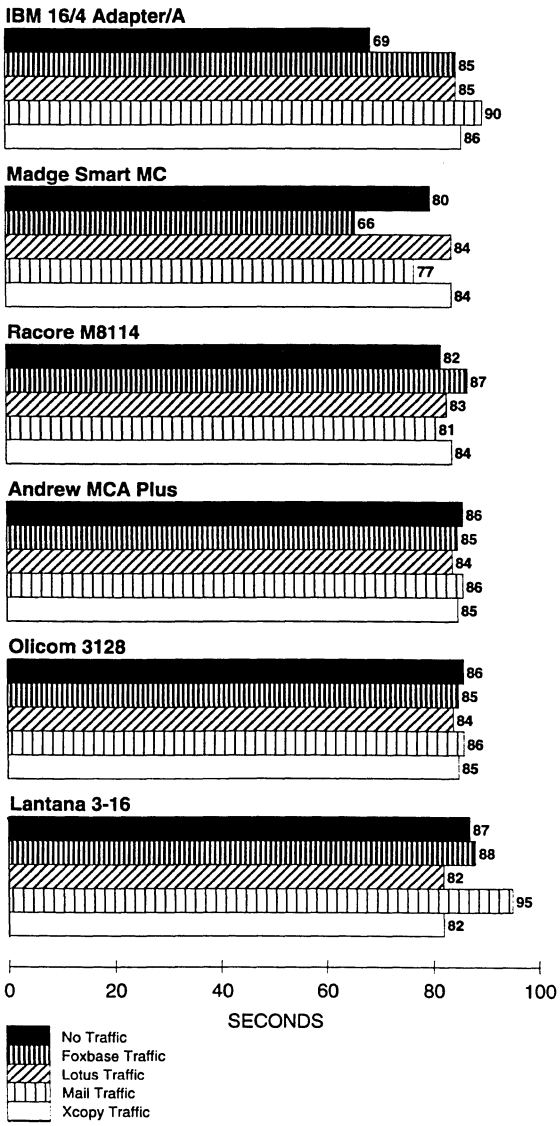


Figure 16b.
Xcopy to Server, MCA Adapters



Microsoft C 5.0

A large aggregate of XLISP 2.0 C source code (10,928 lines, or 245,222 bytes) was compiled and linked, forming an executable file of 147,228 bytes. The test was repeated with traffic running on five secondary workstations. The test primarily transfers data from the server to the workstation (the source code and loading the compiler). Lotus and Xcopy traffic increase data movement to the server; the other traffic conditions intensify general data movement and create a fairly steady stream of ring traffic.

Analysis

The advantages of bus mastering and an efficient driver with good buffer management are clearly demonstrated in times for the Andrew, Olicom, and Madge cards. The 8-bit IBM ISA card struggles under the heavy data load, and the 16-bit MCA IBM 16/4 lags somewhat behind the other 16-bit MCA cards.

The effects of traffic appear to be uniform for the ISA and MCA architectures, showing 10% (MCA) and 20% (ISA) differences between the IBM cards and the fastest cards in each category. The effects of traffic are less pronounced among the MCA adapters as bus mastering and efficient bus arbitration minimize bus bottlenecks in the MCA. Except for the IBM adapters, which use shared memory, performance differences among the cards are minimal.

Xcopy to Server

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

Figure 17a.
Xcopy from Server, ISA Adapters

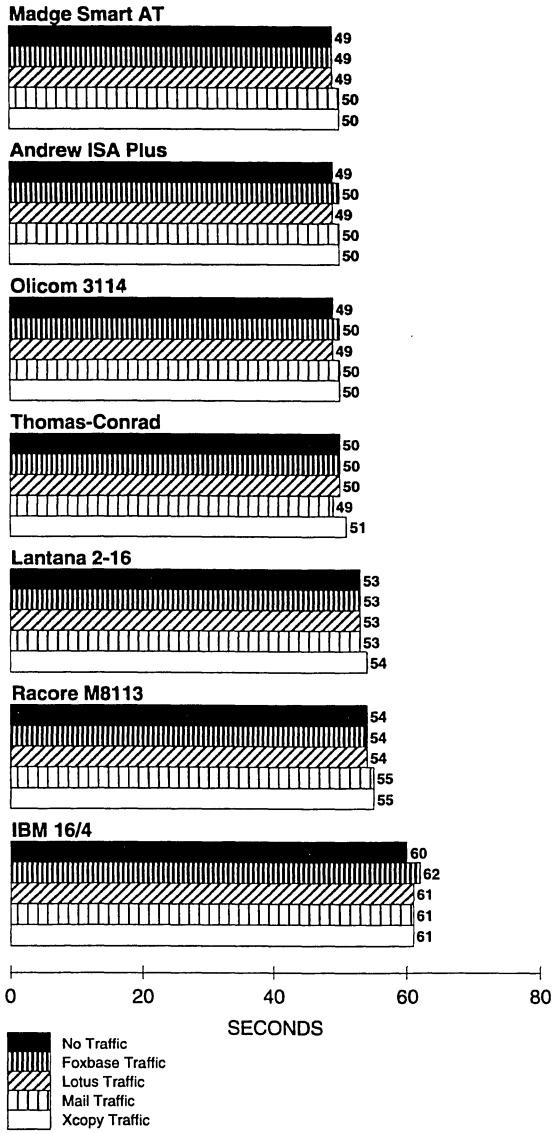
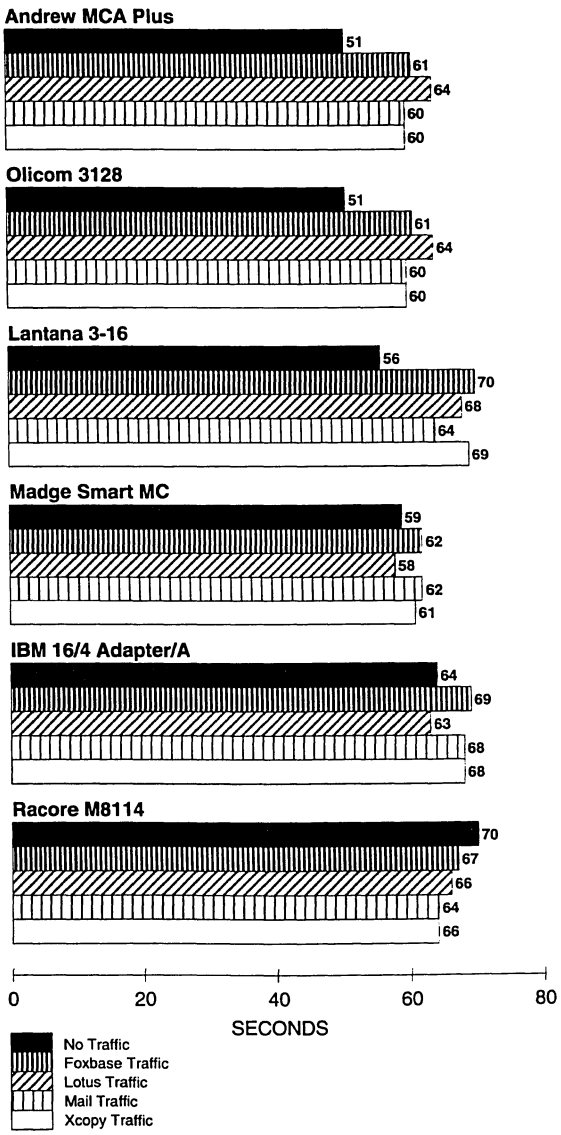


Figure 17b.
Xcopy from Server, MCA Adapters



Analysis

The Xcopy without traffic produces nearly identical times for the 16-bit interface cards in both architectures. The IBM Adapter/A performs about 25% faster than the (usually faster) Andrew and Olicom MCA cards. The large bulk data movement seems to dominate the bus interface width and ring speed. The IBM MCA bus' high ring speed combined with efficient buffer management help it blaze through the Xcopy test with no traffic; cc:Mail and Foxbase traffic slow it appreciably. The 8-bit bus interface creates a bottleneck for the IBM ISA card despite the advantage of high ring transmission speed; the IBM ISA card trails the Andrew and Olicom by about 25%.

Traffic stresses the ring bandwidth, more so for specific traffic among the MCA adapters. cc:Mail and Foxbase traffic produces the most marked (and similar) effects. Lotus and Xcopy traffic is less stressful because Lotus and Xcopy stress the bus interface more than the server operating system, and MCA is more efficient at bulk data transfer. Traffic that stresses the server software's file handling routine (such as cc:Mail and Foxbase in this test) would be more pronounced in MCAs. The traffic effects are more uniform among the ISA bus tests.

Xcopy from Server

The 5M-byte directory tree was copied from the server to the primary workstation using the DOS Xcopy command with the /s parameter. The test is repeated with traffic running on five secondary workstations.

Analysis

Workstation load becomes more influential as the workstation uses resources to write data to disk. With and without traffic, the 16-bit ISA cards outperform the 8-bit IBM

Table 1a. Foxbase+/LAN Tests (ISA Adapters)

No Traffic (times in seconds)

	Andrew/ Olicom	IBM	Lantana	Madge	Racore	Thomas-Conrad
Write Indexes	55	58	55	55	55	55
Create Indexes	15	18	16	15	16	16
Copy Records	18	24	20	18	21	18
Delete Records	24	36	26	25	28	25
Append Files	10	15	11	9	11	10
Pack Database	22	30	24	23	25	23
Process Transactions	23	25	24	22	23	23
Create Indexes	5	6	5	5	6	5
Process Transactions	41	51	46	35	43	43
Append Records, Reindex	58	71	60	58	62	60
Process Transactions	53	72	61	52	57	58
Select Indexed Records	7	7	7	6	6	7
Select Unindexed Records	14	17	14	14	15	14
Group and Subtotal	2	2	1	2	2	2
Two-File Join	2	2	2	1	2	2
Four-File Join	23	25	23	23	23	23

Foxbase Traffic (times in seconds)

	Andrew/ Olicom	IBM	Lantana	Madge	Racore	Thomas-Conrad
Write Indexes	55	57	55	55	56	55
Create Indexes	15	18	15	16	16	15
Copy Records	18	25	20	18	20	18
Delete Records	24	37	27	25	28	25
Append Files	10	14	12	10	11	11
Pack Database	22	30	24	23	25	22
Process Transactions	23	25	23	22	23	23
Create Indexes	5	7	6	5	5	5
Process Transactions	42	53	47	35	44	46
Append Records, Reindex	57	70	61	59	62	61
Process Transactions	54	76	63	53	59	61
Select Indexed Records	7	8	7	7	7	7
Select Unindexed Records	14	17	15	13	15	14
Group and Subtotal	2	2	2	2	2	2
Two-File Join	2	3	2	2	2	2
Four-File Join	22	25	24	22	24	23

Table 1a. Foxbase+/LAN Tests (ISA Adapters) (Continued)

Lotus Traffic (times in seconds)

	Andrew/ Olicom	IBM	Lantana	Madge	Racore	Thomas-Conrad
Write Indexes	55	58	56	55	56	55
Create Indexes	15	18	16	15	16	15
Copy Records	18	24	20	18	20	19
Delete Records	24	36	26	25	28	25
Append Files	11	15	11	9	11	10
Pack Database	22	30	24	23	25	22
Process Transactions	23	25	24	22	23	23
Create Indexes	5	6	5	5	5	5
Process Transactions	41	52	46	35	43	46
Append Records, Reindex	57	71	61	59	62	62
Process Transactions	54	73	61	52	58	61
Select Indexed Records	7	8	7	7	7	7
Select Unindexed Records	14	17	15	13	15	14
Group and Subtotal	2	2	2	2	2	2
Two-File Join	1	2	2	2	2	1
Four-File Join	23	25	23	22	23	23

16/4 card by a large margin (around 24%). Broader differences among the MCA cards indicate different inefficiency levels in server and workstation drivers. For example, the Racore M8114 is slower than the IBM MCA card because of inefficient buffer management at the workstation.

Traffic does not stress the server, and its effects are more uniform between the ISA and MCAs. Among the ISA adapters, the most marked differences (about 23%) are between the 8-bit IBM and the 16-bit cards.

Foxbase+/LAN

Foxbase ran a series of transactions against a banking database: Write indexes to three files, Create Indexes on four files, Copy Selected Records to Temporary Files, Delete Selected Records, Append Files, Pack Database (removing deleted records and reindexing), Process 1,000-Transaction Batch, Create Indexes on History File, Process 1,000-Transaction Batch, Append Records to History File and Reindex, Process 1,000-Transaction Batch, Select 1,000 Records on Indexed Field, Select 1,000 Records on Unindexed Field, Group and Subtotal 200-Record File and Report, Two-File Join and Report, and Four-File Join and Report.

Analysis

The 16-bit cards with bus mastering perform well in the ISA architecture, led by the Madge, Andrew, and Olicom. In the MCA environment, the Andrew, Olicom, and Madge lead with similar times. The Racore and Lantana are slightly less efficient in the ISA bus architecture.

Traffic effects follow trends set in the Xcopy from Server benchmark in both architectures, indicating a predominance of workstation activity over server activity. Performance differences among traffic types are less marked in both architectures.

Transaction Processing

Using five database files in Foxbase+/LAN Version 2.1 (Accounts, Teller, Branch, Transaction, and History), 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. For the one-workstation test, the primary workstation with a test adapter installed ran the test. The three-, five-, and eight-station tests ran on the Everex Step 386iS secondary workstations with five ISA test adapters in five secondary workstations and the appropriate test adapter in the server (AST Premium 386/25 or IBM PS/2 Model 80-111).

The transaction processing suite consisted of eight stages: one workstation processing 960 transactions without and with four indexes on the History file; three workstations each processing 320 (nonoverlapping) transactions without and with indexes; five workstations, each processing 192 transactions without and with indexes; and eight workstations, each processing 120 transactions with-

Table 1b. Foxbase+/LAN Tests (MCA Adapters)

No Traffic (times in seconds)

	Andrew/Olicom	IBM	Lantana	Madge	Racore
Write Indexes	78	80	79	79	79
Create Indexes	23	25	24	24	24
Copy Records	25	29	27	25	28
Delete Records	30	37	34	31	33
Append Files	28	27	29	27	26
Pack Database	31	37	34	32	37
Process Transactions	31	32	31	30	31
Create Indexes	9	9	9	9	9
Process Transactions	52	61	60	51	56
Append Records, Reindex	94	96	96	94	100
Process Transactions	65	79	77	66	73
Select Indexed Records	20	20	20	20	20
Select Unindexed Records	22	24	23	22	22
Group and Subtotal	3	3	3	3	3
Two-File Join	3	3	3	2	3
Four-File Join	35	37	36	35	36

Foxbase Traffic (times in seconds)

	Andrew/Olicom	IBM	Lantana	Madge	Racore
Write Indexes	79	81	79	80	80
Create Indexes	23	25	25	25	25
Copy Records	25	28	28	26	28
Delete Records	30	33	34	30	34
Append Files	30	31	32	29	32
Pack Database	36	36	35	34	34
Process Transactions	31	33	32	32	32
Create Indexes	9	10	9	10	10
Process Transactions	57	59	61	49	58
Append Records, Reindex	99	95	98	93	105
Process Transactions	64	74	79	67	76
Select Indexed Records	16	18	16	21	20
Select Unindexed Records	22	23	23	22	23
Group and Subtotal	3	3	3	3	3
Two-File Join	2	3	3	3	3
Four-File Join	36	38	38	38	38

Table 1b. Foxbase+/LAN Tests (MCA Adapters) (Continued)

Lotus Traffic (times in seconds)

	Andrew/Olicom	IBM	Lantana	Madge	Racore
Write Indexes	79	80	80	79	79
Create Indexes	24	26	24	25	25
Copy Records	25	28	28	26	28
Delete Records	30	33	34	31	34
Append Files	31	31	32	32	32
Pack Database	33	38	34	32	36
Process Transactions	31	32	31	31	31
Create Indexes	9	9	9	10	8
Process Transactions	54	97	60	45	56
Append Records, Reindex	97	100	97	92	103
Process Transactions	65	80	79	67	73
Select Indexed Records	20	22	20	19	20
Select Unindexed Records	22	24	23	22	23
Group and Subtotal	3	3	3	3	3
Two-File Join	3	3	3	3	3
Four-File Join	35	38	38	36	36

out and with indexes. Indexes actually slow processing as they increase disk activity and file contention at the server but do not (in this scenario) speed record lookup.

Analysis

Transaction processing highlights the advantages of a wider bus interface, MCA architecture, and bus mastering. Differences between the Madge AT Ringnode and 8-bit IBM are dramatic. Aggregated results show over 110% performance difference between the fastest and slowest ISA cards and a very high 85% difference between the MCA cards. Differences are even more pronounced in the eight-workstation tests. The Madge AT Ringnode's performance at the server under heavy loading seems to be fastest. The Andrew and Olicom cards are the fastest in the one-station tests and with three stations with indexing, where the Racore and Lantana perform poorly. The 16-bit IBM MCA card's fast ring speed and well-designed chipset are offset by a lack of bus mastering.

Ring Traffic

A one-conversation test measured low-level throughput in two AST Premium 386/25 systems (ISA adapters) or in two IBM PS/2 Model 80 systems (MCA adapters) attached to an MAU with no server. A two-conversation test used four systems simultaneously attached to an MAU with no server. Transmission between the AST systems formed one conversation; transmission between the IBM systems formed another conversation. Throughputs (in bytes/second) were averaged to derive performance scores for one conversation, and the throughputs for all four systems were combined to produce two-conversation performance scores.

Each system was loaded with NETBIOS files recommended by the vendor and with custom NETBIOS sending and receiving programs optimized for throughput with no disk access or processing to bottleneck transmission. Except as noted, data transmissions used 64K-byte NETBIOS send requests to minimize NETBIOS processing overhead. The receive buffer was set to 2,048 bytes, and transmission frame sizes varied from 512 bytes to 1K, 2K, 4K, 8K, and 16K bytes (the maximum 16M bps token-ring transmission rate) in the Config.sys (entered as definable parameters in Dxmt0mod.sys) whenever possible. At the 16M bps ring speed, the largest frame is 16K bytes, but some adapters (due to buffer constraints) support smaller sizes only.

Analysis

Overall, larger frame sizes permit faster data transmission, but doubling the frame size does not double throughput because of ring bandwidth constraints and system overhead. Most of the ISA adapters perform more than twice as fast with the 4K-byte frame than with the 512-byte frame; the MCA versions achieve more than three times the speed with the 4K-byte frame. The Madge AT Ringnode achieves the best raw throughput at frames to 4K bytes with one and two conversations. The Madge MCA version

Figure 18a.
Transaction Processing, One Workstation

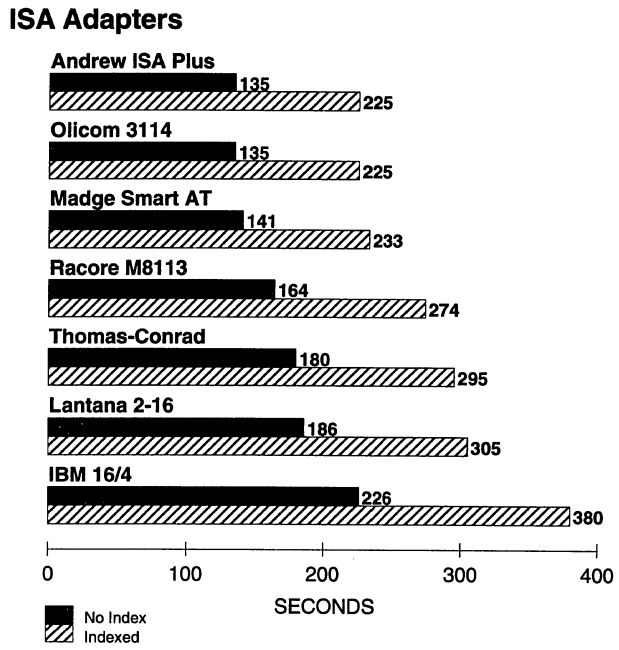
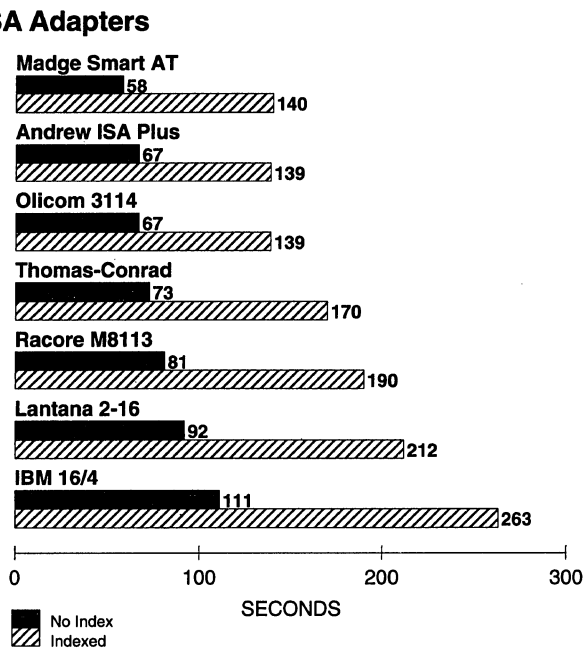


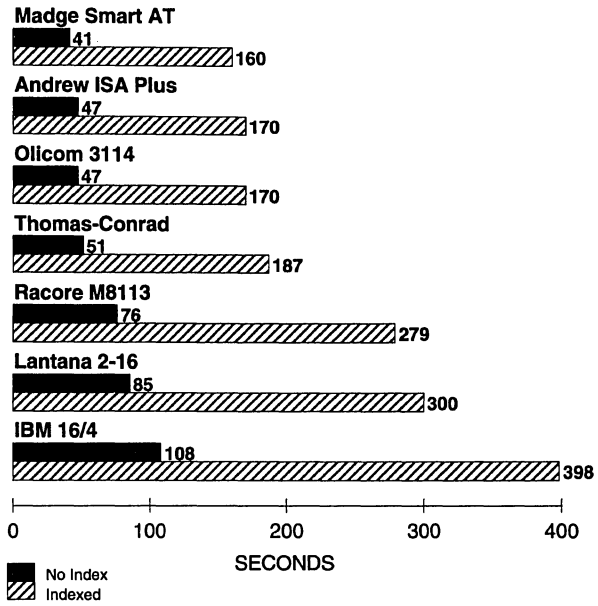
Figure 18b.
Transaction Processing, Three Workstations



also performs fastest at the 2K-byte frame size, but the Andrew, Olicom, and IBM cards take the lead at the 4K-byte setting. (At test time, the Madge LLC driver did not support frames over 4K bytes.) IBM, Racore, and Thomas-Conrad LLC drivers currently support frame sizes over 4K bytes. The IBM cards' ring speeds become less efficient with the higher frame sizes (8K bytes and 16K bytes), where the Thomas-Conrad and Racore cards perform faster.

For most business users, the throughput numbers are informative, but not all-encompassing. The 4M and 16M bps rates cannot coexist on a single ring, so 16M bps cards cannot be added to a ring with existing 4M bps cards; a second ring must be added or existing stations upgraded. Applications that do not use large buffers in their send requests and do not use protocols other than NETBIOS (e.g., NetWare IPX) restrict the ring frame size (the current IPX limit is 4K bytes for workstations). Furthermore, for many applications, performance bottlenecks are server disks, workstation computation, and other areas not affected by the choice of token-ring adapter.

Figure 18c.
Transaction Processing, Five Workstations



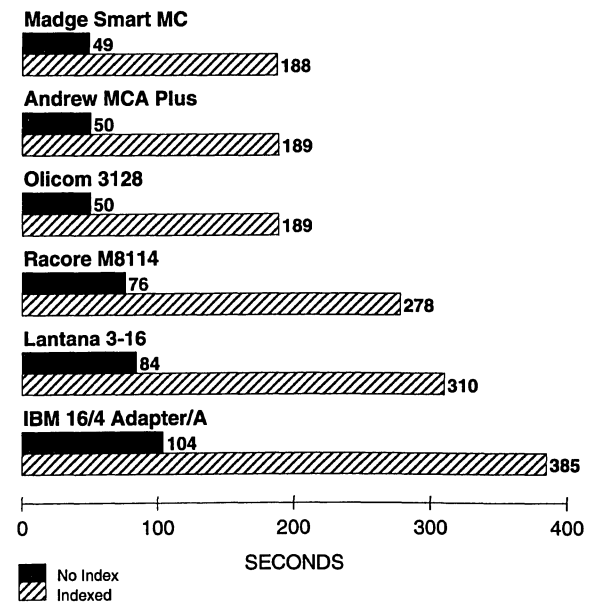
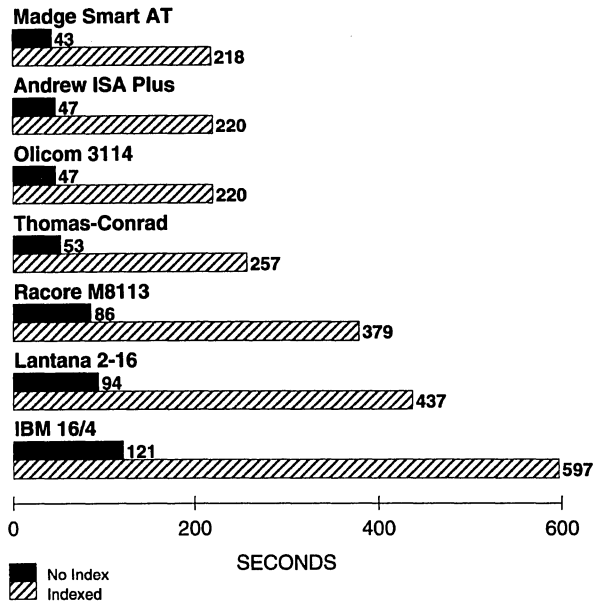
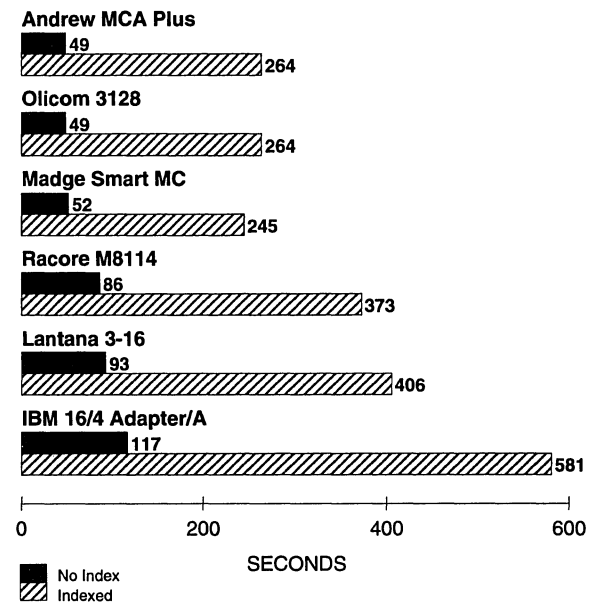


Figure 18d.
Transaction Processing, Eight Workstations.





For applications such as a server-to-server backbone ring or a database application using large buffers and running on NETBIOS, the advantages of the 16M bps performance are clear. Future versions of network applications and drivers may be enhanced to use higher ring speeds, and very heavily loaded rings may benefit from increased ring bandwidth.

Vendors

Andrew Corp.
2771 Plaza Del Amo
Torrance, CA 90503 (213) 320-7126

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

Table 2a. Ring Traffic Tests (ISA Adapters)

One-Conversation Averages (times in bytes per second)

Frame Size	Andrew/Olicom	IBM	Lantana	Madge	Racore	Thomas-Conrad
512 bytes	213157	226616	237844	282457	230425	251064
1K bytes	362269	354903	399591	502962	382090	402734
2K bytes	563899	456600	589862	695652	554914	580513
4K bytes	732167	512042	598131	799221	554914	580523
8K bytes	—	552937	—	—	717087	727964
16K bytes	—	531878	—	—	717087	720482

Two-Conversation Averages (times in bytes per second)

Frame Size	Andrew/Olicom	IBM	Lantana	Madge	Racore	Thomas-Conrad
512 bytes	423899	473104	345062	611964	439145	497679
1K bytes	740978	761482	738039	1018833	744074	826658
2K bytes	1178865	1027029	1139653	1370511	1103349	1169474
4K bytes	1490065	1217511	1154969	1446937	1125734	1308198
8K bytes	—	1288177	—	—	1385748	1485744
16K bytes	—	1303205	—	—	1386144	1492418

Table 2b. Ring Traffic Tests (MCA Adapters)

One-Conversation Averages (times in bytes per second)

Frame Size	Andrew/Olicom	IBM	Lantana	Madge	Racore
512 bytes	211745	247424	202639	335225	211572
1K bytes	380959	431218	357712	539721	371021
2K bytes	623904	626448	565973	725259	575713
4K bytes	902546	804190	538542	728654	592618
8K bytes	—	919827	—	—	832071
16K bytes	—	922598	—	—	832523

Two-Conversation Averages (times in bytes per second)

Frame Size	Andrew/Olicom	IBM	Lantana	Madge	Racore
512 bytes	423899	473104	345062	611964	439145
1K bytes	634831	666037	612861	882615	642517
2K bytes	1034542	936994	1005242	1253359	983285
4K bytes	1490065	1217511	1154969	1446937	1125734
8K bytes	—	1288177	—	—	1385748
16K bytes	—	1303205	—	—	1386144

Lantana Technology, Inc.
4393 Viewridge Avenue, Suite A
San Diego, CA 92123 (619) 565-6400

Madge Networks, Inc.
42 Airport Parkway
San Jose, CA 95131 (408) 441-1300, (800) 876-2343

Olicom USA, Inc.
1002 North Central Expressway, Suite 239
Richardson, TX 75080 (214) 680-8131

Racore Computer Products, Inc.
170 Knowles Drive
Los Gatos, CA 95030 (408) 374-8290

Thomas-Conrad Corp.
1908-R Kramer Lane
Austin, TX 78758 (512) 836-1935, (800) 332-8683

Characteristics

Table 3. Token-Ring Network Adapter Characteristics

	Host Interface	Software Included	LAN Operating System Support	Warranty and Support
Andrew TRA 4/16 ISA Plus	16-bit bus master DMA	Adapter diagnostics software; drivers for Novell NetWare, Microsoft LAN Manager, IBM PC LAN Program (DLC drivers)	Novell NetWare 286 2.1x, 2.2, NetWare 386 3.0-3.11; Banyan VINES/286 3.0, VINES/386 4.0, 4.1 (workstation only); IBM PC LAN Program 1.30, OS/2 EE Communications Manager, OS/2 LAN Server 1.2, 1.3; Microsoft LAN Manager 2.0; 3Com 3+Open 1.1; AT&T Unix 5.3, 5.4; SCO UNIX	1 year, covering parts, labor, and return shipment; toll-free telephone help
Andrew TRA 4/16 MCA Plus	24-bit bus master DMA	Adapter diagnostics software; drivers for Novell NetWare, Microsoft LAN Manager, IBM PC LAN Program (DLC drivers)	Novell NetWare 286 2.1x, 2.2, NetWare 386 3.0-3.11; Banyan VINES/286 3.0, VINES/386 4.0, 4.1 (workstation only); IBM PC LAN Program 1.30, OS/2 EE Communications Manager, OS/2 LAN Server 1.2, 1.3; Microsoft LAN Manager 2.0; 3Com 3+Open 1.1; AT&T Unix 5.3, 5.4; SCO UNIX	1 year, covering parts, labor, and return shipment; toll-free telephone help
IBM 16/4 Token-Ring Adapter	8-bit shared memory	Diagnostic software	Novell NetWare 286 2.1x, 2.2, NetWare 386 3.0-3.11; Banyan VINES/286 3.0, VINES/386 4.0; IBM PC LAN Program 1.30, LAN Server 1.x, OS/2 EE 1.x, AIX 1.2; 3Com 3+Open 1.1	1 year, covering parts and labor; toll-free telephone help
IBM 16/4 Token-Ring Adapter/A	16-bit shared memory	Diagnostic software	Novell NetWare 286 2.1x, 2.2, NetWare 386 3.0-3.11; Banyan VINES/286 3.0, VINES/386 4.0; IBM PC LAN Program 1.30, LAN Server 1.x, OS/2 EE 1.x, AIX 1.2; 3Com 3+Open 1.1	1 year, covering parts and labor; toll-free telephone help
Lantana Cypress/3-16	16-bit bus master DMA	Adapter diagnostics; drivers for Novell NetWare, Microsoft LAN Manager, IBM PC LAN Program (DLC drivers)	Novell NetWare 286 2.1x, 2.2, NetWare 386 3.0-3.11; IBM PC LAN Program 1.30, LAN Server 1.2, 1.3; Microsoft LAN Manager 2.0	2 years, covering parts and labor; telephone help
Lantana Cypress/2-16	16-bit bus master DMA	Adapter diagnostics; drivers for Novell NetWare, Microsoft LAN Manager, IBM PC LAN Program (DLC drivers)	Novell NetWare 286 2.1x, 2.2, NetWare/386 3.0-3.11; IBM PC LAN Program 1.30, LAN Server 1.2, 1.3	2 years, covering parts and labor; telephone help

Table 3. Token-Ring Network Adapter Characteristics (Continued)

	Host Interface	Software Included	LAN Operating System Support	Warranty and Support
Madge Smart 16/4 AT Ringnode	16-bit bus master DMA	Diagnostics; drivers for Smart LAN support software, Smart IPX/SPX protocols, 802.2 (LLC), NETBIOS, LAN Manager NDIS, Enhanced NetWare	Novell NetWare 286 2.1x, 2.2, NetWare 386 3.0-3.11; Banyan VINES/286 3.0, Banyan VINES/386 4.0, 4.1; IBM PC LAN Program 1.30, LAN Server 1.2, 1.3; Microsoft LAN Manager 2.0; 3Com 3+Open 1.1	5 years, covering parts, labor, and return shipment; toll-free telephone help
Madge Smart 16/4 MC Ringnode	16-bit bus master DMA	Diagnostics; drivers for Smart LAN support software, Smart IPX/SPX protocols, 802.2 (LLC), NETBIOS, LAN Manager NDIS, Enhanced NetWare	Novell NetWare 286 2.1x, 2.2, NetWare 386 3.0-3.11; Banyan VINES/286 3.0, VINES/386 4.0, 4.1; IBM PC LAN Program 1.30, LAN Server 1.2, 1.3; Microsoft LAN Manager 2.0; 3Com 3+Open 1.1	5 years, covering parts, labor, and return shipment; toll-free telephone help
Olicom OC-3114 ISA 16/4	16-bit bus master DMA	Diagnostic software; drivers for SCO UNIX 3.2; UNIX System V 3.2, 4.0	Novell NetWare 286 2.1x, 2.2, 3.0, NetWare 386 3.1, 3.11; Banyan VINES/286 3.0, VINES/386 4.0, 4.1; IBM PC LAN Program 1.30, LAN Server 1.2, 1.3, OS/2 EE 1.1, 1.2; Microsoft LAN Manager 2.0; 3Com 3+Open 1.1; SCO Unix, AT&T Unix 5.3, 5.4	1 year, covering parts, labor, and return shipment; support through OEMs
Olicom OC-3128 MC 16/4	24-bit bus master DMA	Diagnostics; drivers for SCO UNIX 3.2; UNIX System V 3.2, 4.0	Novell NetWare 286 2.1x, 2.2, NetWare 386 3.0-3.11; Banyan VINES/286 3.0, VINES/386 4.0, 4.1; IBM PC LAN Program 1.30, LAN Server 1.2, 1.3, OS/2 EE 1.1, 1.2; Microsoft LAN Manager 2.0; 3Com 3+Open 1.1; SCO UNIX, AT&T Unix 5.3, 5.4	1 year, covering parts, labor, and return shipment; support through OEMs
Racore M8113 16/4 ISA	16-bit bus master DMA	Drivers for Novell NetWare to 3.11; Microsoft LAN Manager NDIS; IBM LAN Server	Novell NetWare 286 2.1x, 2.2, NetWare 386 3.0-3.11; IBM PC LAN Program 1.30, LAN Server 1.3; Microsoft LAN Manager 2.0; 3Com 3+Open 1.1	1 year, covering parts, labor, and return shipment; toll-free telephone help
Racore M8114 16/4 MCA	16-bit bus master DMA	Drivers for Novell NetWare to 3.11; Microsoft LAN Manager NDIS; IBM LAN Server	Novell NetWare 286 2.1x, 2.2, NetWare 386 3.0-3.11; IBM PC LAN Program 1.30, LAN Server 1.3; Microsoft LAN Manager 2.0; 3Com 3+Open 1.1	1 year, covering parts, labor, and return shipment; toll-free telephone help
Thomas-Conrad TC4045 16/4 AT	16-bit bus master DMA	TCC drivers for IEEE 802.2 LLC; drivers for Novell NetWare 286 2.1x, 2.2, NetWare 386 3.x/3.11, IBM PC LAN Program 1.30, Microsoft LAN Manager 2.0	Novell NetWare 286 2.1x, 2.2, NetWare 386 3.0-3.11; IBM PC LAN Program 1.30; Microsoft LAN Manager 2.0; 3Com 3+Open 1.1	2 years, covering parts, labor, and return shipment; toll-free telephone help

Table 4a. Token-Ring Network Adapter Features (ISA Adapters)

	Weight	Andrew/ Olicom	IBM	Lantana	Madge	Racore	Thomas-Conrad
Physical Specifications	3						
Adapter length (in.)	0	6.5	7.5	11.0	8.3	13.1	13.1
Adapter height (in.)	0	4.5	4.3	4.5	4.2	4.2	4.2
Adapter-to-host method	0	BM/IO	SM	BM/IO	BM/IO	BM/IO	BM
Bus interface width (bits)	0	16	8	16	16	16	16
EISA adapter available	0	4Q/3Q	—	—	▲	—	—
EISA bus interface width (bits)	0	—	—	—	32	—	—
4M bps data transfers	0	▲	▲	▲	▲	▲	▲
16M bps data transfers	1	▲	▲	▲	▲	▲	▲
Amount of RAM on adapter (KB)	0	128	64	128	128	128	128
Amount of shared RAM (KB)	0	—	64	—	—	—	—
Maximum transmit/receive buffer (KB)	0	4	16	4	16	4	16
Maximum adapters per system	1	4	4	4	4	4	4
Number of ports used for base I/O	0	4	4	4	4	4	>5
Maximum DMA channel settings	1	3	NA	4	2	4	3
Maximum interrupt level settings	2	4	5	6	8	4	9
Remote boot PROM	0	OP	OP	OP	OP	OP	OP
IBM LAN Support Program	1	▲	▲	▲	▲	▲	▲
Diagnostics	2						
Diagnostic software supplier	3	▲	▲	BI	▲	▲	▲
ROM test	1	▲	▲	BI	▲	▲	▲
Internal transmit/receive test	1	▲	▲	BI	▲	▲	▲
Echo test	1	▲	▲	BI	▲	▲	▲
Open-close test	1	▲	▲	BI	▲	▲	▲
Ring insertion/removal test	1	▲	▲	BI	▲	▲	▲
Line monitor test	1	▲	▲	BI	▲	▲	▲
Compatible Network Operating Systems	5						
Novell NetWare 286 2.1x	4	▲	▲	▲	▲	▲	▲
Novell NetWare 286 2.2	1	▲	▲	▲	▲	▲	▲
Novell NetWare 386 3.0	1	▲	▲	▲	▲	▲	▲
Novell NetWare 386 3.1	4	▲	▲	▲	▲	▲	▲
Novell NetWare 386 3.11	1	▲	▲	▲	▲	▲	▲
Banyan VINES/286 3.0	1	WS	▲	—	▲	—	—
Banyan VINES/386 4.0	2	WS	▲	—	▲	—	—
Banyan VINES/386 4.1	1	WS	▲	—	▲	—	—
IBM PC LAN Program 1.30	1	▲	▲	▲	▲	▲	▲

**See footnotes on Page 125.*

Table 4a. Token-Ring Network Adapter Features (ISA Adapters) (Continued)

	Weight	Andrew/ Olicom	IBM	Lantana	Madge	Racore	Thomas-Conrad
IBM OS/2 LAN Server 1.2	2	▲	▲	▲	▲	—	—
IBM OS/2 LAN Server 1.3	1	▲	▲	▲	▲	▲	—
Microsoft LAN Manager 2.0	2	▲	▲	—	▲	▲	▲
3Com 3+Open 1.1	1	▲	▲	—	▲	▲	▲
Other	0	—/UX	3S	—	—	—	—
Standards Supported	2						
IEEE 802.2 LLC	1	▲	▲	▲	▲	▲	▲
IEEE 802.5	0	▲	▲	▲	▲	▲	▲
IBM NETBIOS	1	▲	▲	—	▲	▲	▲
Media Types Included	0						
Type 1, 2, or 6 w/DB9 connector	0	▲	—	▲	▲	▲	—
Type 3 or 9 w/RJ11/45 connector	0	—	—	▲	▲	▲	—

Table 4b. Token-Ring Network Adapter Features (MCA Adapters)

	Weight	Andrew/ Olicom	IBM	Lantana	Madge	Racore
Physical Specifications	3					
Adapter length (in.)	0	11.5	8.5	11.5	9.3	11.5
Adapter height (in.)	0	3.5	3.5	3.5	3.5	3.5
Adapter-to-host method	0	BM	BM	BM	BM	BM
Bus interface width (bits)	0	24	16	16	32	16
EISA adapter available	0	4Q/3Q	—	—	▲	—
EISA bus interface width (bits)	0	—	—	—	32	—
4M bps data transfers	0	▲	▲	▲	▲	▲
16M bps data transfers	1	▲	▲	▲	▲	▲
Amount of RAM on adapter (KB)	0	128	128	128	128	128
Amount of shared RAM (KB)	0	—	—	—	—	—
Maximum transmit/receive buffer (KB)	0	4	16	4	4	4
Maximum adapters per system	1	4	4	4	4	4
Number of ports used for base I/O	0	4	2	4	4	5
Maximum DMA channel settings	1	NA	NA	NA	NA	NA
Maximum interrupt level settings	2	4	8	6	3	4
Remote boot PROM	0	OP	OP	OP	OP	OP
IBM LAN Support Program	1	▲	▲	▲	▲	▲

See footnotes on Page 125.

Table 4b. Token-Ring Network Adapter Features (MCA Adapters) (Continued)

	Weight	Andrew/ Olicom	IBM	Lantana	Madge	Racore
Diagnostics	2					
Diagnostic software supplier	3	▲	▲	BI	▲	▲
ROM test	1	▲	▲	BI	▲	▲
Internal transmit/receive test	1	▲	▲	BI	▲	▲
Echo test	1	▲	▲	BI	▲	▲
Open-close test	1	▲	▲	BI	▲	▲
Ring insertion/removal test	1	▲	▲	BI	▲	▲
Line monitor test	1	▲	▲	BI	▲	▲
Compatible Network Operating Systems	5					
Novell NetWare 286 2.1x	4	▲	▲	▲	▲	▲
Novell NetWare 286 2.2	1	▲	▲	▲	▲	▲
Novell NetWare 386 3.0	1	▲	▲	▲	▲	▲
Novell NetWare 386 3.1	4	▲	▲	▲	▲	▲
Novell NetWare 386 3.11	1	▲	▲	▲	▲	▲
Banyan VINES/286 3.0	1	WS	▲	—	▲	—
Banyan VINES/386 4.0	2	WS	▲	—	▲	—
Banyan VINES/386 4.1	1	WS	▲	—	▲	—
IBM PC LAN Program 1.30	1	▲	▲	▲	▲	▲
IBM OS/2 LAN Server 1.2	2	▲	▲	▲	▲	—
IBM OS/2 LAN Server 1.3	1	▲	▲	▲	▲	▲
Microsoft LAN Manager 2.0	2	▲	▲	—	▲	▲
3Com 3+Open 1.1	1	▲	▲	—	▲	▲
Other	0	—/UX	3S	—	—	—
Standards Supported	2					
IEEE 802.2 LLC	1	▲	▲	▲	▲	▲
IEEE 802.5	0	▲	▲	▲	▲	▲
IBM NETBIOS	1	▲	▲	—	▲	▲
Media Types Included	0					
Type 1, 2, or 6 w/DB9 connector	0	▲	—	▲	▲	▲
Type 3 or 9 w/RJ11/45 connector	0	—	—	▲	▲	▲

▲—Yes, has feature.
BI—Built-in.
BM—Bus Master DMA.
IO—Programmed I/O.
NA—Not applicable.
OP—Optional.
SM—Shared memory.
UX—SCO and/or AT&T Unix 5.3 and 5.4 (Olicom only).
WS—Workstation only.
3S—3+Share 1.2.1.
3Q—Available 3rd quarter 1991 (Olicom only).
4Q—Available 4th quarter 1991 (Andrew only).

Ethernet Network Adapters

A Report from NSTL

In this report:

Synopsis

Focus
When considering which Ethernet adapter to purchase, performance in conjunction with specific adapter features, compatibility issues, support for standards and connectivity software, and price should be evaluated.

Products Tested
Artisoft AE-2
Artisoft Inc.
BICC Isolan 4110-2
BICC Data Networks, Inc.
CNet CN200E
CNET Technology, Inc.
Gateway G/Ethernet
Gateway Communications
Novell NE 2000, NE 1000
Novell Inc.
Pure Data Model PDI8023-16
Pure Data Ltd.
Racal Interlan NI6510
Racal Interlan Inc.
SMC Ethernet PC510
Standard Microsystems Corp.
3Com EtherLink Plus, EtherLink II
3Com Corp.
*Tiara LAN Card/E*16*
Tiara Computer Systems
WD Ethercard Plus16
Western Digital Corp.

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

Overall Rating	Product Name	Performance	Features	Usability	Price
8.5	Racal InterLan NI6510 Data-Link Controller	●	○	●	$495★
8.3	Western Digital Ethercard Plus16	●	●	●	$399★
8.2	Tiara LanCard/E* 16	●	●	○	$595
8.1	Gateway G/Ethernet	●	○	●	$445
8.0	BICC Isolan 4110-2	●	●	○	$495
7.8	SMC Ethernet-PC510	●	●	●	$495
7.4	Artisoft LANtastic AE-2	●	◍	○	$349
7.4	Novell NE2000	●	◍	○	$495
6.5	CNet CN200E	●	◍	◍	$439
6.5	3Com EtherLink Plus	○	●	●	$895
—	PureData PDI8023-16	NA	◍	●	$495

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

Overview

The Ethernet networking technology has as many adherents as detractors, and it is one among several that still have a large installed base. Aside from technological reasons, Ethernet continues to draw interest primarily because it is one of the earliest network technologies that is still in use. Relatively young networking technologies such as token-ring find it difficult to gain a market share in certain application areas because of Ethernet's historic entrenchment.

The introduction of IBM's 16M bps Token-Ring Network in November 1988 provided a high-performance alternative to Ethernet networks. Even though Ethernet still leads the market, current market studies show token-ring overtaking Ethernet in the PC local area network (LAN) market. The token-ring topology is more receptive to adding and deleting nodes and to recabling during operation. Token-ring also has the reputation for more fairly arbitrating contention among nodes because token-passing enforces sharing of the network. Furthermore, Ethernet performance is subject to noticeable degradation under heavy loads because of increased packet collisions and retransmissions.

Standard Ethernet networks are designed to transmit data at the optimum rate of 10M bps over network cables, but the actual data throughput between communicating stations is considerably less owing to protocol overhead and other factors. Network adapter cards provide different performance levels depending on their architectural design and driver software efficiency. This report examines the effects of various performance factors and explores their implications on the adaptability of Ethernet to specific application environments.

This report comprises results from tests performed in March 1990.

Evaluation Criteria

All the Ethernet network adapters tested maintain a Physical Layer (the first layer of the ISO network model) compatibility with the original Ethernet and the IEEE 802.3 CSMA/CD LAN specifications. Cards selected for testing have 16-bit bus interfaces (the 8-bit Novell NE1000 and 3Com Etherlink II were tested for performance comparison), allow thin coaxial cable connection, and support the Novell NetWare operating environment. Market share and visibility were considered in product selection. All the vendors have been in the networking market for at least two years, and each offers at least one Ethernet adapter that has been marketed for at least six months.

The PureData network adapter could not handle Foxbase+/LAN traffic on more than four or five workstations, and therefore is not included in performance and overall ratings because it could not complete all of the performance benchmark tests.

Over 30 vendors now produce Ethernet adapters compatible with the standard Ethernet (Version 2.0) and the various IEEE 802.3 specifications. 3Com, Gateway Communications, Racal InterLan (formerly Micom-InterLan), Western Digital, Novell, and Tiara Computer Systems are among the leading vendors of Ethernet adapter boards for PC, Industry Standard Architecture (ISA—i.e., PC/AT), Extended Industry Standard Architecture (EISA), and Micro Channel Architecture (MCA) bus systems.

Most adapters are available with two alternative media connections, mainly thin and thick Ethernet (10BASE2 and 10BASE5). Tiara offers a choice of Ethernet adapters with 10BASE2 and 10BASE5 or with 10BASE2 and twisted-pair connections. The Tiara now offers a twisted-pair 10BASE-T draft-standard-compatible Ethernet adapter; the PureData allows media connections for 10BASE2, 10BASE5, and twisted-pair wire (10BASE-T compatible with a plug-in module). [IEEE 10BASE5 standard defines 10M bps transmission and a 500-meter cable segment for thick coaxial; 10BASE2 defines thin coaxial 10M bps transmission and a 200-meter cable segment length; 10BASE-T is the 10M bps draft standard for running Ethernet over twisted-pair wiring.]

Performance

Important performance factors for Ethernet adapters are the card's bus interface width, the adapter-to-host data transfer method, on-board RAM,

Ethernet controller chipset, and the network software driver. Because all the Ethernet adapters under test comply with the IEEE 802.3 standard and operate at 10M bps, network bandwidth and media access schemes are significant only when comparing Ethernet to another standard, such as token-ring. An on-board co-processor such as that provided with a bus master may improve the performance of specific tasks. The bus master architecture combines the functions of a communications processor (i.e., the Ethernet controller chip) and bus mastering, thereby reducing the adapter's dependence on the host CPU for communications and I/O processing. Performance results show both the Racal InterLan and BICC bus master cards performing very well in all tests.

Data Bus Width

An adapter card with a 16-bit data path should move a given amount of data twice as fast as a card with an 8-bit data path, but this theory does not automatically translate into a two-to-one throughput ratio in favor of 16-bit cards (even in throughput-only tests). In tests with two Compaq 386S and two Compaq 386/25 systems simultaneously transmitting and receiving data blocks using the NetWare IPX transport protocol, overall throughput for the 8-bit cards is over 50 percent of the corresponding throughput for 16-bit cards. The 8-bit Novell NE1000 provides 57 percent of the 16-bit NE2000's throughput, and the 8-bit 3Com Etherlink II provides 68 percent compared to the 16-bit Etherlink Plus. On-board RAM buffers for both 8-bit cards is only 8K bytes; increasing on-board RAM to 16K bytes (as on most of the 16-bit cards) might bring the 8-bit cards' performance even closer to the level of the 16-bit cards.

The NE1000 barely achieves 40 percent of the NE2000's throughput in the Compaq 386/25, compared to 66 percent in the Compaq 386S. Corresponding figures for the Etherlink II and Etherlink Plus are 73 percent in the 386/25 and 78 percent in the 386S. (The 8-bit cards are slower in 32-bit systems than in 8/16-bit systems, probably because of inefficiencies in memory and I/O cycle timings for 8-bit operations on the 32-bit system's AT-compatible bus).

The performance disparity between 8- and 16-bit cards becomes less pronounced in application environments where throughput is not the overriding consideration. In the application performance tests, both 8-bit cards achieve higher percentages of their 16-bit counterparts' performance. In fact, the Etherlink II's overall applications performance with and without traffic approaches 96 percent of the Etherlink Plus', making their relative performance almost indistinguishable. However, the Etherlink Plus drivers may be partly at fault as will be discussed.

Adapter-to-Host Data Transfer Method

Data transfer between a network adapter and the host system's memory can take place using shared memory, direct memory access (DMA), programmed I/O, or bus mastering. Among these methods, bus mastering often provides the fastest data transfer; otherwise, variables in adapter design, the host bus timing characteristics, device driver management, and DMA channel widths and speeds make it difficult to compare the other three transfer methods. Direct memory access is generally considered to be slower than programmed I/O or shared memory in AT-class systems, especially with the 8-bit DMA channel.

Shared memory adapters use memory directly addressable by the Intel 8086 series processors running in real mode; more specifically, memory between 640K and 1 megabyte. Within that range, many adapters require up to 16K in a contiguous block. Among the test cards, only PureData and Western Digital indicated that their cards use shared memory.

For programmed I/O (non-DMA) transfers, an adapter card uses one or more of the processor's I/O ports as the transport medium, and the CPU controls the data transfer. DMA channels access memory directly, bypassing the CPU, but DMA controllers in current AT (ISA) bus technology run slower than the main processor, limiting the DMA transfer speed. DMA channels are either 8 or 16 bits wide, and 16-bit DMA transfer outperforms 8-bit DMA transfer. Both the 3Com Etherlink cards use DMA transfer, and most of the other cards use programmed I/O or shared memory as their main data transfer method.

Bus mastering often provides the most efficient adapter-to-host data transfers. The bus master directly controls the computer's address, memory, and control signals, freeing the main CPU from setup and control of transfer operations. The BICC and Racal InterLan are bus master

cards. Although bus mastering is technically a faster transfer method, in powerful systems with light processing loads such as an 80386 system running DOS, the host CPU may perform data transfers faster than a bus master's processor. Unlike Micro Channel bus masters, which control the main system bus, AT bus master cards must use DMA channels. AT bus masters are not designed to handle the complex main system bus access arbitration scheme used by Micro Channel bus masters.

Controller Chipset

The Ethernet controller chip primary handles CSMA/CD protocol processing, the data link-level processing of packet transmission/reception, and error checking and correction. The controller chip is the adapter's primary component for interaction with the host CPU when packets are received or transmitted. In a bus master architecture, with the assistance of driver software, the bus master coprocessor controls the DMA channel for data transfers between the controller chip and the host system.

The Artisoft, Gateway, Novell, PureData, and Western Digital cards use the National Semiconductor DP8390 controller, and SMC and Tiara use the Fujitsu EtherStar MB86950 controller. The BICC and Racal InterLan bus master cards use nonstandard Ethernet controllers. BICC uses the Advanced Micro Devices AM7990 controller, and the Racal InterLan uses a proprietary chip. Only the 3Com cards use the Intel 82586 communications controller.

Test results do not clearly demonstrate the influence of the Ethernet controller on performance. The 3Com Etherlink Plus' poor overall performance cannot be attributed to the Intel 82586 chip because the 8-bit Etherlink II using the same chip outperforms the 8-bit Novell NE1000, which uses the NSC 8390 controller.

On-Board RAM

RAM buffers allow faster and more reliable communications with the Ethernet controller chips. Driver software can quickly fetch incoming data from the Ethernet controller and temporarily store the data in RAM buffers before passing it to the operating system. Furthermore, large amounts of data to be transmitted can be moved into the buffers for fast access by the controller chip.

Sometimes adapters run higher level protocols using processors and RAM on the adapter board. The 3Com Etherlink Plus has this capability, although it is unclear whether its Novell driver uses this feature. As can be seen in the performance results, the Gateway and Tiara cards both use 64K-byte on-board RAM buffers and both perform very well.

Network Operating System Drivers

Almost all Ethernet adapter manufacturers supply drivers for Novell NetWare, and a good number offer drivers for Banyan Vines as well. Although the effect of drivers on performance is hard to isolate from the effects of chipset and data transfer methods, a good software driver providing efficient protocol processing can have a large influence on performance. The driver software allocates the card's available RAM and often takes on the time-consuming task of copying data among buffers. Some cards and drivers support transmission of (nonstandard) extra large data packets that provide large performance gains under certain operating conditions.

Product Evaluations

Artisoft AE-2

Product Summary

- Good overall performance
- Uses programmed I/O for data transfer
- 16K bytes of on-board RAM
- Least expensive; best performance for low price
- Not supported by Vines/386 4.0, IBM PC LAN 1.30, IBM LAN Server 1.1, 3+Open 1.1, 3+Share 1.2.1, TCP/IP

BICC Isolan 4110-2

Product Summary

- Very good overall performance
- Uses bus master for data transfer
- Good diagnostic tools
- Below average documentation
- Best support for Ethernet standard, including ISO

CNet CN200E

Product Summary

- Uses programmed I/O for data transfer
- 16K bytes of on-board RAM
- Compatible with Novell NE2000
- Supported only by Novell NetWare/286 2.1x and NetWare/386 3.0

Gateway G/Ethernet

Product Summary

- Very good overall performance
- Uses programmed I/O for data transfer
- 64K bytes of on-board RAM
- Good standards support
- Average documentation
- Not supported by Vines/286 3.0, Vines/386 4.0, IBM PC LAN 1.30, IBM LAN Server 1.1, 3+Open 1.1

Novell NE2000

Product Summary

- Uses programmed I/O for data transfer
- 16K bytes of on-board RAM
- Good overall performance
- Manual is well documented and organized
- Supported by very few network operating systems

PureData I8023-16

Product Summary

- Uses shared memory for data transfer
- 16K bytes of on-board RAM
- Manual very well organized
- Supported only by Novell NetWare/286
- Excellent usability results
- Good diagnostic features

Racal InterLan NI6510

Product Summary

- Excellent overall performance
- Bus master capability
- Good media support
- Manuals well organized
- Not supported by Vines/286 3.0, Vines/386 4.0, IBM PC LAN 1.30, 3+Share 1.2.1

SMC PC510

Product Summary

- Good overall performance
- Uses programmed I/O for data transfer
- 16K bytes of on-board RAM
- Manuals not well organized
- Very good standards support
- Not supported by 3+Share 1.2.1

Com Etherlink Plus

Product Summary

- Uses DMA for data transfer (shared memory or programmed I/O optional)
- 256K bytes of on-board RAM
- Highly dependable
- High price with poor overall performance
- Very good documentation
- Not supported by IBM PC LAN 1.30 and IBM LAN Server 1.1

Tiara LAN Card/E*AT

Product Summary

- Excellent overall performance
- Best overall performance under heavy traffic conditions
- Uses programmed I/O for data transfer
- 64K bytes of on-board RAM
- Manuals not well organized
- Not supported by Vines/286 3.0, Vines/386 4.0, IBM PC LAN 1.30

WD EtherCard PLUS16

Product Summary

- Uses shared memory data transfer
- 16K bytes of on-board RAM
- Very good overall performance
- Manuals not well organized
- Not supported by IBM LAN Server 1.1

Product Recommendations

Racal InterLan NI6510

Top overall performance results recommend the Racal InterLan NI6510 for either server or workstation use. Although not the least expensive card, its price is in line with most adapters in its class. The primary reason for recommending this product is its marginal support for different network operating systems and communications standards.

Western Digital EtherCard Plus16

Despite its second place ranking, the Western Digital EtherCard Plus16 may be the most appealing of the adapters because of its very good performance and well-rounded features. Western Digital offers the broadest support for different network operating systems and respectable support for different Ethernet standards. The high-quality EtherCard Plus16 is priced lowest in its class and should work well in workstation or server installations.

Rating Summaries

Figure 1.
Artisoft AE-2 Ratings

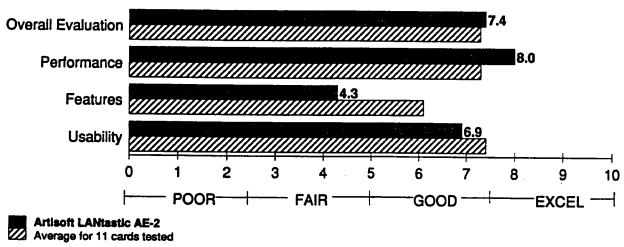


Figure 2.
BICC Isolan 4110-2 Ratings

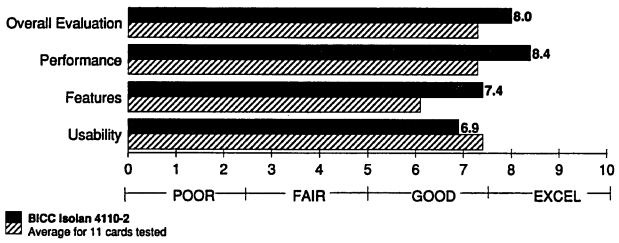


Figure 3.
CNet CN200E Ratings

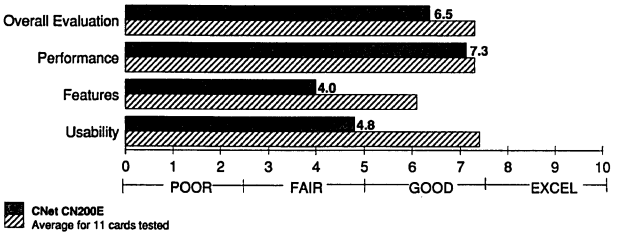


Figure 4.
Gateway G/Ethernet Ratings

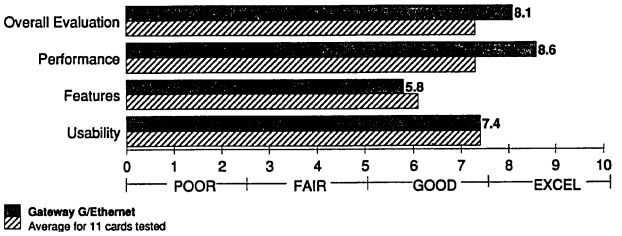


Figure 5.
Novell NE2000 Ratings

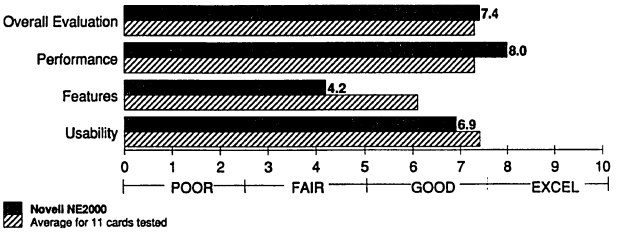


Figure 6.
PureData PD18023-16 Ratings

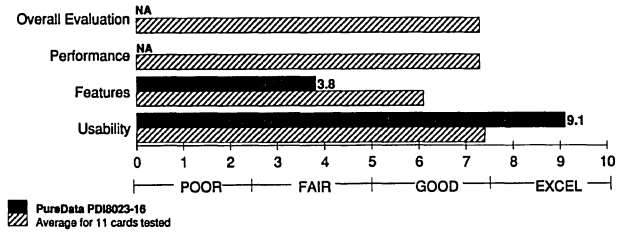


Figure 7.
Racal Interlan NI6510 Ratings

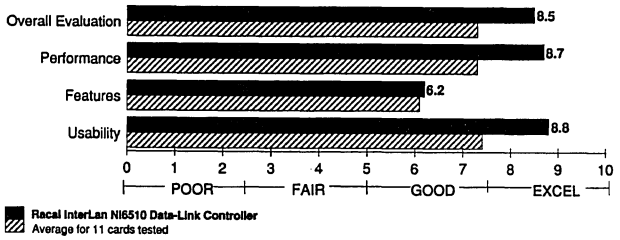


Figure 8.
SMC Ethernet-PC510 Ratings

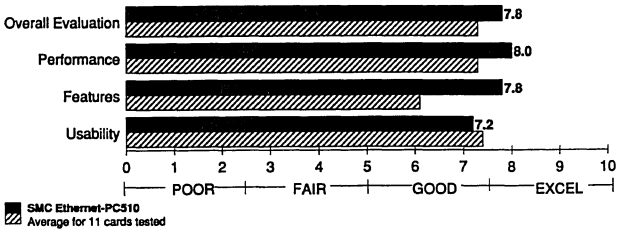


Figure 9.
3Com EtherLink Plus Ratings

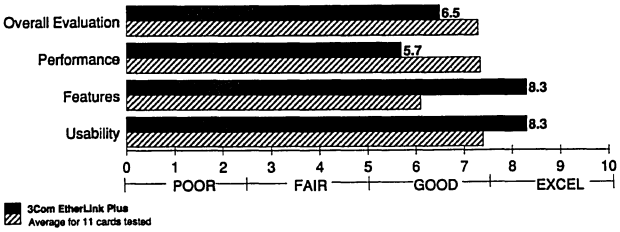


Figure 10.
Tiara LanCard/E*16 Ratings

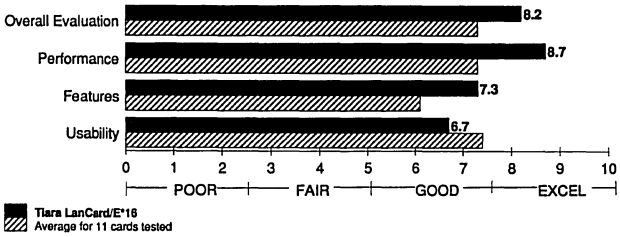
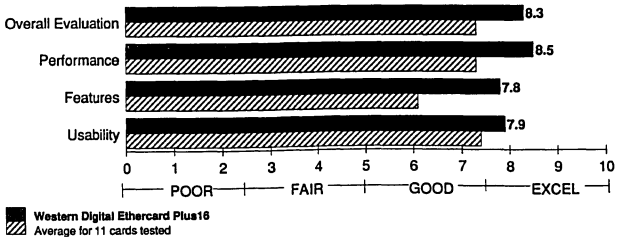


Figure 11.
WD Ethercard Plus16 Ratings



Overall Evaluation

Although the top five Ethernet adapters are distinguished little by their overall evaluation scores, contrasting sets of strengths and weaknesses may provide the deciding factor for many businesses. The top-rated Racal InterLan provides excellent performance and slightly above-average features, whereas the Western Digital earns more well-rounded scores in all the ratings categories. Likewise, the Tiara's excellent performance and above average features may be compromised by comparatively poor usability; and the Gateway's very good performance may not compensate for average usability and below-average features.

Methodology

Overall Score = ((7 x Performance Score) + Features Score + (2 x Usability Score)) ÷ 10

Performance

Test results seem to indicate that the adapter-to-host data transfer method and amount of on-board RAM for data buffering are the most important performance factors. Adapters with bus master ar-

chitecture, adapters using shared memory for data transfer, and those with the most on-board RAM perform best overall. Not surprisingly, 16-bit adapters outperform 8-bit adapters overall. Among the 16-bit adapters, the 3Com Etherlink Plus performs unexpectedly slowly (probably because of poorly implemented driver software) despite being one of the most reliable of the adapters tested.

Although the Tiara and Racal InterLan earn the highest combined application and throughput scores, the Gateway and Tiara are fastest in the application benchmarks because of their 64K bytes of on-board RAM. The Racal performs better in the low-level throughput tests, and the Tiara performs better on transaction processing (indicating efficient IPX drivers).

Some of the cards show isolated performance strengths and weaknesses. The BICC and Western Digital excel in the throughput tests, and the Western Digital presumably benefits from its shared memory data transfer method. The Novell NE2000 attains excellent transaction processing times (efficient server and workstation IPX drivers). Notably poor transaction processing performance characterizes the 3Com Etherlink Plus and the 8-bit 3Com Etherlink II and Novell NE1000.

Methodology

Performance ratings for the Ethernet adapters are based on performance indexes for the application and transaction processing tests and for the low-level throughput tests.

Overall Performance Score = (7.5 x Application/TPS Score) + (2.5 x Throughput Score)
Overall Performance Index = (Performance Score + 5) ÷ (Standard Performance Score + 5)

Features

The features ratings are based on each product's support for design characteristics or features that enhance its compatibility and performance, and on its support for selected operating systems and standards.

3Com's high features rating results from its good network operating system support and its wide support for operating environments and communications standards. The Etherlink cards also come with a set of diagnostics tools and utilities. SMC and Western Digital provide the widest network operating system support followed by BICC and 3Com.

Although most of the cards support IBM NETBIOS in one form or another, not many support the Microsoft/3Com-specified LAN Manager Network Driver Interface Specification (NDIS) or IEEE 802.2 Logical Link Control (LLC) standards; and only SMC and 3Com support both. BICC, SMC, and 3Com support IEEE 802.2; and Gateway, Racal InterLan, SMC, 3Com, Tiara, and Western Digital support NDIS.

Methodology

The features ratings are obtained by comparing each interface card against a list of features and specifications determined to be important for an Ethernet network adapter card.

Features Score = (Sum of Weighted Features x Weighting Factors) ÷ Sum of the Weights

Usability

Usability ratings for Ethernet network interface cards, as indeed for all network adapter cards, are primarily based on the ease of installing and configuring the board itself and software drivers supplied with it. Because all network interface cards require unique configuration, the means of resolving potential conflicts with other adapters installed in the system must be as uncomplicated as possible.

NSTL found the PureData to have the most flexible and elegant configuration and set-up procedures encountered thus far. Unlike the other test adapters, the PureData uses software to configure all its hardware setup options. PureData's top usability rating results primarily from its excellent configuration software; it also receives good marks for its documentation.

The best alternative to "auto configuring" software is a card with a much simplified switch/jumper block set-up. The ideal setup would have all the switch blocks lined up on the upper edge of the card for easy access without removing the card from the system. Each switch and/or jumper block should be clearly identified along with the values for each selection option. Racal InterLan's jumper block setup is closest to the ideal, with all the blocks in a single column at the back end of the

board and each block and individual value selections clearly marked. An easily accessible and configurable jumper block and good documentation give the Racal InterLan its very good usability score. The Western Digital setup also features uncomplicated jumper settings.

3Com provides the finest documentation and comprehensive diagnostic software with its Etherlink Plus. The other cards earn good to above-average usability scores, and most supply documentation acceptable in quality, organization, and comprehensiveness. Documentation supplied with the Artisoft, Gateway, SMC, Tiara, and Western Digital rates slightly below average. BICC's documentation is somewhat lacking in comprehensiveness and not quite "well organized." The CNet documentation contains grammatical errors that may make it difficult to understand and/or open to misinterpretation.

Methodology

Usability ratings evaluate the ease of installing each card (setup, configuration) and the inclusiveness of the documentation.

Usability Score = ((5 x Installation Score) + Manual Organization Score + Manual Clarity Score + Manual Comprehension Score)) ÷ 8

Performance Results

Performance considerations for PC-based Ethernet networks are generally influenced by the hardware design of the adapter board and the software drivers that support the board's function in the host system. In analyzing the benchmark test results, the performance factors can be narrowed to the type of Ethernet controller chipset, on-board firmware, on-board RAM buffer size and speed, board-to-system data transfer method (DMA, programmed I/O, bus mastering, or shared memory) and interface width (i.e., 8 or 16 bits), and driver software loaded to support the board. Although all the adapters in the test suite use an ISA bus design, the BICC and Racal InterLan feature a bus master adapter-to-system data transfer method. All others mainly use programmed I/O for transfers between the adapter and host CPU.

Test Configuration

The test network was set up with a Compaq 386/20 server running Novell SFT NetWare 2.15A, a Compaq Deskpro 386/25 as the primary workstation, 16 Compaq Deskpro 286S secondary workstations, and a Compaq 386/20 controller workstation to automate the tests. The network was wired using standard Ethernet thin coaxial cable (RG 58A/U). 3Com Etherlink Plus (used as the standard adapter) adapters were installed in the controller workstation and in 13 secondary workstations throughout the tests. The test adapters were installed in the server and in the remaining four workstations.

Before testing each adapter, NSTL regenerated the Novell server operating system software using the driver files appropriate to the card under test. The five workstations containing test cards were set up with the NetWare workstation shell matching the cards. (A server generates the workstation shells from vendor-supplied software driver files.) Workstations with nontest cards use the same adapters and NetWare shells throughout testing.

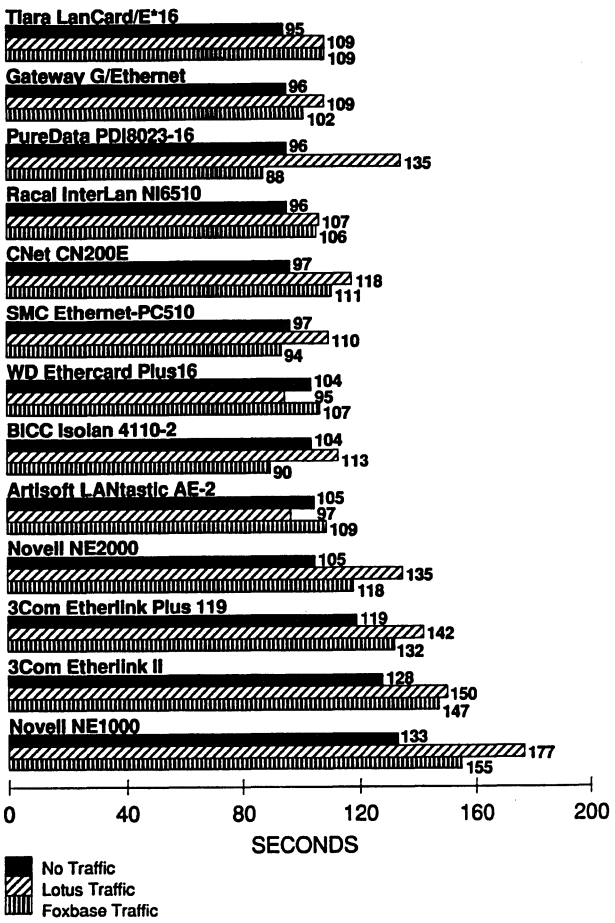
Lotus 1-2-3

A Lotus macro is invoked to load and save a 3-megabyte spreadsheet, moving a substantial amount of data across the network. This test provides a very balanced data transmission scenario between workstation and server. The test is repeated with Foxbase traffic and again with Lotus 1-2-3 traffic running concurrently on five secondary workstations.

Analysis

The SMC and Racal adapters perform very well across all three Lotus tests. The Western Digital performs very well under steady background traffic. The Gateway and Tiara, which have larger RAM buffers than the other cards, are the fastest

Figure 12.
Lotus 1-2-3



with no background traffic. As always, driver implementations in the server and workstation contribute to variations in performance under varying loads.

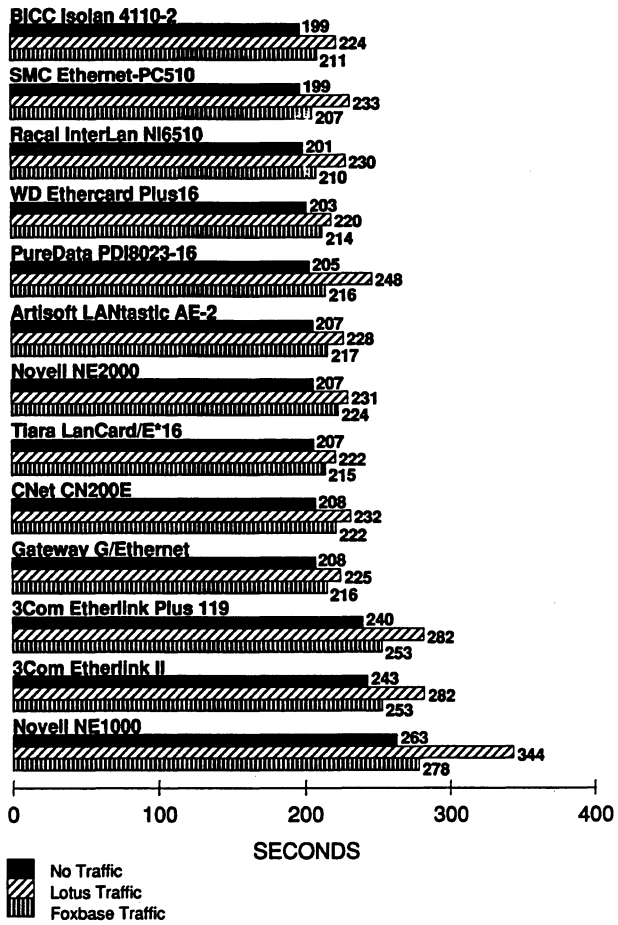
Lotus test results with and without traffic seem to accentuate the performance differences between 8-bit and 16-bit (bus interface) cards more than with the other applications. Even so, the 8-bit 3Com Etherlink II performs fairly well under the Lotus test, and certainly better than the Novell NE1000. The 16-bit 3Com Etherlink Plus performance is not much better than that of the 8-bit cards.

Microsoft C 5.0

A large ensemble of XLISP 2.0 C source code (10,928 lines totaling 245,222 bytes) is compiled and linked, forming an executable file of 147,228 bytes. The total number of bytes downloaded from the server is far larger than the amount of data traveling from workstation to server. The test is repeated with Foxbase traffic and again with Lotus 1-2-3 traffic running concurrently on five secondary workstations.

This test serves primarily to pump data from the server to the workstation (the source code and loading the compiler) similar to the XCopy from Server benchmark test. Lotus traffic increases data movement to the server and provides consistent background traffic, and Foxbase traffic increases data movement and creates a fairly sporadic stream of network traffic.

Figure 13.
Microsoft C 5.0



Analysis

The SMC, Western Digital, and BICC adapters perform well across all three traffic conditions (although they are not necessarily the fastest in all three cases). The Tiara and Racal also perform quite well. Times for most of the 16-bit cards are fairly close, except for the ultra-reliable 3Com Etherlink Plus, which returns times almost identical to the 8-bit counterpart, the Etherlink II. Test results show that on an unloaded network, the SMC drivers are very efficient at moving large amounts of data from the server; the Western Digital card performs better under constant network loads.

Lotus traffic contributes to a noticeable performance decrease (10 to 25 percent) for all the adapters and accentuates performance differences between the 8- and 16-bit cards. Even among the 16-bit cards, the broad range of times probably reflects differences in driver efficiency and on-board RAM usage. The less demanding Foxbase traffic produces a narrower performance spread between adapters. The smaller Foxbase records bottleneck the server less, and network use is more sporadic and less intensive than with Lotus traffic.

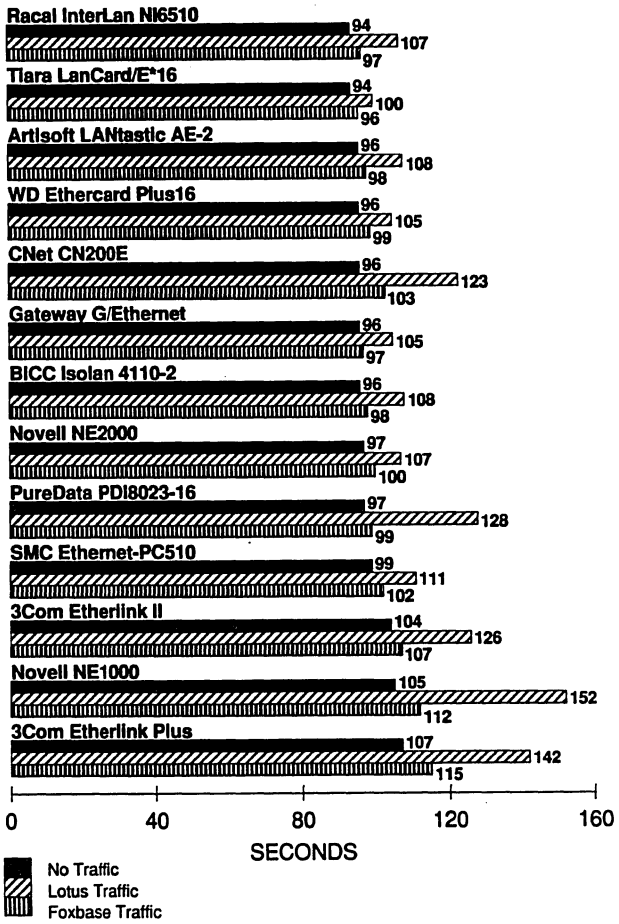
Print to Queue

The NetWare Capture command copies a 656, 380-byte text file to LPT1, dispatching the file to the server's printer queue. (Times in the figures indicate the file copy time and the total time from issuance of the command until the first page is output.) The test is repeated with Foxbase traffic and again with Lotus 1-2-3 traffic running concurrently on five secondary workstations.

Analysis

With no network traffic, printing to queue is similar to the XCopy to Server test in that data moves from workstation to server, but the operations are not identical. The volume of data moved from workstation to server is nearly one-tenth the volume moved in the XCopy operation; the size of data blocks read from disk may vary between XCopy and Print operations; and transmission packet size variances occur between different adapter boards and drivers. The Tiara and Racal-InterLan perform the fastest with no traffic, although times for the 16-bit cards (except the 3Com Etherlink Plus) are very close.

Figure 14.
Print to Queue



With traffic, this test measures more than just raw system-to-board interface speed. The efficiency of server software drivers in managing multiple sessions and the effective use of on-board RAM for packet buffering or protocol execution can significantly influence performance. The Gateway and Tiara cards deliver above average performance among the 16-bit cards, and both have 64K bytes of on-board RAM. All the 16-bit cards except the Etherlink Plus return similar results in the traffic tests. The Etherlink Plus performs quite slowly relative to the other 16-bit cards, possibly because its Novell-written driver uses the 256K-byte RAM buffer and 80186 processor for some protocol processing. Using the RAM buffer and 80186 slows protocol processing in the NSTL tests more so than if the protocol were run at the 80386 workstation. But the Etherlink Plus' slow performance might also be caused by its inefficient driver.

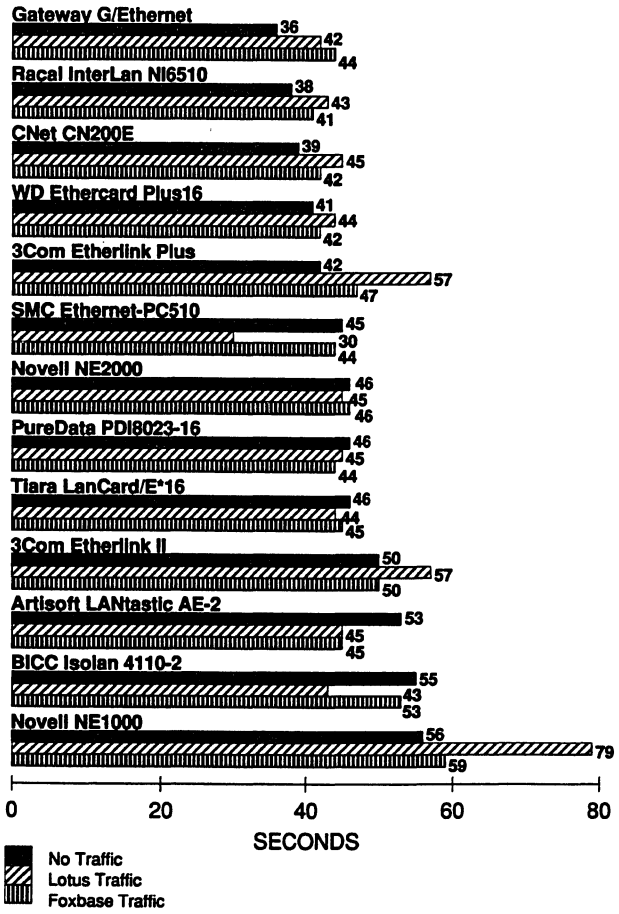
XCopy to Server

A 5-megabyte directory tree (130 files in 13 directories) is copied to the server using the DOS XCopy command with the /s parameter; the source tree is located on the primary workstation's local hard disk. The test is repeated with Foxbase traffic and again with Lotus 1-2-3 traffic running concurrently on five secondary workstations.

Analysis

With a large volume of data moving from workstation to server and stressing the system-to-adapter interface, the Gateway, Racal, Western Digital, SMC, and CNet cards perform quite well overall. The SMC is most effective with a constant level of background network traffic (Lotus traffic) and improves its performance (relative to the other adapters) as traffic levels increase. The bus master Racal card provides consistently good performance under all test conditions. The 8-bit 3Com Etherlink II performs satisfactorily.

Figure 15.
Xcopy to Server



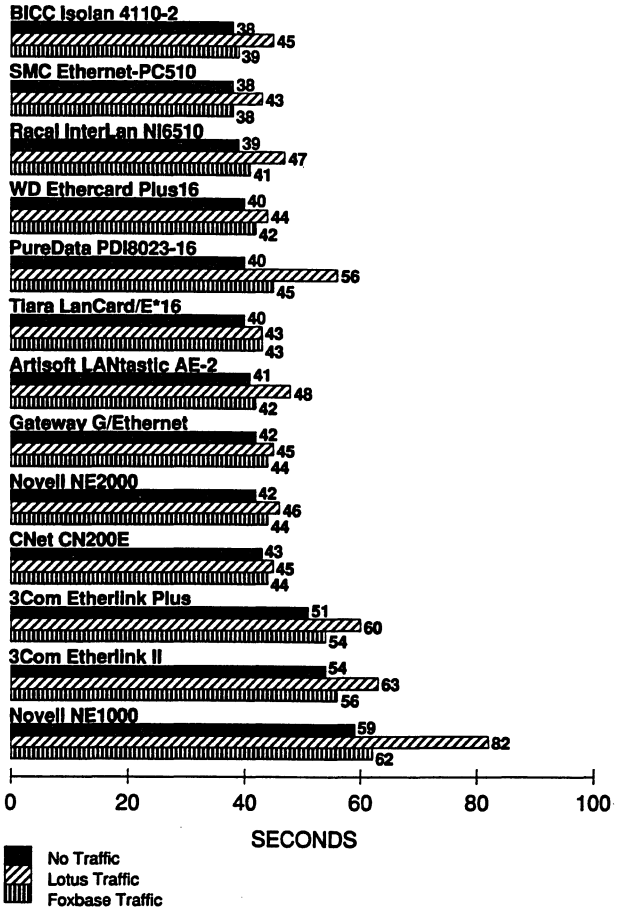
XCopy from Server

A 5-megabyte directory tree (130 files in 13 directories) is copied from the server to the primary workstation using the DOS XCopy command with the /s parameter. The test is repeated with Foxbase traffic and again with Lotus 1-2-3 traffic running concurrently on five secondary workstations.

Analysis

The workstation load becomes a performance issue as the workstation uses resources to write the data to disk. This test is similar to the Microsoft C 5.0 test in that a large quantity of data moves from server to workstation. The similarity is reflected in the SMC's excellent results under all conditions and results for the Tiara, BICC, and Western Digital cards with traffic. The BICC and Racal bus master cards perform well. Results for the 8-bit Novell and 3Com cards are less than spectacular, but not unacceptable.

Figure 16.
Xcopy from Server



Transaction Processing

Using five database files in Foxbase+/LAN 2.1 (i.e., Account, Teller, Branch, Transaction, and History files), this benchmark measures the speed at which a group of transactions is processed. For each transaction, the program 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 test records the time for one workstation processing 960 transactions without indexes and then with four indexes on the History file. This transaction processing test is repeated on 3, 4, 10, and 16 workstations, respectively processing 320, 240, 96, and 60 (nonoverlapping) transactions without and with the indexes. Although indexes typically speed record lookups, in this benchmark the indexes slow processing as they increase disk activity and file contention at the server.

Figure 17a.
Transaction Processing: One Workstation

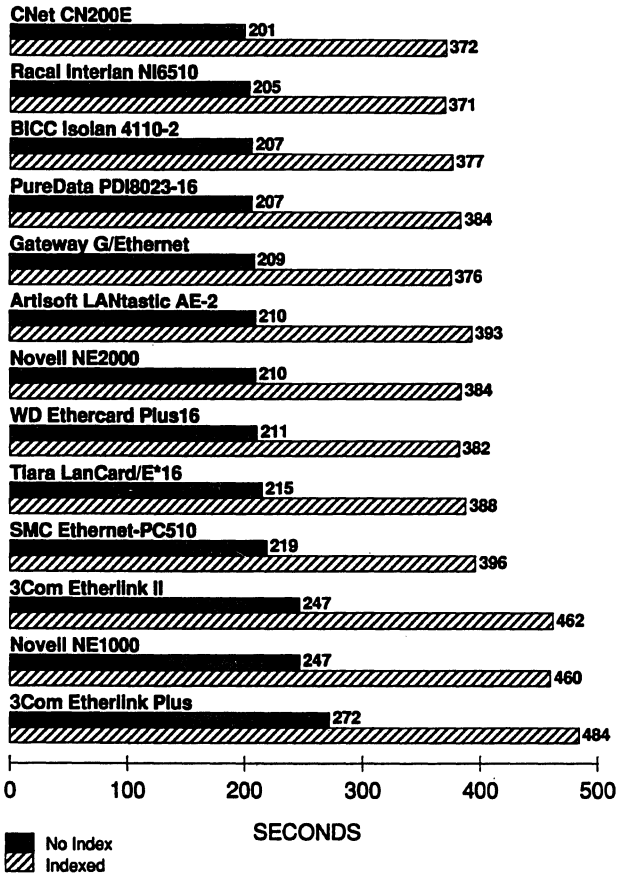


Figure 17b.
Transaction Processing: Three Workstations

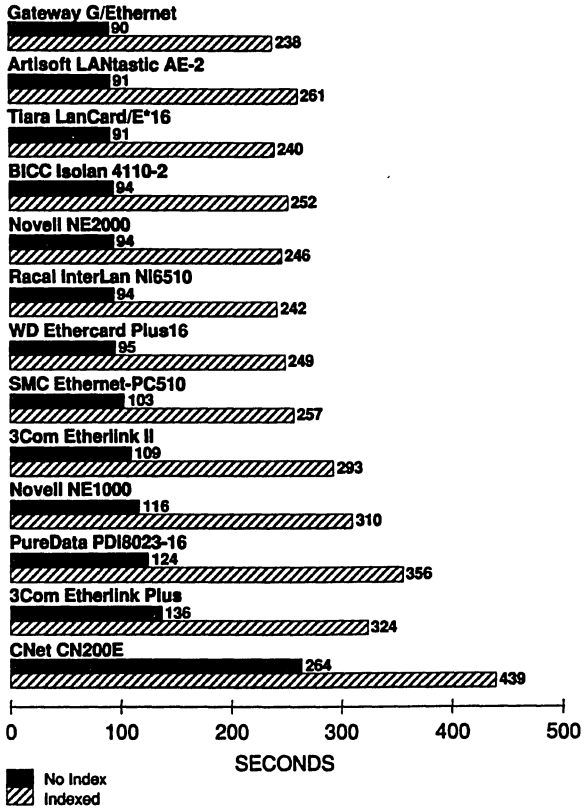


Figure 17c.
Transaction Processing: Four Workstations

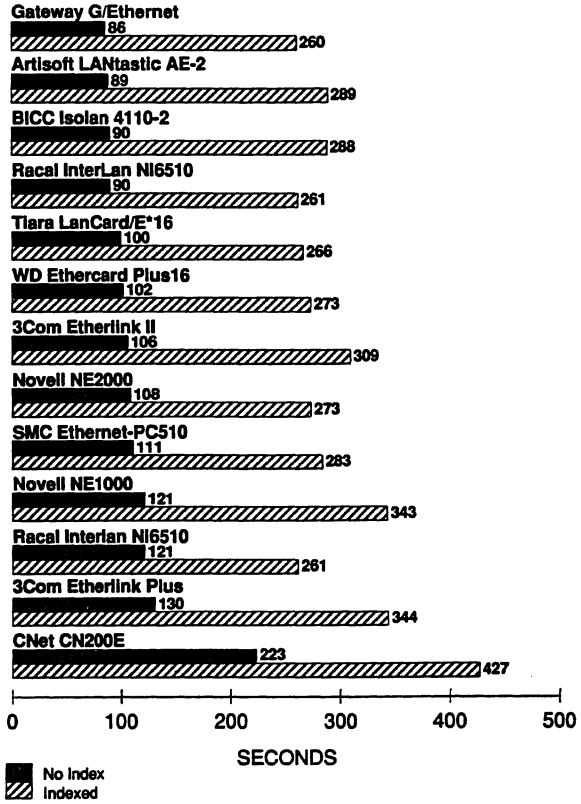
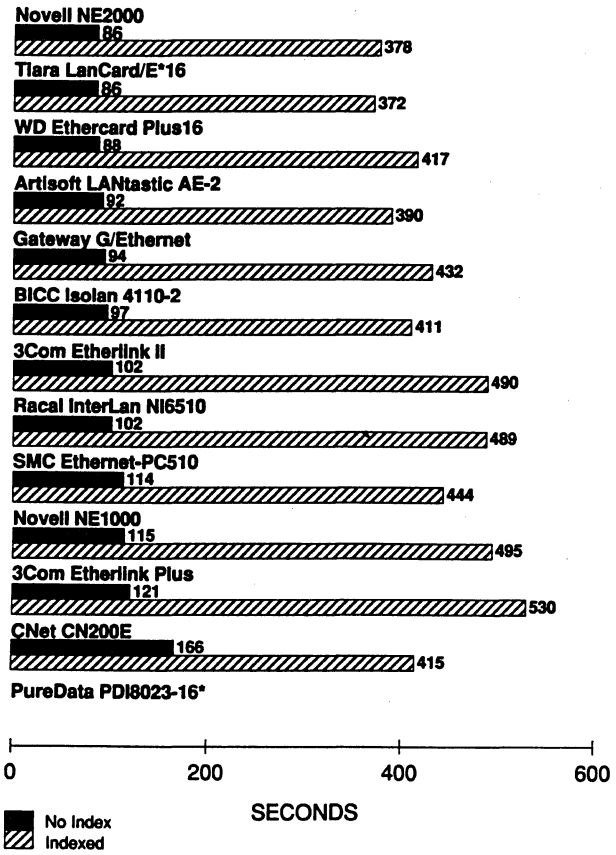
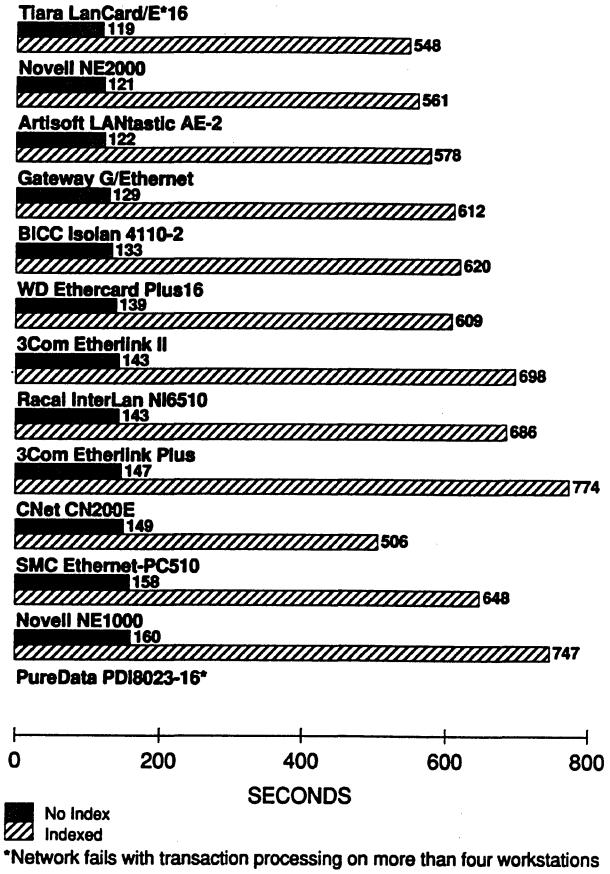


Figure 17d.
Transaction Processing: Ten Workstations



*Network fails with transaction processing on more than four workstations

Figure 17e.
Transaction Processing: Sixteen Workstations



*Network fails with transaction processing on more than four workstations

Analysis

Transaction processing highlights the advantage of the 16-bit bus interface. The Gateway and Tiara cards perform very well across most test configurations, quite possibly because of their larger RAM buffers. The CNet performs best under the heaviest load (16 workstations with indexes), which generates a large number of small packets on the network. The CNet fares less well under less stressful conditions. The Etherlink Plus again exhibits performance similar to the 8-bit cards, which is most likely attributable to inefficient NetWare drivers.

Foxbase+/LAN

1. 51,100 records are 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 are indexed.
3. The first three of every ten Account records are copied to three temporary files.
4. The records copied in Test 3 are deleted from the Account file.
5. The temporary files created in Test 3 are appended to the Account file.
6. The Account file is packed and reindexed.
7. 1,000 transactions are processed, each updating a record in the Account, Teller, and Branch tables. A History record is written for each transaction.
8. Four indexes are created on the 1,000-record History file.
9. Test 7 is repeated, and the four History file indexes are updated each time a History record is written.
10. Blocks of 1,000 records are appended to the History file.

Table 1. Foxbase +/LAN

(times in seconds)	Artisoft AE-2	BICC Isolan 4110-2	CNet CN200E	Gateway G/Ethernet	Novell NE1000	Novell NE2000	PureData PDI8023-16	Racal InterLan	SMC Ethernet-PC510	3Com EtherLink II	3Com EtherLink Plus	Tiara LanCard/E* 16	WD Ethercard Plus16
No Traffic													
Test 1	232	229	230	231	252	232	231	230	228	245	240	230	228
Test 2	67	63	68	67	93	68	66	64	63	84	80	67	65
Test 3	98	89	99	98	159	98	96	92	83	138	129	98	93
Test 4	140	127	143	138	254	142	139	128	134	216	196	139	132
Test 5	101	113	62	64	90	99	61	78	94	82	73	63	109
Test 6	204	198	180	180	256	201	179	181	184	238	211	181	200
Test 7	63	63	61	59	73	64	61	59	63	71	70	62	64
Test 8	6	5	6	5	8	5	6	5	5	7	7	5	5
Test 9	106	104	102	102	132	106	103	101	109	126	119	102	104
Test 10	61	58	60	60	82	61	60	58	59	74	71	61	59
Test 11	145	141	141	141	169	143	141	135	143	166	159	138	141
Test 12	11	9	9	9	11	10	10	10	10	10	10	11	9
Test 13	55	51	53	53	78	54	52	51	58	70	65	53	53
Test 14	5	4	5	5	6	5	4	5	4	5	5	4	4
Test 15	7	7	8	8	9	8	8	7	7	9	9	8	8
Test 16	31	30	31	30	39	30	30	29	32	36	35	30	30
Foxbase Traffic													
Test 1	233	229	232	231	254	232	*	230	227	247	240	231	229
Test 2	68	66	71	68	96	69	*	66	62	86	82	69	68
Test 3	100	93	104	100	166	101	*	95	82	141	136	99	96
Test 4	160	138	157	141	269	150	*	135	151	224	207	141	140
Test 5	137	157	98	103	120	141	*	115	153	114	98	103	155
Test 6	265	253	236	221	322	266	*	230	261	305	261	226	259
Test 7	75	70	72	68	89	72	*	75	75	84	77	66	74
Test 8	10	10	10	10	12	10	*	10	9	11	11	10	10
Test 9	121	122	112	112	147	119	*	109	130	149	141	109	118
Test 10	62	60	64	61	84	61	*	59	58	76	75	61	61
Test 11	154	155	154	150	186	159	*	145	165	181	177	142	156
Test 12	11	12	13	11	12	12	*	11	12	11	11	11	11
Test 13	69	66	64	66	97	66	*	63	70	81	80	63	67
Test 14	5	4	6	5	6	5	*	6	5	5	5	4	5
Test 15	7	8	8	7	10	8	*	7	8	9	9	7	7
Test 16	33	31	31	31	43	32	*	31	33	37	38	32	33

**Network fails with Foxbase traffic on four workstations.*

Table 1. Foxbase +/LAN (Continued)

(times in seconds)	Artisoft AE-2	BICC Isolan 4110-2	CNet CN200E	Gateway G/Ethernet	Novell NE1000	Novell NE2000	PureData PDI8023-16	Racal InterLan	SMC Ethernet-PC510	3Com EtherLink II	3Com EtherLink Plus	Tiara LanCard/E* 16	WD Ethercard Plus16
Lotus Traffic													
Test 1	236	235	238	234	277	237	237	236	241	256	252	232	232
Test 2	74	71	75	72	123	74	81	72	68	97	93	71	69
Test 3	113	107	112	108	224	113	132	112	91	166	159	107	104
Test 4	170	171	163	155	385	173	182	164	147	275	255	153	156
Test 5	108	105	80	81	133	104	100	88	89	107	98	80	119
Test 6	256	250	214	223	353	154	270	232	214	298	259	219	244
Test 7	67	67	69	64	94	67	70	64	71	79	81	63	68
Test 8	7	6	6	6	9	6	6	6	6	8	9	6	6
Test 9	120	119	113	112	173	122	131	115	126	156	151	109	113
Test 10	66	64	67	64	106	67	73	65	65	85	84	63	64
Test 11	156	159	153	150	214	163	164	153	165	195	191	146	156
Test 12	10	11	11	10	11	11	11	9	11	11	10	10	11
Test 13	70	66	64	63	112	69	74	65	59	88	83	62	64
Test 14	5	5	5	5	6	5	5	6	5	5	6	5	5
Test 15	8	8	7	8	11	8	8	8	8	10	9	8	8
Test 16	34	33	35	33	53	34	36	33	38	42	43	33	32

11. Test 9 is repeated with the indexed History file increased to 10,000 records.
12. 1,000 Account records selected in indexed order are "printed" to disk.
13. A report created from 1,000 Account records selected on an unindexed field is sent to disk.
14. The 1,000-record Teller file is grouped and subtotaled, and the report sent to disk.
15. The Teller file is joined with the Branch file, and the report sent to disk.
16. The History, Branch, Teller, and Account files (1,000, 100, 1,000, and 50,000 records) are joined, and the report sent to disk after the History file is sorted.

Analysis

The Tiara and Gateway cards demonstrate consistently good performance in all three traffic situations, exhibiting the same performance characteristics as in the multistation transaction processing tests and indicating that their larger RAM buffers may be responsible. With no background traffic, the Racal performs very well in all configurations, followed in the rankings by the Gateway, PureData, and Tiara. Overall, the 16-bit cards (except for the 3Com Etherlink Plus) perform similarly, indicating that the Foxbase benchmark operations are more workstation and server processing bound than network bound. The very weak 8-bit Novell NE1000's averages times between 27 and 36 percent slower than the fastest cards across all tests.

Low-Level Throughput

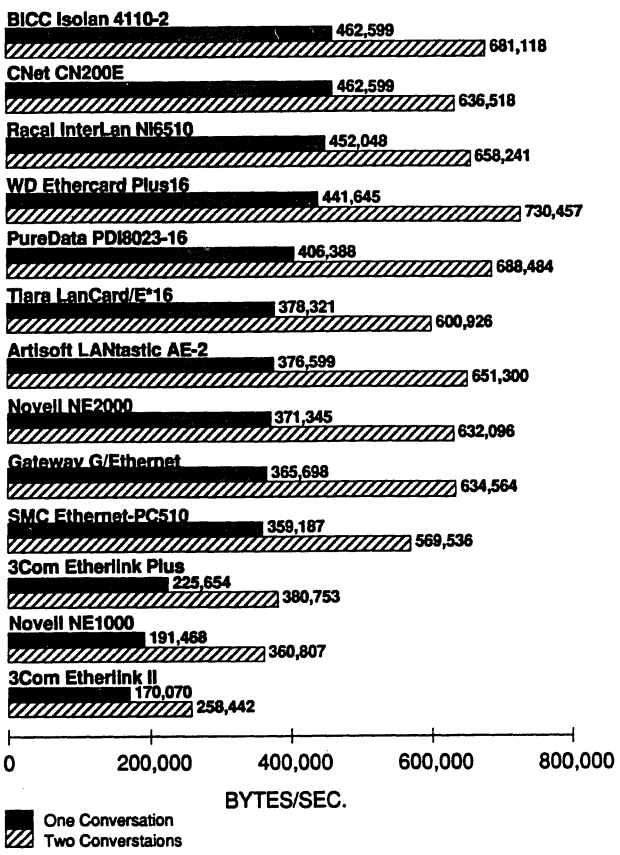
This test measures each card's throughput (bytes per second) sending a 3-megabyte block between two workstations using NetWare's IPX transport protocol. Data is transmitted between two Compaq 386/25 systems (one conversation) and also between two Compaq 386S systems (second conversation). Data is written through IPX with 512-byte

buffers, and the adapter drivers independently manage the actual size of the data field within an Ethernet frame (which often ranges from 46 to 1,500 bytes). Throughputs are averaged to derive performance scores for one conversation; and the throughputs for all four systems are combined to produce two-conversation performance scores. Although this test is a fair measurement of raw hardware and driver performance, it is less realistic than application testing because of the static buffer sizes (512 bytes) passed to the IPX drivers and the exclusion of server operations.

Analysis

The low-level throughput tests distinguish the BICC and Racal bus master boards and the Western Digital board from the others. Both tests stress the interface between the workstation and adapter, and the network access method is exercised more with two simultaneous conversations than with one. The Western Digital card again demonstrates superior performance with large volumes of data traveling on a network with traffic.

Figure 18.
Low-Level Throughput



The 8-bit Novell and 3Com cards provide between 35 and 52 percent of the BICC's throughput. Results indicate inefficient IPX drivers for the 3Com Etherlink Plus because its performance improvement over the 8-bit cards is much less than that shown by the other 16-bit cards.

Vendors

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

BICC Data Networks, Inc.
1800 W. Park Drive
Westboro, MA 01581 (508) 898-2422

CNet Technology, Inc.
62 Bonaventura Drive
San Jose, CA 95134 (408) 954-8000

Gateway Communications, Inc.
2941 Alton Avenue
Irvine, CA 92714 (714) 553-1555

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

Pure Data Ltd.
180 W. Beaver Creek Road
Richmond Hill, ON, Canada L4B 1B4 (416) 731-6444

Racal InterLan, Inc.
155 Swanson Road
Boxborough, MA 01719 (508) 263-9929, (800) 526-8255

Standard Microsystems Corp.
35 Marcus Boulevard
Hauppauge, NY 11788 (516) 273-3100, (800) SMC-4YOU

3Com Corp.
3165 Kifer Road
Santa Clara, CA 95052 (408) 562-6400, (800) NET-3COM

Tiara Computer Systems, Inc.
2700 Garcia Avenue
Mountain View, CA 94043 (415) 965-1700

Western Digital Corp.
2445 McCabe Way
Irvine, CA 92714 (800) 638-5323

Characteristics

Table 2. Ethernet Network Adapter Characteristics

	Host Interface	Software Included	LAN OS Support
Artisoft AE-2 Ethernet	16-bit programmed I/O	Drivers for Novell NetWare and Artisoft LANtastic	Novell NetWare/286 2.1x, NetWare/386 3.0; and Artisoft LANtastic
BICC ISOLAN 4110-2	16-bit bus master	Diagnostic software; drivers for NetWare, PC-NFS/MPS, PC/TCP/MPS, NETBIOS/MPS, OS/2 EE	Banyan Vines 4.0; IBM PC LAN 1.30, LAN Server 1.1; Novell NetWare/286 2.1x, NetWare/386 3.0; 3Com 3+Open 1.1; TCP/IP
CNet CN200E	16-bit programmed I/O	No diagnostic software included	Novell NetWare/286 2.1x, NetWare/386 3.0
Gateway G/Ethernet	16-bit programmed I/O	Diagnostic software	Novell NetWare/286 2.1x, NetWare/386 3.0; 3Com 3+Share 1.2.1; TCP/IP
Novell NE1000	16-bit programmed I/O	Diagnostic software not included	Novell NetWare/286 2.1x, NetWare/386 3.0
Novell NE2000	16-bit programmed I/O	Diagnostic software not included	Novell NetWare/286 2.1x, NetWare/386 3.0
Pure Data	16-bit shared memory	Diagnostic software; drivers for Novell NetWare/286 2.1x	Novell NetWare/286 2.1x
Racal-Interlan N6510	16-bit bus master	Diagnostic software; drivers for Novell NetWare/286 2.1x, NetWare/386 3.0; NDIS 2.0; NCSA Telnet	IBM LAN Server 1.1; Novell NetWare/286 2.1x, NetWare/386 3.0; 3Com 3+Open 1.1; TCP/IP
SMC PC510	16-bit programmed I/O	Diagnostic software; drivers for Novell NetWare/286 2.1x, NetWare/386 3.0; Readme file, Configuration batch file	Banyan Vines 4.0; IBM PC LAN 1.30; LAN Server 1.1; Novell NetWare/286 2.1x, NetWare/386 3.0; 3Com 3+Open 1.1; TCP/IP
3Com EtherLink II	16-bit programmed I/O, shared memory, or DMA	Diagnostic software; 3Com 3+ drivers, and 3+Open drivers (NDIS drivers)	Banyan Vines 4.0; IBM PC LAN 1.30, IBM LAN Server 1.1; Novell NetWare/286 2.1x, NetWare/386 3.0; 3Com 3+Open 1.1, 3+Share 1.2.1; TCP/IP
3Com EtherLink Plus	16-bit programmed I/O	Diagnostic software; LinkPlus optimizer; 3Com 3+ drivers	Banyan Vines 4.0; Novell NetWare/286 2.1x, NetWare/386 3.0; 3Com 3+Open 1.1, 3+Share 1.2.1; TCP/IP
Tiara LAN Card/E*AT	16-bit programmed I/O	Diagnostic software; drivers for SCO Xenix, interactive Unix, DECnet-DOS, and NETBIOS	IBM LAN Server 1.30; Novell NetWare/286 2.1x, NetWare/386 3.0; 3Com 3+Open 1.1, 3+Share 1.2.1; TCP/IP
WD Ethercard Plus16	16-bit shared memory	Diagnostic software; drivers for Novell NetWare/286 2.0, 2.1x, NetWare/386 3.0 (workstation only); 3Com 3+Share; NDIS; DECnet DOS/PCSA	Banyan Vines 4.0; IBM PC LAN 1.30; Novell NetWare/286 2.1x, NetWare/386 3.0; 3Com 3+Open 1.1, 3+Share 1.2.1; TCP/IP

Table 3. General Features

	Weight	Artisoft AE-2	BICC Isolan 4110-2	CNet CN200E	Gateway G/Ethernet	Novell NE1000	Novell NE2000	PureData PDI8023-16	Racal InterLan	SMC Ethernet-PC510	3Com EtherLink II	3Com EtherLink Plus	Tiara LanCard/E* 16	WD Ethercard Plus16
Features	2													
Adapter Length (in.)	0	7.5	6.3	7	7.5	6	8.2	9.5	10	8.2	6.6	13.2	9.3	10
Adapter Height (in.)	0	4.2	4.2	4	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Adapter-to-Host Method	0	PIO	BM	PIO	PIO	PIO	PIO	SM	BM	PIO	SM/ DMA/ PIO	DMA/ PIO	PIO	PIO
Bus Interface Width (bits)	0	16	16	16	16	8	16	16	16	16	8	16	16	16
MCA Adapter Available	0	—	▲	▲	▲	—	▲	—	—	—	—	—	▲	▲
MCA Adapter Bus Interface Width (bits)	0	NA	16	16	16	NA	16	NA	NA	NA	NA	NA	16	16
EISA Adapter Available	0	—	—	—	—	—	—	—	▲	—	—	—	—	—
EISA Adapter Bus Interface Width (bits)	0	NA	NA	NA	NA	NA	NA	NA	32	NA	8	16	NA	NA
Data Transfer Rate (M bps)	0	10	10	10	10	10	10	10	10	10	10	10	10	10
Amount of RAM on Adapter (KB)	0	16	0	16	64	8	16	16	—	16	8	256	64	16
Amount of ROM on Adapter (KB)	0	*a	0	8	32	8	8	8	*a	*a	INA	*a	—	*a
Amount of Shared RAM on Adapter (KB)	0	0	0	8	0	0	0	16	0	0	0	INA	0	16
Number of I/O Ports Used for Base I/O	0	4	32	16	8	4	4	16	4	16	8	16	10	16
Maximum Interrupt Level Settings	1	8	4	11	9	4	4	8	4	6	4	10	10	8
LED Indicators	1	—	—	▲	—	—	—	▲	—	—	—	—	▲	▲
Diagnostic Software Included	1	▲	▲	—	▲	—	—	▲	▲	▲	▲	▲	▲	▲
Loop-Back Testing	1	—	▲	—	▲	—	—	▲	▲	▲	▲	▲	▲	▲
Interstation Transmission	1	▲	—	—	—	—	—	—	▲	—	▲	▲	—	▲
Frame Overrun Statistics *b	1	▲	▲	▲	▲	▲	▲	▲	—	—	▲	▲	▲	—
Collision Statistics *b	1	▲	▲	▲	▲	▲	▲	▲	—	—	▲	▲	▲	—
Built-In Time Domain Reflectometer	1	—	▲	—	—	—	—	—	—	—	INA	INA	▲	—
Ethernet Controller Chipset	0	*A	*B	*A	*A	*A	*A	*A	*C	*D	*E	*E	*D	*A
Remote Boot PROM/EPROM	0	▲	▲	*O	*O	*O	*O	*O	*O	*O	*O	*O	*O	*O
Standards Supported	1													
IEEE 802.2 Support	1	—	▲	—	—	—	—	—	—	▲	▲	▲	—	INA
NETBIOS Support	0	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Method of NETBIOS Support	0	*P	NBI	NBI	NNE	NNE	NNE	NNE	NNE	*c	INA	INA	TP	*P
NDIS Interface	1	—	—	—	▲	—	—	—	▲	▲	▲	▲	▲	▲
Media Supported	1													
Thin/Thick Coax Cable	1	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Twisted-Pair Wire	1	—	—	—	—	—	—	Y1	Y2	—	—	—	—	—
Fiber Optic Cable	0	—	—	INA	INA	—	—	INA	—	—	INA	INA	INA	—

▲—Yes, has feature.
**a—ROM options range from 0 to 8K for SMC, 8 to 16K for Artisoft E-2 and Racal; 16 to 64K for 3Com EtherCard PLUS16; and 16 to 128K for EtherLink Plus.*

Table 3. General Features (Continued)

	Weight	Artisoft AE-2	BICC Isolan 4110-2	CNet CN200E	Gateway G/Ethernet	Novell NE1000	Novell NE2000	PureData PDI8023-16	Racal InterLan	SMC Ethernet-PC510	3Com EtherLink II	3Com EtherLink Plus	Tiara LanCard/E* 16	WD Ethercard Plus16
Features	2													
Compatible Network Operating Systems	6													
Novell NetWare/286 v2.1x	3	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Novell NetWare/386 v3.x	2	▲	▲	▲	▲	▲	▲	—	▲	▲	▲	CL	▲	▲
Banyan Vines 286 V3.0	1	—	—	—	—	—	—	—	—	▲	—	SR	—	▲
Banyan Vines 386 V4.0	1	—	▲	—	—	—	—	—	—	▲	—	SR	—	▲
IBM PC LAN Program 1.30	1	—	▲	—	—	—	—	—	—	▲	—	—	—	▲
IBM LAN Server 1.1	1	—	▲	—	—	—	—	—	▲	▲	—	—	▲	—
3 + Share 1.2.1	4	—	—	—	▲	—	—	—	—	—	▲	▲	▲	▲
3 + Open 1.1	1	—	▲	—	—	—	—	—	▲	▲	▲	▲	▲	▲
TCP/IP	1	—	▲	—	▲	INA	INA	—	▲	▲	▲	▲	▲	▲
Other	0	*N	*d	*N	*N	*N	*N	*N	*e	*N	*f	*f	*g	*h

**b—Board can pass diagnostic software frame overrun and collision statistics to network operating systems.*
**c—Both Monolithic and NDIS NETBIOS driver.*
**d—Supports PC-NFS/MPS.*
**e—Supports NCSA Telnet.*
**f—Supports DECnet.*
**g—Supports SCO Xenix, Interactive UNIX, and DECnet-DOS.*
**h—Supports Xerox Network Systems (XNS).*
**A—National Semiconductor DP8390.*
**B—Advanced Micro Devices AM7990.*
**C—InterLan X 802.3 controller.*
**D—Fujitsu EtherStar MB86950.*
**E—Intel I82586.*
**N—None.*
**O—Optional.*
**P—Proprietary.*

CL—Client.
SM—Shared memory.
SR—Server.
TP—Third party.
Y1—Yes; also supports 10BASE-T specification with a plug-in module.
Y2—Yes; 10BASE-T version announced February 1990.
DMA—Direct memory access.
INA—Information not available.
NBI—NETBIOS Interface.
NNE—Novell NETBIOS emulator.
NA—Not applicable.
PIO—Programmed I/O.

Equipment Prices

		Price ($)
Ethernet Network Adapters		
	Artisoft AE-2 Ethernet	349
	Boot PROM	60
	64K RAM upgrade	50
	BICC ISOLAN 4110-2	495
	CNET CN200E	439
	Gateway G/Ethernet	445
	Boot PROM	35
	Novell NE1000	395
	Novell NE2000	495
	Pure Data I8023-16	495
	10BaseT Plug-in Module	5
	Racal Interlan N6510	495
	Boot PROM	50
	SMC PC510	495
	3Com EtherLink II	345
	Etherstart II 3C503-ES	49
	Transceiver cable clips	30
	3Com EtherLink Plus	895
	128K RAM Upgrade Kit	115
	Tiara LAN Card/E*AT	595
	Boot PROM	50
	WD EP16	399
	Lattisnet Transceiver	155

■

Arcnet Network Adapters

A Report from NSTL

In this report:

Synopsis

Focus
NSTL evaluated Arcnet network adapter features and specifications weighted to indicate their importance to compatibility, connectivity, reliability, ease of use, and performance.

Products Tested

CN190SBT
CNet Technology, Inc.

ANET-TP/16
Compex

AMT-216
Lanmaster

PcARC/50
Network Interface Corp.

PcARC-AT/50
Network Interface Corp.

PDI516Plus T
PureData Ltd.

PC550
Standard Microsystems Corp.

TC6045 Arc-Card/AT
Thomas-Conrad Corp.

*LanCard/A*AT TP*
Tiara Computer Systems, Inc.

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 Rating	Product Name	Performance	Features	Usability	Price
8.7	PureData PDI516Plus T	●	●	●	$395 ★
8.4	Tiara LanCard/A*AT TP	●	●	●	$385 ★
8.1	Thomas-Conrad TC6045 Arc-Card/AT	●	●	●	$379
7.8	Standard Microsystems PC550	●	●	●	$695
7.7	Network Interface PcARC-AT/50	●	●	●	$550
7.5	Lanmaster AMT-216	●	●	○	$295
7.4	Compex ANET-TP/16	●	●	●	$159 ★
7.1	CNet Technology CN190SBT	●	●	●	$395
5.6	Network Interface PcARC/50	◍	●	●	$295

Overview

Arcnet (Attached Resource Computer Network) technology operates at a nominal data transfer rate of 2.5M bps using a distributed star architecture. Developed in 1977 by Datapoint Corp. of San Antonio, TX, as a means of interconnecting minicomputers and peripheral resources, it predates the other local area network technologies.

Arcnet lacks the stature of the Ethernet and token-ring technologies, primarily because it is not a recognized IEEE standard. However, it claims a 10 to 15 percent share of the PC LAN market (some supporters claim a 20 percent share), and analysts predict its market share will grow. One reason for Arcnet's enduring presence is the Arcnet Trade Association, which campaigns against misconceptions, works on architectural improvements, and organizes regular conferences.

Arcnet network components typically include the network interface card residing in each PC and active and/or passive hubs that serve as wire concentrators, repeaters, and media converters. These components determine the network's topology, access method, and transmission media. The network interface card incorporates all processing logic (Arcnet controller chip, transceiver, and support circuitry) for protocol processing, packet formatting, error checking, and connecting with the PC data bus.

Evaluation Criteria

NSTL evaluated a series of 16-bit (bus interface) Arcnet adapters that support twisted-pair media and Novell NetWare 386. Test results for the 8-bit Network Interface PcARC/50 are included for comparison with the 16-bit cards. Vendor market share and visibility are considerations in product selection. The test field includes low-cost products (based on suggested retail price) and higher priced products with advanced features. Lantana Technology's Aster/3 and Aquila Communications' AQ-PCA 316 were dropped because of problems encountered during testing.

Arcnet Basics

Arcnet offers the most flexible network architecture. Using a variant of the basic star topology, a central hub (typically with 8 or 16 ports) connects PCs directly to the server. Users can interconnect hubs to achieve a distributed star topology. Active hubs serve as signal regenerators, but lower cost passive hubs can connect network nodes at a limited distance without signal regeneration. A PC must be within 100 feet of a passive hub or within 2,000 feet of an active hub. Open ports on passive hubs and end-stations on a bus topology must be terminated with resistors to match the impedance of the cable (93 ohms on RG-62 coaxial cable; approximately 100 ohms on twisted-pair cable). Active hubs employ self-terminating ports and require no terminating resistors. In a coaxial bus topology, up to eight PCs can be connected to a cable segment using BNC T-connectors with a maximum end-to-end distance of 1,000 feet. Standard Microsystems (SMC) offers a two-port active hub called Active Link that can connect two coaxial bus cable segments. Bus topology reduces the amount of cable required to wire a LAN and reduces the number of central hubs or eliminates them all together.

Twisted-pair wiring also supports end-to-end connection of PCs in a daisychain arrangement. Up to 10 systems can connect to a single wire segment using a variation of the bus topology. Point-to-point connections can run 400 feet (800 feet with the Thomas-Conrad twisted-pair wiring scheme). The bus and star topologies can be mixed in a given network, providing great flexibility.

Recommended Arcnet cable types include:

- Coaxial cable
  - –RG-62/U (93-ohm nominal impedance)
  - –RG-59/U (75 ohms)
  - –RG-11/U (75 ohms)
- Twisted-pair wire
  - –AT&T voice and data bundles
  - –IBM Type 1
  - –IBM Type 2
  - –IBM Type 3 telephone

- Duplex fiber optic
  - –50-micron core diameter
  - –62.5-micron core diameter
  - –100-micron core diameter
  - –200-micron core diameter

NSTL's tests used twisted-pair cabling, which generated several network compatibility problems (unlike coaxial cable, which has standard physical and electrical specifications). A standard cabling media such as AT&T's voice and data cable (which bundles IBM's Type 1 and Type 3 data cables) will cause fewer problems. Wire polarities must be maintained, end-connectors and terminators must be matched, and the proper tools must be used to avoid intermittent problems. Some vendors support standard flat telephone cable (also known as satin cable) in star topologies for short distances, while others do not recommend it. Vendors emphasize the importance of matching a cable to a specific connector. An Application Note from PureData states "it is generally inappropriate to crimp solid conductors into RJ-11 connectors, since these devices were designed to support stranded wire."

Performance

Arcnet interface card performance depends primarily on the network software driver, although the bus interface width, adapter-to-host data transfer method, on-board RAM, and LAN controller also play important roles.

The complex interaction between the adapter board and device driver is difficult to analyze without the developer's knowledge. Even with a large RAM buffer, performance may be relatively poor because of inefficient device driver design. Vendors often claim definite performance advantages by circumventing COM9026 RAM arbitration logic in dual-ported memory arrangements and implementing proprietary arbitration logic external to the chip. Zero-wait state bus transfers can improve the data transfer times between the adapter and the CPU, but poor interrupt handing or data buffer management can offset fast hardware designs.

On-Board RAM

Most Arcnet adapters implement 2K bytes of on-board RAM, and the host CPU and LAN controller chip can access four 512-byte "pages" of a standard Arcnet frame for transmitting and receiving. Software drivers regulate access to the buffers with hardware-assisted RAM arbitration logic. Increasing on-board memory confers no performance advantage except with dual porting and/or multiple buffering techniques. Dual porting allows the host CPU and LAN controller simultaneous access to the transmit and receive buffer segments; multiple buffering queues receive and transmit multiple packets.

Without dual porting and/or multiple buffering, the size of the RAM buffer may be less critical to performance than it is for Ethernet or token-ring adapters. Standard Arcnet limits data packets to 508 bytes; Ethernet and token-ring protocols allow larger transmission packets. NSTL's Ethernet and token-ring adapter evaluations (Reports 800-201 and 800-101, respectively) showed that the amount of on-board RAM affects adapter performance under those protocols appreciably. (The Arcnet maximum packet size will increase from 512 bytes to 4K bytes with the introduction of 20M bps ARCnetplus.) Table 1 summarizes data transmission specifications for the Arcnet, Ethernet, and token-ring network technologies.

Bus Interface

All other factors being equal, a 16-bit data path should move a given amount of data twice as fast as an 8-bit data path. Unfortunately, other factors are rarely equal in a network computing environment. No two 16-bit or 8-bit cards are identical, component for component, and factors such as disk access times, memory management efficiencies, and wait states skew the performance ratio such that performance differences between 8- and 16-bit cards are less pronounced. In the application performance tests, the 8-bit Network Interface PcARC/50 card achieves 53 percent of its 16-bit counterpart's performance. In contrast, the low-level throughput tests show marked differences between the 8- and 16-bit cards. In the low-level 3M-byte transfer using the NetWare IPX transport protocol, the 8-bit Network Interface PcARC/50 card's throughput level is about 47 percent of the 16-bit PcARC-AT/50 card's throughput.

Table 1. Data Transmission Specifications

Specifications	Arcnetplus	Arcnet	Ethernet	Token Ring
Data Rate (Mbps)	10	2.5	10	16
Best-Case Throughput (Kbps)	1,025	211	1,082	1,908
Minimum Packet Size (Bytes)	12.5	8.75	72.0	21.0
Maximum Packets/Sec.	204,100	26,000	17,400	95,200
Maximum Packet Size (Bytes)	4,224	512	1,526	18,000
Maximum User Data Area (Bytes)	4,096	508		
Minimum Overhead Area (Bytes)	8	4		
Maximum Nodes	2,047	255	1,023	260

Adapter-to-Host Data Transfer

The network adapter can communicate with the host system memory using shared memory, direct memory access (DMA), programmed I/O, or other schemes such as bus mastering. The SMC PC550 and CNet use programmed I/O, and the other test adapters are memory mapped.

Shared memory adapters map on-board memory into PC address space between 640K bytes and 1M byte (many adapters require up to 16K bytes of PC memory in a contiguous block). The CPU issues memory read and write commands to the adapter's shared memory under the control of the device driver. Adapter buffer memory locations can be randomly accessed by the device driver.

For programmed I/O accesses, the adapter card uses one or more of the processor's I/O ports for data transfer. The CPU controls the data transfer by issuing I/O read and write commands as instructed by the device driver. Programmed I/O implementations transfer data between the adapter's RAM buffer and the CPU (similar to shared memory methods), but without the capability to directly access random memory locations in the adapter's RAM buffer. Buffer memory access is controlled by the adapter hardware logic upon receiving I/O read and write commands.

The effect of the adapter-to-host data transfer method on performance is not readily apparent. NSTL's tests show that the SMC and CNet adapters with I/O mapping perform slowest overall, possibly because of additional wait states.

Controller Chipset

All the Arcnet adapters use SMC or NCR controller chips (the original COM9026 or more recent variants, such as the SMC COM90C65 and NCR 90C146 and 90C198 with integrated components and surface mount technology). Arcnet LAN controller chips manufactured by SMC and NCR adhere to a common standard specification, so their relative effects on adapter performance are minimal using the current 2.5M bps Arcnet technology.

A controller that integrates functions usually implemented by other chips will enhance its overall communications control functions and improve performance. Additional support circuitry that can be integrated with the VLSI chip can conceivably enhance performance for tasks other than normal communications. The NCR 90C198 used on the Tiara card implements dual-ported adapter RAM buffer access and command or buffer chaining using the external 8K-byte RAM buffer (for 8-bit addressing; 4K bytes for 16-bit addressing). At test time, Tiara did not have a software driver available to take advantage of these design features. The 90C198 uses a 16-bit address/data bus interface compared to the 9026's 8-bit line. The 90C198's design gives it reduced wait state operation compared to the 9026 even without a custom driver.

Network Operating System Drivers

Network adapters include drivers for one or more network operating systems. All the Arcnet adapter manufacturers supply drivers for Novell NetWare 286. Lanmaster, PureData, SMC, and Thomas-Conrad also currently provide NetWare 386 drivers. A software driver's efficient protocol

processing can significantly influence performance, as seen in the PureData's 13 percent gain using its proprietary PDA386OS driver in place of the Novell Turbo RXNET driver.

Adapter Configuration

Most network adapters designed for standard ISA bus systems avoid conflicts with other system resources and option cards using hardware switches and/or jumpers. Multiple setting options that enhance setup flexibility can complicate configuration. Clearly marked option blocks identifying the main parameters (I/O base address, interrupt request line, base memory address for RAM/ROM) and specific selections for each parameter facilitate manual configuration. With few exceptions, the adapters' documentation is very helpful when configuring hardware jumpers and switches.

Only the PureData provides a software utility for adapter configuration and diagnostics. Diagnostic software is included with many of the adapters and optional for the CNet, Lanmaster, Network Interface, and SMC cards.

Diagnostic Tools

The Arcnet environment simplifies network fault isolation. Basics such as termination and nonduplicated node IDs can easily be checked. LED indicators standard on most adapter cards and hubs (the Thomas-Conrad adapters do not feature LEDs) provide valuable information on cabling and network status, communications activity, and reconfiguration diagnostics.

Although hardware features such as on-board LEDs are valuable, diagnostic software increases the reliability of an Arcnet network. Not all the diagnostic programs provide the same types of utility functions, but most basic diagnostics incorporate internal board circuitry checking for accessing the RAM buffer, verifying board settings, and testing network connections.

Operating System Support

Network adapters must be equipped with drivers for the widely used network operating systems, and interfaces and drivers for well-established communications and high-level transport protocols. All the adapter cards support the NETBIOS standard in one form or another. As of publication, only PureData and Thomas-Conrad support the Microsoft/3Com NDIS protocol specification. (Arcnet vendors indicate that Microsoft will soon bundle an NDIS-compatible Arcnet driver with Microsoft LAN Manager 2.0.) According to SMC, it wrote the driver in collaboration with Microsoft for NDIS compliance; the suggestion is that all Arcnet adapters fully compatible with SMC adapters will be supported under Microsoft LAN Manager.

All the test cards support Novell NetWare 286 and NetWare 386. Only the CNet and Compex do not have drivers for VINES/286 and VINES/386. PureData supports the IBM PC LAN Program, and SMC supports 3Com's 3+Share. Very few adapters support the OS/2-based IBM LAN Server, Microsoft LAN Manager, and 3Com 3+Open. PureData currently supports all LAN Manager-based networks; SMC supports 3Com 3+Open.

A few support other network operating environments as Artisoft LANtastic, CBIS Network-OS, Univation's LifeNet, and Western Digital's ViaNet. Table 2 lists supported network operating systems.

Summary

Among the adapters with the best overall performance results, the PureData and Thomas-Conrad use the dual-ported shared memory adapter-to-host I/O transfer with custom drivers. The Tiara card uses memory mapping for data transfer and the new NCR 90C198 VLSI controller chip; Tiara does not currently supply a custom NetWare driver.

The slow CNet and SMC cards use programmed I/O data transfers and standard 2K-byte RAM buffers. The SMC's performance is significantly improved with the SMC Nodal Priority chip installed on the file server PC550 adapter. The Nodal Priority chip lets the file server use the token for multiple transmissions (i.e., processing more workstation requests) before releasing it.

Specific adapter features, compatibility issues, usability, and price are as important as performance when choosing Arcnet adapters, maybe even more so than when choosing Ethernet or token-ring adapters. Adapters with more consistent ratings in all the evaluation categories have a decided advantage over a high-performance adapter with poor features and a high price. Most users

should choose an Arcnet adapter for its features (simplicity, reliability, maintenance, and other usability factors) rather than its performance. (NSTL's overall evaluation methodology weights features, usability, and performance equally.)

Excellent performance and a competitive price make the Tiara the best choice for network server installation. The PureData's very good performance and excellent overall rating make it another obvious selection. The Thomas-Conrad offers good overall performance, but users will be restricted to Thomas-Conrad equipment, hubs, and adapters. Relatively inexpensive cards like the Compex and Lanmaster make very good workstation adapters.

SMC's fourth place ranking may be surprising in view of the vendor's market leadership, but it is precisely because of SMC's leadership standing that other competitors benefit. Competitors license technology from the market leader and strive to provide incremental performance improvements as well as appeal factors, such as enhanced usability. Reduced production overhead gives these vendors a competitive product pricing advantage as well.

Product Evaluations

CNet Technology CN190SBT

Product Summary

- Uses programmed I/O for data transfer
- 16-bit interface
- 2K bytes of RAM on adapter
- Limited network operating system support

Compex ANET-TP/16

Product Summary

- Uses shared memory for data transfer
- 16-bit interface
- 2K bytes of RAM on adapter
- Lowest priced 16-bit test adapter
- Limited network operating support

Lanmaster AMT-216

Product Summary

- Uses shared memory for data transfer
- 16-bit interface
- 4K bytes of RAM on adapter
- Twisted-pair cabling not compatible with SMC
- Poor documentation
- Good overall performance
- Supported by Banyan Vines/286 3.0 and Vines/386 4.0, Novell NetWare 286 2.1x, and NetWare 386 3.x only

Network Interface PcARC/50

Product Summary

- Uses shared memory for data transfer
- 8-bit interface
- 2K bytes of RAM on adapter
- Good performance for an 8-bit card
- Good network operating system support

Network Interface PcARC-AT/50

Product Summary

- Uses shared memory for data transfer
- 16-bit interface
- 8K bytes of RAM on adapter
- Good overall performance
- Good network operating system support

PureData PDI516Plus T

Product Summary

- Uses shared memory for data transfer
- 16-bit interface
- 4K bytes of RAM on adapter
- Well-organized manual
- Good overall performance; fastest low-level performance
- Excellent adapter configuration utility; good diagnostics

Standard Microsystems PC550

Product Summary

- Uses shared memory for data transfer
- 16-bit interface
- 2K bytes of RAM on adapter
- Good network operating system support

Thomas-Conrad TC6045 Arc-Card/AT

Product Summary

- Uses shared memory for data transfer
- 16-bit interface
- 2K bytes of RAM on adapter
- Uses twisted-pair cabling scheme not compatible with that of SMC
- Best overall performance with traffic; fastest under Foxbase traffic
- Good network operating system support

Tiara LanCard/A*AT TP

Product Summary

- Uses shared memory for data transfer
- 16-bit interface
- 8K bytes of RAM on adapter
- Excellent overall performance
- Fastest performance under cc:Mail traffic and in Foxbase transaction processing

Product Recommendations

PureData PDI516Plus T

The PureData is excellent for network server or workstation installation. It uses dual-ported shared memory adapter-to-host I/O transfer with custom drivers. It provides excellent network operating system support and comes with a software-based configuration utility and diagnostics.

Tiara LanCard/A*AT TP

The Tiara is also excellent for network server or workstation installation. It uses memory mapping and the new NCR 90C198 VLSI controller. The Tiara is priced lower than the PureData but does not currently provide a custom NetWare driver and lacks support for many widely used network operating systems.

Compex ANET-TP/16

The Compex' bargain price makes it a good workstation card. Its performance and usability are average; it does not provide drivers for NetWare 386, Vines/286, or Vines/386.

Rating Summaries

Figure 1.
CNet Technology CN190SBT Ratings

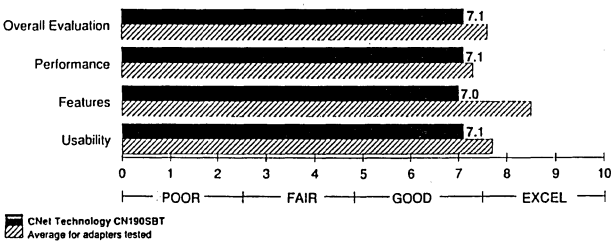


Figure 2.
Compex ANET-TP/16 Ratings

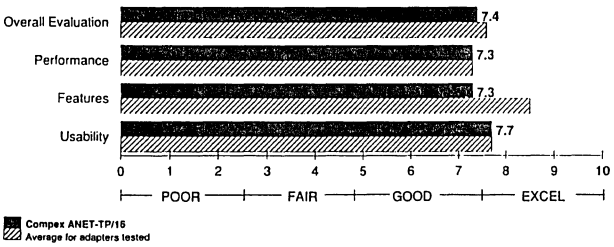


Figure 3.
Lanmaster AMT-216 Ratings

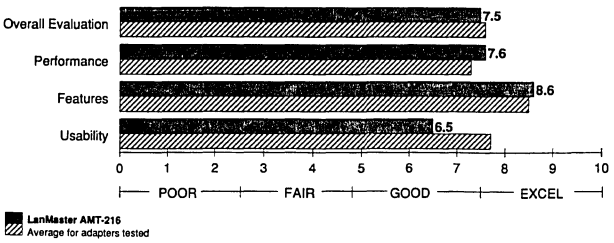


Figure 4.
Network Interface PcARC/50 Ratings

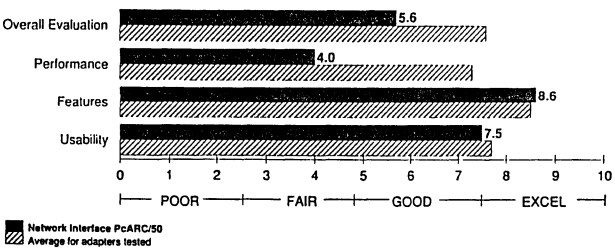


Figure 5.
Network Interface PcARC-AT/50 Ratings

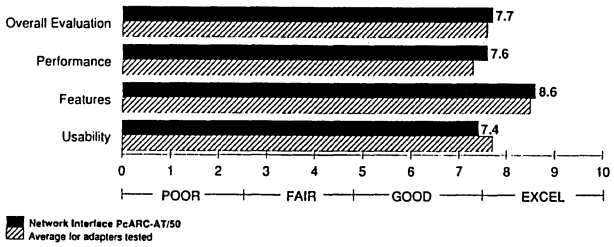


Figure 6.
PureData PDI516Plus T Ratings

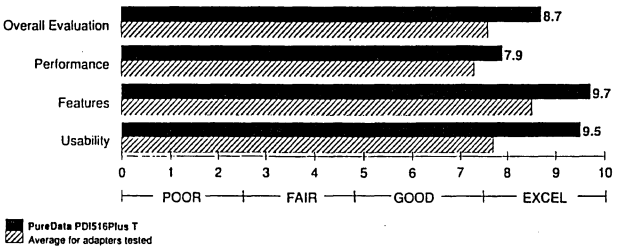


Figure 7.
Standard Microsystems PC550 Ratings

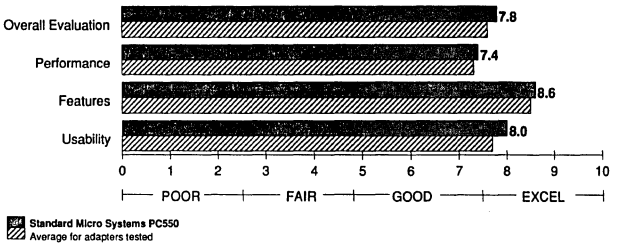


Figure 8.
Thomas-Conrad TC6045 Arc-Card/AT Ratings

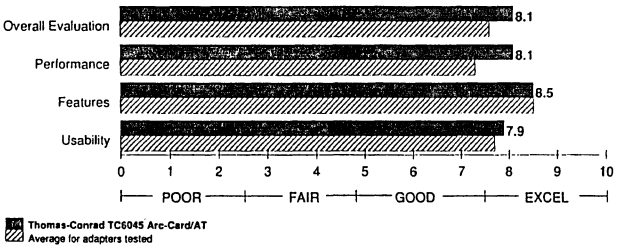
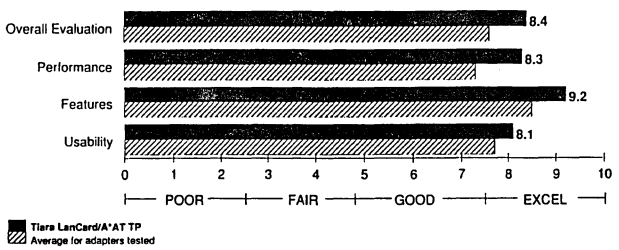


Figure 9.
Tiara LanCard/A*AT TP Ratings



Overall Evaluation

The PureData provides the best raw throughput using a custom device driver and wide support for all popular network operating systems and interface standards. The PureData's configuration utility completely eliminates the use of hardware switches and jumpers. Users quickly select all hardware setup options and generate a NetWare workstation shell once, using the same IPX program with different configuration options.

The Tiara and Thomas-Conrad excel at the high-level application tests and application/transaction processing tests. The Tiara uses a 16-bit NCR 90C198 controller that reduces wait-state cycles and services host CPU transmit commands faster than the 90C26 controller on the other adapters. Tiara provides an interactive configuration utility, and the driver diskette includes diagnostic software that performs a self-test based on the configuration settings. The Thomas-Conrad configuration requires hardware switch settings. Both the Tiara and Thomas-Conrad provide limited network operating system support.

Limited support for network operating systems, interface standards, and media characterize most of the Arcnet adapters. The Lanmaster provides good performance and above-average features, but its documentation is inadequate, and configuration sheets are inconsistent. The Network Interface cards must be removed to change jumper block settings for the interrupt request line. The CNet and Compex currently support only the Novell NetWare network operating system; neither supports fiber optic cabling. The Compex manual covers more than one product, but none in detail.

Methodology

The Overall Evaluation represents a weighted average of each network adapter's scores for performance, features, and usability.

Overall Evaluation Score = (5 x Performance Score) + (3 x Usability Score) + (2 x Features Score) ÷ 10.

Performance

Performance test results indicate that the software driver, data transfer method from adapter to host memory, and RAM data buffer arbitration method have the greatest influence on speed. Adapters that use shared memory for adapter-to-host transfers perform fastest overall.

The Tiara's NCR 90C198 controller incorporates a 16-bit interface plus the functions of semiconductor elements such as the transceiver and AT bus interface circuitry. The improved 90C198 design reduces wait-state cycles, thereby servicing host CPU transmit commands faster than the 90C26. The Tiara and Thomas-Conrad perform fastest overall in the high-level application tests and perform very well on the application/transaction processing tests.

The Thomas-Conrad excels in the combined traffic tests, followed at a distance by the Tiara and PureData. Efficient handling of traffic at the server can be attributed primarily to a well-written device driver.

The PureData provides the best raw throughput using its custom device driver. The PureData driver provides a 13 percent improvement over the card's performance when tested with the Novell Turbo RXNET driver. With the Tiara card, the Turbo RXNET driver does not take full advantage of the buffer- and command-chaining features of the NCR 90C198 controller chip.

The relative performance of the 8-bit Network Interface PcARC/50 comes as no surprise. The 8- and 16-bit Network Interface cards exhibit an approximate 2-to-1 performance ratio, not taking into account the different wait states. In the high-level application/transaction processing tests, the 8-bit PcARC/50 attains 53 percent of the performance of the 16-bit PcARC-AT/50. The ratio drops to 47 percent with the low-level throughput.

Methodology

Performance ratings for the Arcnet adapters are based on performance indexes for the application and transaction processing tests combined with those for the low-level throughput tests. The Overall Performance Index is calculated from the Overall Performance Score divided by the Standard Performance Score. The Overall Performance Score is a weighted average of scores for the application/transaction processing tests and the throughput tests.

Features

NSTL evaluated adapter design characteristics that enhance compatibility, performance, and support for operating systems and standards. Most of the adapters scored above average with good network operating system support. Exceptions are the CNet and Compex, which currently support only Novell NetWare and do not support fiber optic cabling.

The PureData supports all the popular network operating systems and incorporates important design features such as software-assisted configuration. The PureData also scores well for its standards and media support. Each adapter comes with a configuration utility and diagnostic software. (The diagnostics utility included on the software driver diskette is for the coaxial adapter only.)

Compex, Thomas-Conrad, and Tiara claim to provide diagnostic software, but only Tiara includes diagnostics on the driver diskette. The Tiara diagnostic software performs a self-test based on the configuration settings using a loopback procedure.

All the Arcnet adapters support the IBM NETBIOS standard, at least via the network operating system NETBIOS emulation. Only PureData and Thomas-Conrad currently support the Microsoft/3Com-specified LAN Manager Network Driver Interface Specification (NDIS) standard. Lack of support for one or more operating systems and interface standards, limited configuration flexibility, and limited or no diagnostic tools account for the average features scores earned by many of the products.

All of the vendors offer products for coaxial and twisted-pair cabling. CNet and Lanmaster offer Arcnet adapters with both types of media connectors; CNet and Compex do not currently provide adapters with a fiber optic cable interface.

Methodology

NSTL compared the products against a master list of Arcnet hardware and software features and specifications determined to be important in an Arcnet network adapter. NSTL tested most of the features during its evaluation to ensure their support. The Features score is a weighted average of scores for the individual features. A detailed list of features and their methodology weights appears in Table 3.

Usability

Usability ratings are based on the adapters' installation and configuration procedures and on supplied software drivers. Organized and well-written documentation should facilitate installation and configuration.

Network interface cards often require unique configuration settings that may conflict with other host subsystems. Almost all the test adapters use switch and/or jumper blocks for selecting node ID, interrupt request line, I/O base address, and base memory address.

Like its Ethernet configuration utility, PureData's Arcnet configuration is superb. A very flexible configuration and setup tool completely eliminates the use of hardware switches and jumpers. Users quickly select all hardware setup options and generate a NetWare workstation shell once, using the same IPX program with different configuration options.

Tiara's configuration utility provides interactive option selection. As selections are made, the software graphically illustrates the jumper and/or switch block on the board with an enlarged representation of the selected setting. Lanmaster's configuration utility is similar to Tiara's, but assistance is somewhat limited. The Lanmaster configuration utility lists available NetWare configuration options, and once the user makes a selection, the program presents a graphical representation of the switch settings.

An Arcnet adapter that provides no configuration utility should make the switch/jumper block setup as simple as possible, preferably with all the switch blocks aligned at the top edge of the card to preclude having to remove the card to change settings. Thomas-Conrad's piano-style switches make it easier to see how the switch is currently set. Thomas-Conrad minimizes ambiguities through the use of graphical aids in its documentation.

Most of the adapters clearly identify switch block and jumper settings, but not all satisfy accessibility requirements. The Network Interface and SMC switch blocks are easily accessible at the top edge of the card. The other cards position switch blocks for I/O base and RAM base address settings at the top edge and a jumper block for interrupt request line at the bottom, necessitating removal of the card.

Documentation is good overall except for Compex and Lanmaster. The Compex manual uses

small print and covers a family of products, with few details on any one. The Lanmaster documentation focuses on the marginal configuration utility and does not address hardware installation and configuration problems. Lanmaster provides loose configuration sheets covering switch settings, but the sheets are not consistent from one board package to the next. The well-organized PureData documentation uses graphics, and the technical reference section is among the best.

Methodology

Usability ratings are based on adapter installation and configuration and documentation quality. Usability is a weighted average of scores for the individual criteria.

Usability Score = (5 x Installation Score) + (1 x Manual Organization Score) + (1 x Manual Clarity Score) + (2 x Manual Comprehension Score) ÷ 9.

Performance Results

A network interface card's performance is generally determined by its hardware design and the quality of its software interface to the network operating system. The contribution of either factor varies depending on the network technology. Hardware design at minimum encompasses the on-board processor, ROM firmware, RAM, I/O transfer method, and component integration (i.e., reducing pathways between components). In NSTL's test scenario, the type of Arcnet controller chipset, on-board RAM arbitration, board-to-system data transfer method, and software driver (and possibly firmware, if used) are the most significant performance considerations.

Controller Chipset

The highly standardized COM9026 family of Arcnet controllers and variants (manufactured by NCR and SMC) used by many Arcnet adapters yield little performance differentiation at the chipset level. The Network Interface PcARC-AT/50 uses the 16-bit NCR 90C146 controller, the Tiara uses the 16-bit NCR 90C198, and the other adapters use 8-bit COM9026-type controllers. (The controller data path width is not related to the adapter's host interface bus width.)

New controller chips such as the SMC 90C66 integrate the functions of several external chips to improve the adapter's performance. Component integration maximizes the efficiency of intercomponent communication, which translates into more efficient network communications. The Tiara's 16-bit NCR 90C198 controller permits a larger buffer RAM than the COM9026-based adapters; unfortunately, the Tiara does not come with a device driver capable of taking advantage of the larger RAM buffer.

RAM Buffer Size

The RAM buffer becomes a distinguishing performance factor when it exceeds the 2K-byte Arcnet standard and implements advanced software features such as buffer chaining. A dual-ported 2K-byte RAM buffer permits simultaneous access to different transmit and receive buffers for the COM9026 controller and host CPU. Double buffering of transmit and receive frames (implemented through on-board firmware or in device driver software) permits overlapping receive and transmit sessions for simultaneous transfers at an even faster pace. Without dual porting, the buffer can be accessed by either the CPU or the controller, but not both at one time.

All test adapters using shared-memory architecture implement dual-ported RAM (according to the vendors). Several vendors advertise up to 8K bytes of on-board RAM, but the added RAM provides no performance advantage without command and buffer chaining implemented in the device driver. None of the test adapters implements command and buffer chaining.

The standard Arcnet COM9026 controller can manage four simultaneous receive and/or transmit message frames, each containing a 512-byte Arcnet packet. The expanded on-board RAM option may be less important for Arcnet adapters than for Ethernet and token-ring architectures, which support very large packet sizes at the data link level.

I/O Transfer

Although the influence of specific I/O transfer methods on adapter performance is difficult to measure, NSTL's test results show some correlation between network adapter performance and specific I/O transfer methods. Most of the Arcnet adapters use shared memory host data transfers and perform uniformly faster than the CNet and SMC, which use programmed I/O.

Device Driver Software

NSTL tests the cards using the Novell Turbo RXNET driver because Novell NetWare 386 drivers were available from only a few of the vendors. The Turbo RXNET uses larger packets (4K bytes) at the higher protocol layers than standard RXNET drivers (576 bytes). SMC, PureData, Thomas-Conrad, and Lanmaster supplied custom turbo drivers for NetWare 386 3.x.

Test Configuration

NSTL's test network uses a Compaq Deskpro 386/20 server configured with 9M bytes of RAM, a 150M-byte hard disk, and Novell NetWare 386 3.1 Revision A. The network includes a Compaq Deskpro 386/25 primary workstation, 16 Everex 386iS secondary workstations, and a Compaq Deskpro 386/25 controller workstation that automates the tests. The primary workstation is configured with 8M bytes of RAM and a 300M-byte hard drive; the secondary workstations are equipped with 4M bytes of RAM and 40M-byte drives.

Network connections use standard twisted-pair telephone wire with two eight-port SMC hubs in a mixed star and daisychain topology. SMC PC550 adapters (not tested) are installed in the controller workstation and 13 secondary workstations throughout the benchmark test suite. For each test cycle, the test Arcnet adapter is installed in the server, the primary workstation, and three secondary (or traffic) workstations.

Before testing, the server disk is purged of all files, and all the applications and test files are regenerated. The server disk is purged at specified intervals when a suite of tests is executed using a batch file. NetWare is set up to automatically load the appropriate NetWare 386 driver (or the Turbo RXNET driver) as a NetWare Loadable Module (NLM). Workstation shell drivers are regenerated for each adapter (the primary workstation and three secondary workstations) using the driver files supplied by the adapter vendor. Workstations with SMC PC550 (nontest) adapters retain the same NetWare shell.

Application Benchmarks

Five application benchmarks measure the Arcnet adapter's speed printing to the network using the DOS Copy and NetWare Capture commands, executing DOS Xcopy operations, and executing typical operations in Lotus 1-2-3 Release 3, Microsoft C, and Foxbase+/LAN. Application benchmarks are timed at the primary workstation with the secondary stations idling (no traffic) and repeated with background network traffic generated by Lotus 1-2-3, Foxbase+/LAN, cc:Mail, and Xcopy on five secondary workstations (including the three with test cards installed).

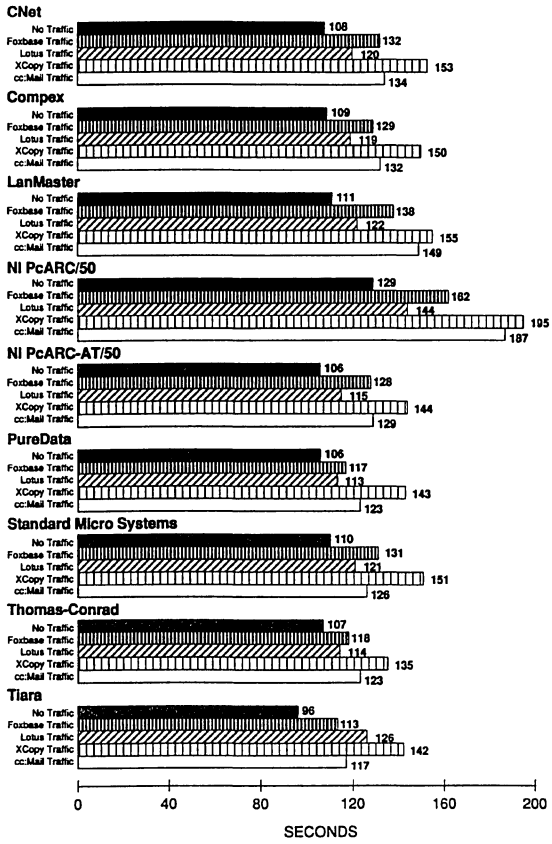
Foxbase traffic consists of each workstation performing a transaction no more than 30 times a minute. The transaction looks up indexed records in three files and locks, updates, and unlocks one record in each file. Lotus traffic consists of each secondary workstation executing a macro that combines and saves files metered to be active no more than once every 20 seconds on each station. In cc:Mail, each workstation submits a 100K-byte file every 44 seconds; Xcopy moves a 128K-byte directory tree from the server to the five traffic workstations once every 19 seconds.

Additionally, the Arcnet adapters are tested running a suite of 16 Foxbase+/LAN database benchmarks and with transaction processing and low-level throughput. Transaction processing in Foxbase+/LAN runs on 1, 3, 10, and 16 workstations with and without indexes.

Throughput Test

Raw throughput is measured in two Compaq Deskpro 386/25 workstations. The workstations log in to the server and are then linked peer to peer with custom IPX send and receive programs optimized for throughput without disk access or processing to bottleneck transmission. One workstation is set up in send mode (it also controls the exchange timing function), the other in passive receive mode.

Figure 10.
Lotus 1-2-3



Lotus 1-2-3

A Lotus macro loads and saves a 3M-byte spreadsheet, moving a substantial amount of data over the network. The test is repeated with four traffic applications running concurrently on five secondary workstations.

Analysis

The Lotus test emphasizes an adapter's efficiency in loading and saving a file at the server; contributions of workstation performance are emphasized less. The Lotus test highlights performance differences between the 8-bit Network Interface PcARC/50 and 16-bit bus interface cards, especially under traffic conditions, and accentuates performance differences between the 16-bit adapters.

Microsoft C 5.0

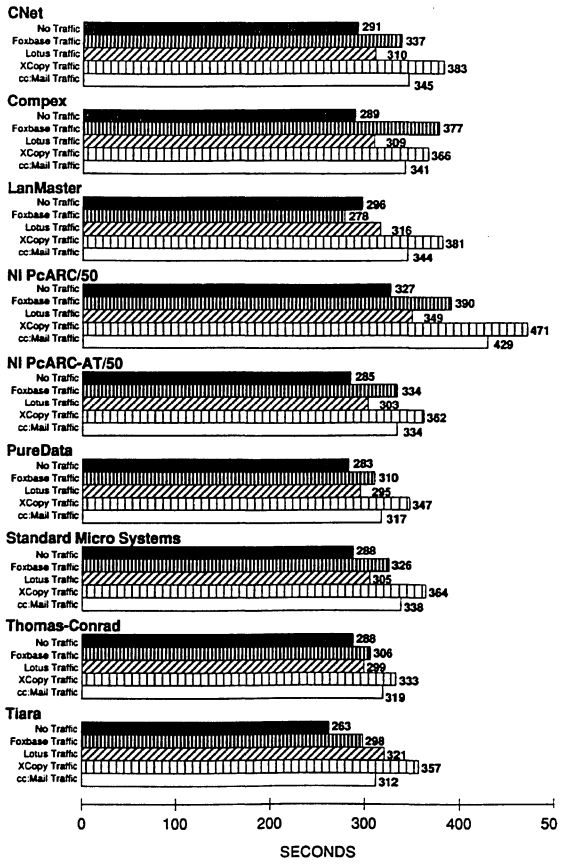
Microsoft C compiles and links a large XLISP source code file (10,928 lines totaling 245,222 bytes) forming an executable file of 147,228 bytes. The test is repeated with four traffic applications running concurrently on five secondary workstations.

Analysis

The Microsoft C test serves primarily to transfer data from the server to the workstation (downloading the source code and loading the compiler). Lotus traffic increases data movement to the server; Foxbase traffic increases data movement and creates a fairly steady stream of network traffic. Xcopy and cc:Mail increase network activity through numerous workstation requests and data movements.

The Tiara, Thomas-Conrad, and PureData cards perform very well across all combined four-traffic and no-traffic conditions. The performance range for the 16-bit cards varies nearly 3 to 1 from

Figure 11.
Microsoft C 5.0

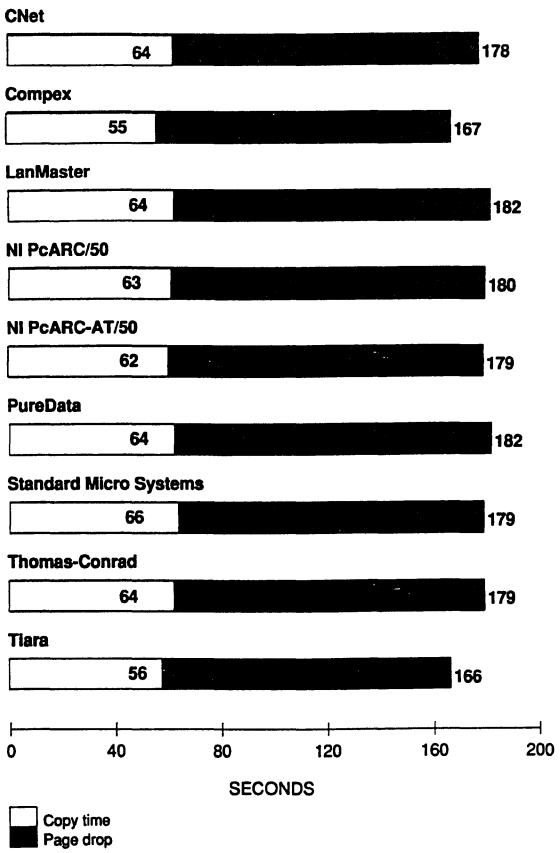


the fastest to the slowest 16-bit card; the spread varies from 9 percent under Lotus traffic, 15 percent with Xcopy traffic, to 16 percent with no traffic. Performance differences among the 16-bit cards may reflect differences in driver software quality. The Tiara uses a fast NCR 90C198 controller chip with a 16-bit interface and reduced wait-state operation. Performance differences between the 8-bit Network Interface PcARC/50 and the 16-bit cards are accentuated more with traffic (except for Lotus traffic) than without.

Print to Queue

The NetWare Capture command is invoked to dispatch files to server printer queue, then a 1,134,421-byte Ventura file is copied to LPT1. The test time includes the file copy time and the total time until the first page drops into the printer's output tray.

Figure 12.
Print to Queue



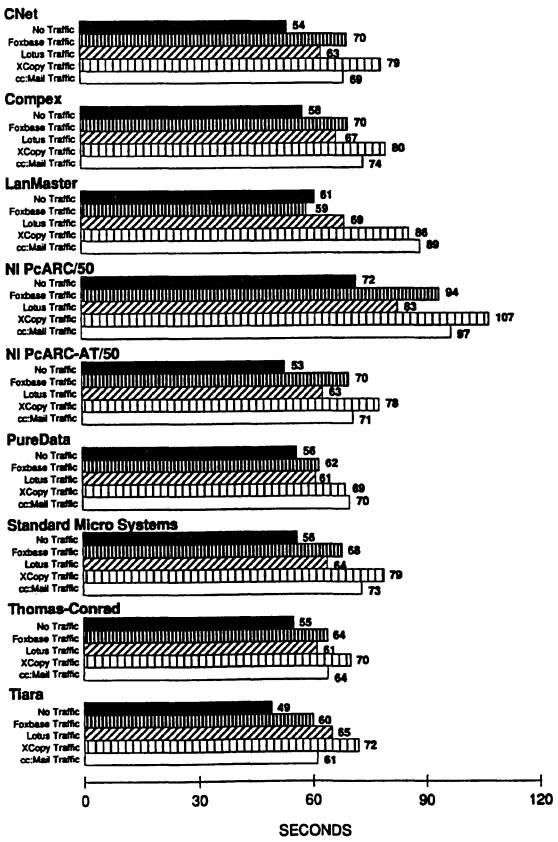
Analysis

With no network traffic, printing to queue is similar to a file copy operation in that a quantity of data is transported to the server with little additional processing at the workstation. Overall, performance differences are minimal. The adapter-to-host interface appears not to be a dominant performance factor in that the 8-bit Network Interface PcARC/50 attains a print-to-queue time similar to the 16-bit cards.

Xcopy to Server

A 5M-byte directory tree (130 files in 13 directories) is copied to the server using the DOS Xcopy command with the /s parameter; the source tree is located on the primary workstation's local hard disk (300M-byte Compaq Type 38 drive). The test is repeated with four traffic applications running concurrently on five secondary workstations.

Figure 13.
Xcopy to Server



Analysis

The Tiara performs much faster overall than the other cards with no traffic and in the combined traffic Xcopy tests, followed by the Thomas-Conrad. Presumably the Tiara's fast Arcnet controller chip and the Thomas-Conrad's good network driver contribute appreciably to their performance. Other good performers in this test category are PureData, CNet, Network Interface, and SMC.

Xcopy from Server

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

Analysis

The Xcopy test strains the server's capability to write to disk, as well as its response to write requests from the traffic workstations. The Tiara, Thomas-Conrad, and PureData cards achieve very good results. The Xcopy tests (both to and from the server) accentuate performance differences between the 8-bit and 16-bit cards, indicating the Xcopy tests' dependence on adapter bus interface width.

Transaction Processing

For each transaction, Foxbase+/LAN Version 2.1 reads from the Transaction file; locates and locks a record in each of the Accounts, Teller, and Branch files; adds a record to the History file with a lock; updates all locked records; and unlocks all records. The test records the times for one workstation processing 960 transactions without indexes and then with four indexes on the History file. This transaction processing test is repeated with 3 (320 transactions each), 10 (96 transactions each), and 16 (60 transactions each) workstations without and with indexes. Although indexes typically speed record

Figure 14.
Xcopy from Server

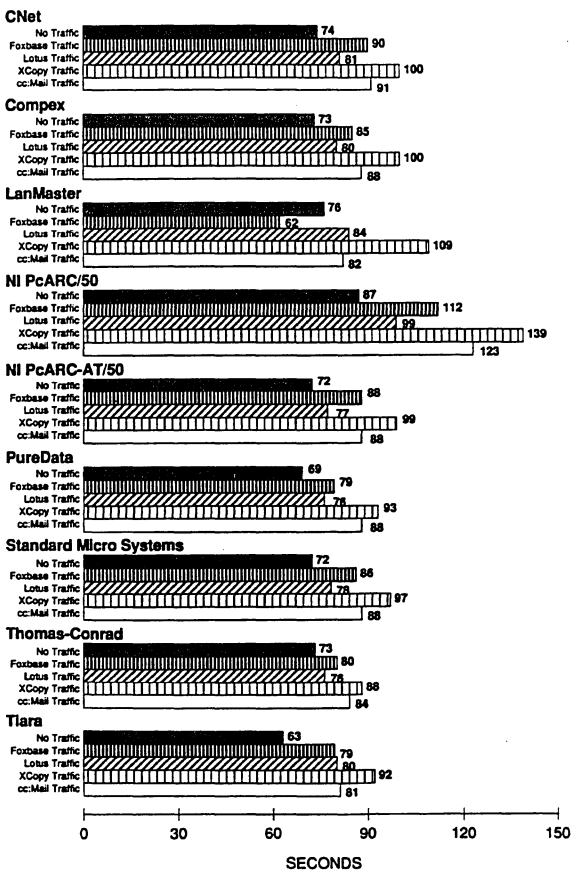


Figure 15a.
Transaction Processing: One Workstation

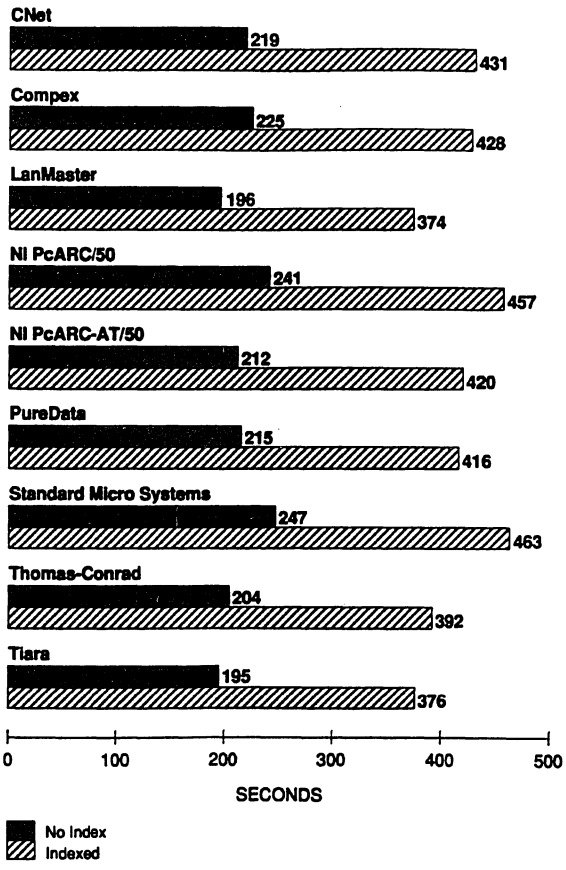


Figure 15b.
Transaction Processing: Three Workstations

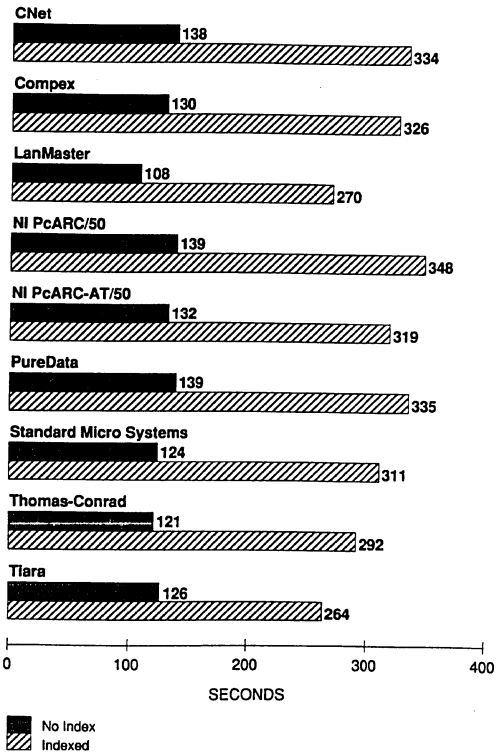


Figure 15c.
Transaction Processing: Ten Workstations

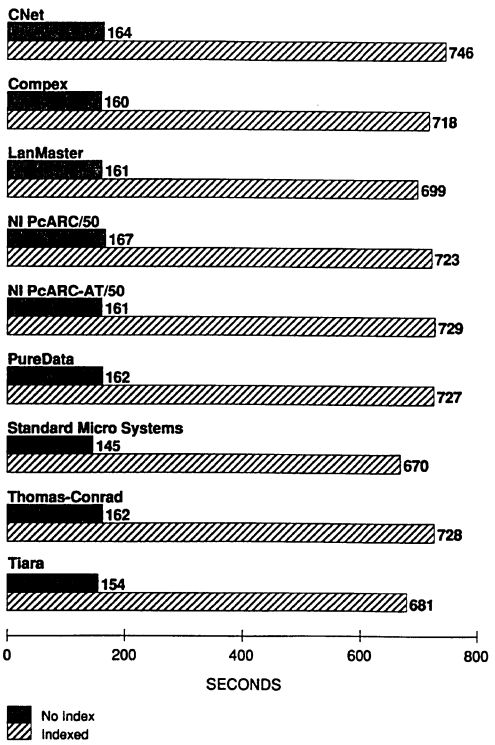
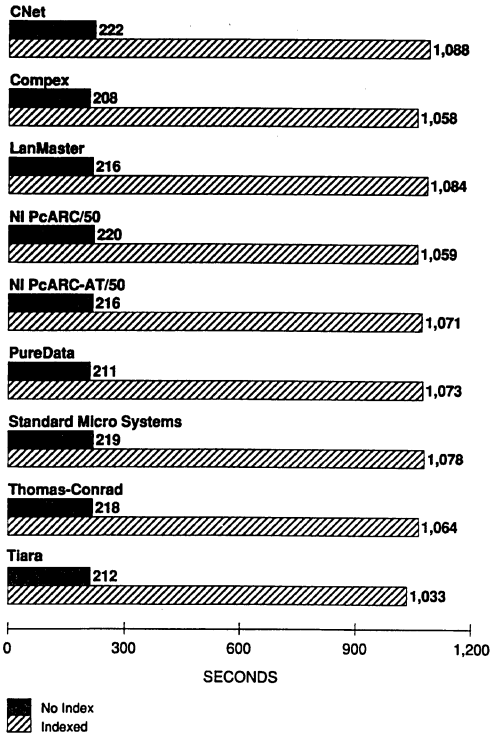


Figure 15d.
Transaction Processing: Sixteen Workstations



lookups, in this benchmark the indexes slow processing as they increase disk activity and file contention at the server.

Analysis

The transaction processing benchmark obscures differences between the single 8-bit card and the 16-bit cards. Although the 8-bit Network Interface PcARC/50 returns the slowest performance, the difference is insignificant. Among the high-level application benchmarks, the transaction processing test places the heaviest load on the server. The test clearly shows the efficiency of the driver software in facilitating numerous file lock and unlock requests and handling increased disk activity under heavy load conditions.

The Tiara and Lanmaster yield the best performance overall in all the workstation configurations, but not significantly better than the rest of the cards. The SMC outperforms the others in the 10-workstation test. Although SMC claims its Nodal Priority architecture does not appreciably influence performance in installations with fewer than 50 nodes, it does appear to have some influence in the 10-workstation traffic configuration (10 active; 9 logged in, but inactive).

Foxbase+/LAN

Foxbase+/LAN performs NSTL's 16-test database benchmark suite with no traffic and with two traffic applications running concurrently on five secondary workstations. Each adapter's time for each test iteration is the geometric mean of its times for the 16 tests.

Analysis

With no traffic, the Tiara finishes first with excellent performance, followed by the PureData. The Thomas-Conrad is fastest with Foxbase traffic, followed by the Lanmaster. With Foxbase traffic, the Lanmaster, SMC, and Thomas-Conrad finish within a few seconds of each other; with Lotus traffic, the Network Interface and Lanmaster show a slight edge.

Figure 16.
Foxbase+/LAN

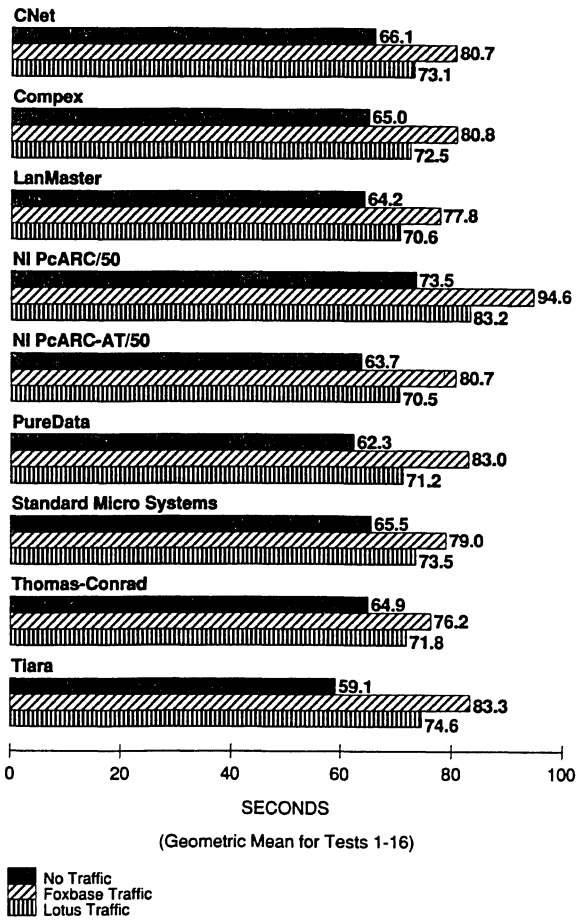
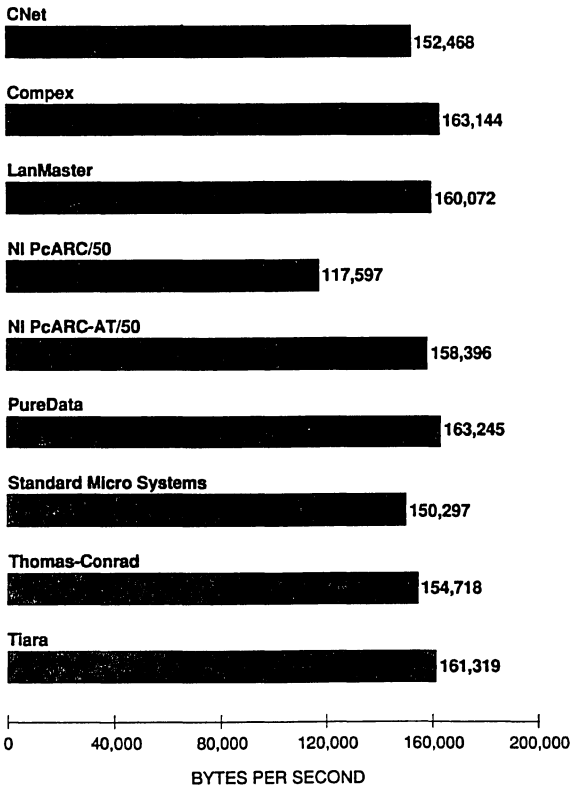


Figure 17.
Low-Level Throughput



Low-Level Throughput

A 3M-byte block of data is transferred between two Compaq 386/25 workstations using NetWare's IPX transport protocol. Throughputs are averaged to derive performance scores for one conversation.

Analysis

The PureData card distinguishes itself in the low-level test, which stresses the adapter-to-system bus interface and the network access method. Driver software efficiency is the most important factor. Drivers that take full advantage of the new Novell Extended Packet standard (which allows 2K-byte and 4K-byte IPX frames in place of the 576-byte IPX packet) should provide the best performance. The 576-byte NetWare IPX packet tends to require more token transmissions than might be necessary with an Arcnet packet (508 of 512 bytes are data) for large file transfers.

Vendors

CNet Technology, Inc.
62 Bonaventura Drive
San Jose, CA 95134 (408) 954-8000

Compex
4055 E. LaPalma, Unit C
Anaheim, CA 92807 (508) 898-2422

Lanmaster
1401 N. 14th Street
Temple, TX 76501 (817) 771-2124

Network Interface Corp.
15019 W. 95th Street
Lenexa, KS 66215 (913) 894-2277

PureData Ltd.
200 West Beaver Creek Road
Richmond Hill, ON, Canada L4B 1B4 (416) 731-6444

Standard Microsystems Corp.
35 Marcus Boulevard
Hauppauge, NY 11788 (516) 273-3100

Thomas-Conrad Corp.
1908-R Kramer Lane
Austin, TX 78758 (512) 836-1935

Tiara Computer Systems, Inc.
1091 Shoreline Boulevard
Mountain View, CA 94043
(415) 965-1700

Characteristics

Table 2. Arcnet Network Adapter Characteristics

	Host Interface	Software Included	LAN Operating System Support
CNet Technology CN190SBT	16-bit programmed I/O	Drivers for NetWare 2.1x and 3.x; no diagnostic software	Novell NetWare 286 2.1x, NetWare 386 3.x
Compex ANET16-TP/16	16-bit shared memory	Diagnostic software; drivers for NetWare 2.1x and 3.x	Compex ReadyLink; Novell NetWare 286 2.1x, NetWare 386 3.x; Artisoft LANtastic; and CBIS Network-OS
Lanmaster AMT-216	16-bit shared memory	Drivers for NetWare 2.1x and 3.x, configuration utility	Novell NetWare 286 2.1x, NetWare 386 3.x; Banyan Vines 3.0 and 4.0; no diagnostic software
Network Interface PcARC/50	8-bit shared memory	Drivers for Novell NetWare 286 2.1x; no diagnostic software	Novell NetWare 286 2.1x, NetWare 386 3.x; Banyan Vines 3.0 and 4.0; CBIStwork-OS; Western Digital ViaNet
Network Interface PcARC-AT/50	16-bit shared memory	Drivers for Novell NetWare 286 2.1x; no diagnostic software	Novell NetWare 286 2.1x, NetWare 386 3.x; Banyan Vines 3.0 and 4.0; CBIStwork-OS; Western Digital ViaNet
PureData PDI516Plus T	16-bit shared memory	Network and adapter diagnostics; auto configuring drivers for Novell NetWare 286 2.1x and NetWare 386 3.x; configuration utilities	Novell NetWare 286 2.1x, NetWare 386 3.x; Banyan Vines 3.0 and 4.0; 3Com 3+Share 1.2.1, 3+Open 1.1; Microsoft LAN Manager 1.x and 2.0; IBM PC LAN Program 1.3x, LAN Server 1.x
Standard Microsystems PC550	16-bit shared memory	Turbo II high-performance drivers for Novell NetWare 286 2.1x, NetWare 386 3.x	Novell NetWare 286 2.1x, NetWare 386 3.x; Banyan Vines 3.0 and 4.0; 3Com 3+Share 1.2.1, 3+Open 1.x
Thomas-Conrad TC6045 Arc-Card/AT	16-bit shared memory	Accelerated drivers for Novell NetWare 286 and NetWare 386 and Artisoft LANtastic; no diagnostic software	Novell NetWare 286 2.1x, NetWare 386 3.x; Banyan Vines 3.0 and 4.0; Artisoft LANtastic; Performance Technology PowerLan
Tiara LanCard/A*AT TP	16-bit shared memory	Drivers for NetWare 286 2.1x; diagnostic software	Novell NetWare 286 2.1x, NetWare 386 3.x; Banyan Vines 3.0 and 4.0

Table 3. Arcnet Network Adapter Features

	Weight	CNet Technology CN190SBT	Compex ANET16-TP/16	Lanmaster AMT-216	Network Interface PcARC/50	Network Interface PcARC-AT/50	PureData PDI516Plus T	Standard Micro-systems PC550	Thomas-Conrad TC-6045 Arc-Card/AT	Tiara LanCard/A*AT TP
Features	1									
Adapter Length (in.)	0	8.3	7.5	7.5	8	8	11.5	13.5	7	7
Adapter Height (in.)	0	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Adapter-to-Host Method	0	PIO	SM	SM	SM	SM	SM	PIO	SM	SM
Bus Interface Width (bits)	0	16	16	16	8	16	16	16	16	16
MCA Adapter Available	0	▲	—	—	—	—	▲	▲	▲	—
MCA Adapter Bus Interface Width (bits)	0	16	NA	NA	NA	NA	16	32	16	NA
EISA Adapter Available	0	—	—	—	—	—	—	▲	—	—
EISA Adapter Bus Interface Width (bits)	0	NA	NA	NA	NA	NA	NA	32	NA	NA
Maximum Transmit/Receive Buffer (K bps)	0	8	2	16	2	8	4	2	2	8
Number of I/O Ports Used for Base I/O	0	16	3	3	16	16	7	32	4	8
Maximum Interrupt Level Settings	1	11	9	7	11	11	8	8	11	11
LED Indicators	2	▲	▲	▲	▲	▲	▲	▲	—	▲
Diagnostic Software Included	1	—	▲	—	—	—	▲	—	▲	▲
Arcnet Controller Chipset	0	A	B	C	B	D	B	B	C	E
Remote Boot PROM/EPROM	1	OP	OP	OP	OP	OP	OP	OP	OP	OP
Maximum ROM Available (K bps)	0	8	2	8	2	2	32	8	8	8
Standards Supported	1									
NETBIOS Support	2	▲	▲	▲	▲	▲	▲	▲	▲	▲
Method of NETBIOS Support	0	NOS	NOS	NOS	NOS	NOS	NOS,TP	NOS	NOS	NOS,TP
NDIS Interface	1	—	—	—	—	—	▲	—	▲	—
Media Supported	1									
Coaxial Cable	2	▲	▲	▲	▲	▲	▲	▲	▲	▲
Single Twisted-Pair/Coaxial	0	▲	—	▲	—	—	—	—	—	—
Twisted-Pair Wire	2	▲	▲	▲	▲	▲	▲	▲	▲	▲
Fiber Optic Cable	1	—	—	▲	▲	▲	▲	▲	▲	▲
Compatible Network Operating Systems	3									
Novell NetWare 286 2.1x	6	▲	▲	▲	▲	▲	▲	▲	▲	▲
Novell NetWare 386 3.	6	▲	▲	▲	▲	▲	▲	▲	▲	▲
Banyan Vines 286 3.0	2	—	—	▲	▲	▲	▲	▲	▲	▲
Banyan Vines 386 4.0	2	—	—	▲	▲	▲	▲	▲	▲	▲
Microsoft LAN Manager 1.x	0	—	—	—	—	—	▲	SMC1	—	—
Microsoft LAN Manager 2.x	0	—	—	—	—	—	▲	SMC1	TC1	—
IBM PC LAN Program 1.3x	0	—	C1	C1	—	—	▲	▲	—	▲
IBM LAN Server 1.x	0	—	—	—	—	—	▲	SMC1	—	—
3 + Share 1.2.1	0	—	—	—	—	—	—	▲	—	—
3 + Open 1.1	1	—	—	—	—	—	▲	▲	TC1	—
Other	0	—	F	G	H	H	—	—	I	—

▲—Yes, has feature.
A—NCR90C98A.
B—SMC90C26.
C—NCR902C26.
C1—Works with Performance Technology and Western Digital NETBIOS drivers (not supplied by vendor).
D—NCR90C146.
E—NCR90C198.
F—Artisoft LANtastic, CBIS Network-OS, Compex ReadyLink.
G—CBIS Network-OS, Univation LifeNet, Western Digital ViaNet.
H—CBIS Network-OS, Western Digital ViaNet.
I—Artisoft LANtastic, Performance Technology PowerLan.
NA—Not applicable.
NOS—Network Operating System NETBIOS emulator.
OP—Optional.
PIO—Programmed I/O.
SM—Shared memory.
SMC1—Microsoft will provide NDIS and SMC Arcnet driver with LAN Manager 2.0.
TP—Third party.
TC1—NDIS driver to be released to support this operating system.

Equipment Prices

		Price ($)
Arcnet Network Adapters		
	CNet Technology CN190SBT	395
	Compex ANET-TP/16	159
	Lanmaster AMT-216	295
	Network Interface PcARC/50	295
	Network Interface PcARC-AT/50	550
	PureData PDI516Plus/T	395
	NetWare Remote Boot PROM	75
	Standard Microsystems PC550	495
	File Server Board with Nodal Priority	695
	Thomas-Conrad TC6045 Arc-Card/AT	379
	Tiara LanCard/A*AT TP	385

■

486 Servers

A Report from NSTL

In this report:

Synopsis

Focus

This report compares and contrasts Intel 80486-based servers optimized for use as database and network file servers in multiuser and client/server environments.

Products Tested

PowerCache 33/4
Advanced Logic Research (ALR)

PowerPro Array
Advanced Logic Research (ALR)

SystemPro 486
Compaq Corp.

PowerLine 433SE
Dell Computer Corp.

PowerLine 450SE
Dell Computer Corp.

DECpc 433T
Digital Equipment Corp.

Vectra 486/33T
Hewlett-Packard Co.

PS/2 Model 95 XP 486
IBM

System 3445
NCR

LSX 5020
Olivetti Systems and Networks

Product Recommendations

- Dell PowerLine 433SE
- Olivetti LSX 5020
- IBM PS/2 Model 95 XP 486

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	Performance	Features	Usability	Price
EISA Bus Architecture					
8.9	Dell PowerLine 433SE	●	●	●	$10,098 ★
8.8	Olivetti LSX 5020	●	●	●	$18,619 ★
8.2	Compaq SystemPro 486	●	●	●	$18,999
8.2	Hewlett-Packard Vectra 486/33T	●	●	●	$14,897
8.0	Digital Equipment DECpc 433T	●	○	●	$18,615
7.2	ALR PowerPro Array	●	○	●	$18,095
–	Dell PowerLine 450SE	–	●	●	$12,098
MCA Bus Architecture					
7.8	IBM PS/2 Model 95 XP 486	●	○	●	$23,520 ★
7.6	ALR PowerCache 33/4	●	○	●	$16,896
7.0	NCR System 3445	○	●	●	$20,995

Overview

NSTL evaluated 80486-based systems engineered primarily for network file server or multiuser environments. Many of the test systems are also suited for use as high-performance workstations for engineering and programming applications. Each system features at least 8M bytes of 32-bit RAM and two spindle hard disk subsystems, facilitating better comparison of the SCSI and arrayed subsystems. For capacity and price/performance comparatives, NSTL also tested the Dell and Compaq with a larger number of disks in their disk arrays. All systems run as Novell NetWare 3.11 file servers with two Madge token-ring adapters installed.

In comparing EISA and MCA file server performance, it should be noted that differences between Madge's implementation of the EISA and MCA generate performance differences between the bus architectures. The Madge EISA token-ring adapter contains 32-bit data lines and 32-bit address lines. The Madge MCA token-ring adapter also contains 32-bit address lines, but uses 16-bit data lines.

NSTL chose to use network adapters from one manufacturer in all test systems so file server performance of systems with like bus architectures could be directly compared. Vendors such as IBM, however, offer their own 32-bit bus master token-ring adapters.

Product Highlights

ALR PowerCache 33/4

ALR engineered the PowerCache for file server applications and high-performance CAD environments. It reduces wait states on memory accesses using a 128K-byte direct-mapped write-back memory cache. System RAM expands to 32M bytes by installing DRAM SIMMs on the system's memory card, which resides in a proprietary 64-bit memory slot. Only one 32-bit and three 16-bit MCA expansion slots remain after the installation of a SCSI bus master controller and video adapter. A swing-out chassis design accommodates a shock-mounted, full-height mass storage device. Maximum internal storage capacity equals 1.2G bytes. System security features include keyboard and boot password support and a server mode. On-site service and extended warranties are available.

ALR PowerPro Array

The PowerPro Array functions as a network file server or in data-intensive, multiuser environments. The ALR's drive array subsystem provides up to 1.36G bytes of storage built around a 32-bit EISA bus master caching controller with 2M bytes of RAM (expandable to 8M bytes). The system's Advanced Disk Array (ADA) controller supports disk striping, spanning, and mirroring. An upgradable processor architecture provides a path for moving to faster processors in the future. Five 32-bit EISA expansion slots are available in the system's test configuration, and system RAM expands to 49M bytes by installing 80-ns. DRAM SIMMs on the system board. Security features include boot and keyboard password support, a network server mode, and a chassis lock. On-site service and extended warranties are available.

Dual-processor slots facilitate symmetric processing with two 33MHz 486 CPUs. Each processor supports a 512K-byte secondary direct-mapped write-back memory cache. In symmetric processing, the operating system keeps a single list of the tasks that need to be performed, and any available CPU selects its next task from that list. Multiprocessing operating systems currently available include Banyan VINES, SCO UNIX, and Microsoft LAN Manager.

Compaq SystemPro 486

Compaq's 32-bit Intelligent Drive Array (IDA) bus master controller performs parallel data transfers to a series of cooperative disk drives and simultaneously services multiple requests for user data. The IDA controller supports up to four drive array pairs for a maximum capacity of 1.68G bytes. The system offers a secondary 512K-byte direct-mapped write-through processor cache. Its EISA expansion bus provides six open expansion slots, including proprietary memory and processor slots. An integrated VGA controller, with graphics accelerator, saves an expansion slot. System memory expands to 256M bytes of RAM using proprietary DRAM modules. Security features include a chassis lock, server mode, and boot and keyboard password protection. The SystemPro design supports symmetric processing with two 33MHz 486s, two 33MHz 386s, or one of each type of processor. Currently only SCO UNIX MPX, Banyan VINES SMP, and the multiprocessing version of LAN Manager take advantage of the unit's symmetric processing capabilities.

Dell PowerLine 433SE and PowerLine 450SE

The 33MHz and 50MHz Dell systems are identical except for their processors. In NSTL's network server tests, they provide similar overall performance because both CPUs run faster than the overall network. Dell recommends that users configure its disk array subsystem for "independent seeks" for NetWare file server applications. Independently seeking drives provide significantly better performance but do not offer the redundancy features available with hardware striping. Dell's removable processor card also provides an upgrade path.

The test system's chassis provides seven EISA expansion slots. A standard high-resolution VGA adapter is included for such video-intensive dedicated workstation applications as computer-aided design (CAD). The expansion chassis provides 5G bytes of storage capacity with room for 11 half-height or 5 full-height devices. Drive array storage expands to 2G bytes. A 128K-byte secondary direct-mapped memory cache reduces wait states on memory accesses, and system RAM expands to 128M bytes. A SmartVu LED display window provides diagnostic information. Dell includes one year of on-site service through Xerox Corp.

Digital Equipment DECpc 433T

The DECpc 433T, designed as a PC LAN server, multiuser system, or high-performance workstation, supports Digital's PathWorks network operating system and is NetWare certified as a server or a workstation. The system's efficient SCSI hard disk subsystem provides above average file server performance. A programmable, two-line, 40-character LCD display provides diagnostic, system maintenance, and status information. Digital's expansive chassis accommodates four full-height or nine half-height devices for a maximum internal storage capacity of 5.9G bytes. Five 32-bit EISA slots remain after the installation

of a video adapter and disk controller. System RAM expands to 64M bytes by installing SIMMs on the motherboard; a secondary 128K-byte direct-mapped write-through cache expands to 256K bytes. Security features include boot password protection and front panel and chassis locks. On-site service and extended warranties are available.

Hewlett-Packard Vectra 486/33T

The Vectra 486/33T PC, engineered for LAN, multiuser, or high-performance workstation environments, can support over 200 LAN users or 100 UNIX multiuser terminals. File server performance is above average when the system is configured with its bus-mastered SCSI-2 hard disk subsystem which features tagged-command queuing, zero latency read, and disk caching. Two dedicated memory slots support up to 64M bytes of SIMM memory. The system chassis supports four half-height or two full-height mass storage devices for a maximum 2G-byte internal storage capacity; six EISA expansion slots are available in the test system. A secondary 128K-byte two-way set-associative write-through memory cache reduces wait states. Security options include keyboard and chassis locks, password protection, and a server mode. Hewlett-Packard includes one year of on-site service in its list price; extended warranties are available.

IBM PS/2 Model 95 XP 486

The Model 95 XP 486 is the most powerful of the PS/2 product line. The system's SCSI bus master host adapter with cache is well equipped for network server environments. An optional secondary 256K-byte two-way set-associative write-through memory cache snaps on to the system's i486 processor complex. The backbone of the system is an MCA bus containing eight 32-bit expansion slots, six of which are available in the unit's test configuration. The base 8M bytes of RAM expands to 64M bytes on the motherboard using 70-ns. DRAM SIMMs. An integrated XGA video adapter supports video-intensive standalone workstation applications. XGA supports resolutions up to 1,024 x 768 and delivers faster performance than VGA adapters. The tower case provides space for five internal 5.25-inch drives to increase storage capacity to 1.6G bytes. An optional secondary storage case for SCSI devices increases mass storage options. Security features include a chassis lock, server mode, and boot and keyboard password protection. On-site service is available; dealers may offer extended warranties.

NCR System 3445

The System 3445 serves as a network database server. NCR's expansive chassis supports seven half-height or five full-height mass storage devices that plug into a "cableless" SCSI bus board. The NCR provides the most internal storage capacity at 7G bytes; a 2.1G-byte drive array is optional. A SCSI II controller with onboard RISC processor resides in a dedicated slot. The system does not offer a secondary memory cache, relying on the 8K-byte memory cache built into its 486 processor. RAM expands to 128M bytes by installing proprietary 4M-byte and 16M-byte memory expansion boards in the system's four dedicated memory slots. The 33MHz processor can be replaced with a 50MHz CPU. Security options include a chassis lock, boot and keyboard password protection, and a network server mode. NCR provides a built-in, high-resolution VGA port for video-intensive dedicated workstation applications. Six 32-bit slots and one 16-bit MCA slot are available in the test configuration. NCR offers on-site service and extended warranties.

Olivetti LSX 5020

The LSX 5020, aimed at medium-sized companies or departments of larger corporations, provides excellent overall file server performance. Low-level testing shows the unit's SCSI hard disk subsystem's efficiency while performing random reads. The EISA-based system provides six open expansion slots in the test configuration. The chassis supports three half-height or two full-height devices for a maximum internal storage capacity of 2.8G bytes. Memory caching is limited to the 486's 8K-byte internal cache; system board memory expands to 64M bytes using DRAM SIMMs. Security features include a chassis lock, keyboard and boot passwords, and a network server mode. The Olivetti's control panel features a programmable LCD message display, function buttons, and numerous LED indicators. Olivetti offers on-site service and extended warranties.

Feature Comparison

Bus Architecture

Although the ISA bus is the predominant architecture, EISA and IBM's MCA are gaining support among system vendors. Since the 32-bit bus of EISA and MCA systems offer higher throughput, easier system configuration, and support for multiple intelligent devices, we have not included any ISA-based systems in this review. EISA additionally offers the capability to accept existing 8-/16-bit ISA expansion boards. Support for 32-bit I/O is a logical match for 486 (and 386) processors that handle data in 32-bit chunks. MCA and EISA also provide a high-speed burst mode that moves data across the expansion bus faster than an ISA environment.

Architecture

- ALR PowerPro, Compaq, Digital, Dell, Hewlett-Packard, and Olivetti feature EISA expansion buses.
- ALR PowerCache, IBM, and NCR use MCA bus architectures.

Expansion Slots

- Dell and NCR provide seven open expansion slots in their test configurations.
- Compaq, Hewlett-Packard, IBM, and Olivetti provide six open slots.
- ALR PowerPro and Digital are limited to five free expansion slots.
- ALR PowerCache has only four slots available.

Memory Subsystem

- Compaq supports up to 256M bytes of 80-ns. DRAM; expanded by adding proprietary 2M-byte, 8M-byte, and 32M-byte modules to a 32-bit, six-socket memory expansion board.
- Dell and NCR upgrade to 128M bytes of 80-ns. DRAM; Dell utilizes DRAM SIMMs on its standard memory board, whereas NCR uses 4M-byte or 16M-byte proprietary memory boards.

- Digital, IBM, and Olivetti offer up to 64M bytes of 70-ns. DRAM SIMMs on their system boards; Hewlett-Packard supports up to 64M bytes of RAM using 80-ns. SIMMs on proprietary memory boards.
- ALR's PowerPro supports up to 49M bytes of 80-ns. SIMMs on the system board; the ALR PowerCache uses a memory board to install up to 32M bytes of 80-ns. SIMMs.

Memory Caching

Memory caching improves performance by reducing wait states on memory accesses. The 80486 processor contains 8K bytes of built-in memory cache. Including a secondary memory cache typically improves performance by 5% to 10% in memory-intensive applications. Most secondary caches are write-through caches which do not perform cache memory writes but merely pass the writes through to the system memory.

- ALR has implemented a write-back cache design that performs cache memory writes as well as memory reads.
- IBM supports an optional 256K-byte two-way set-associative write-through memory cache module that attaches to the system's processor complex.
- Hewlett-Packard includes a 128K-byte two-way set-associative write-through memory cache.
- ALR's PowerPro and PowerCache feature direct-mapped write-back memory caches; 512K bytes and 128K bytes, respectively (the PowerPro supports 512K-byte cache per processor installed).
- Compaq includes a 512K-byte direct-mapped write-through memory cache.
- Digital and Dell use 128K-byte direct-mapped write-through memory caches; Digital's cache can be expanded to 256K bytes.
- NCR and Olivetti do not have secondary memory caches.

Mass Storage

Mass storage expansion capabilities, a primary consideration in network environments, vary according to the available drive bays and subsystem interface supported. Larger footprint systems generally offer more mass storage options. Purchasers of tower units will most likely be satisfied with the internal storage capacity. SCSI disk subsystems permit a larger number of physical drives and greater storage capacity than ESDI-based subsystems. Disk arrays typically provide a unique combination of high capacity, data redundancy, data integrity, and fast sequential transfer speeds. Drive bays allow combinations of full-height and half-height drives to be installed.

Expansion

- ALR PowerCache supports three half-height, one full-height, and one 3.5-inch drive.
- ALR PowerPro accommodates two drive array pairs and three half-height drives.
- Compaq can be configured with 11 devices.
- Digital allows nine half-height or four full-height devices.
- Dell accommodates 11 half-height or 5 full-height devices.
- Hewlett-Packard supports four half-height or two full-height devices.
- IBM provides five available 5.25-inch half-height storage bays.
- NCR accommodates seven half-height or five full-height devices.
- Olivetti supports three half-height or two full-height mass storage devices.

Maximum Internal Storage Capacity

- The ALR PowerCache, Digital, Hewlett-Packard, IBM, and Olivetti do not support drive arrays.
- Compaq provides up to 1.68G bytes maximum drive array storage.
- ALR PowerCache supports a 1.2G-byte SCSI hard drive.
- ALR PowerPro supports a four-drive, 1.36G-byte array.
- Dell supports up to 5G bytes of storage; maximum drive array storage is 2G bytes.
- Digital, Hewlett-Packard, IBM, and Olivetti support 5.9G bytes, 2G bytes, 1.6G bytes, and 2.8G bytes of internal mass storage, respectively.
- NCR provides up to 7G bytes of storage; a 2.1G-byte drive array is supported.

Miscellaneous Features

- ALR PowerPro and Compaq support symmetric processing; the only multiprocessing operating systems currently available are Banyan VINES, SCO UNIX, and Microsoft LAN Manager.
- ALR PowerPro, Compaq, Dell, and IBM feature upgradable processor architectures; NCR's 33MHz CPU can be replaced with a 50MHz 486 processor.
- Olivetti supports the Intel i860 application processor.

Product Evaluations

ALR PowerCache 33/4

Product Summary

- 33MHz 80486 CPU
- 8M-byte RAM expandable to 32M bytes using 80-ns. DRAM SIMMs
- Secondary 128K-byte direct-mapped write-back memory cache
- Four 16-bit and two 32-bit MCA expansion slots; one proprietary 64-bit memory slot
- 25-pin serial, parallel, and mouse ports
- 15MHz ESDI hard disk controller with 32K-byte cache standard
- Accommodates three half-height, one full-height, and one 3.5-inch mass storage device
- Primary hard drive shock-mounted on a swinging door
- Server mode, boot and keyboard password protection
- 1.2G-byte maximum internal storage capacity
- Disk-based MCA configuration utility, diagnostics
- On-site service and extended warranties available

ALR PowerPro Array

Product Summary

- Upgradable 33MHz 80486 CPU
- Support for multiple processors
- 17M-byte RAM expandable to 49M bytes using 80-ns. DRAM SIMMs
- Secondary 512K-byte direct-mapped write-back memory cache (per processor)
- Eight 32-bit EISA expansion slots; two proprietary processor slots
- 9-/25-pin serial, parallel, and mouse ports
- Super VGA adapter standard
- Advanced disk array controller with 2M-byte (expandable to 8M bytes) cache; up to four drives mount on a swinging door
- Accommodates nine half-height mass storage devices
- 1.36G-byte maximum internal drive array storage capacity
- Chassis lock, boot and keyboard password protection
- Disk-based EISA configuration utility, diagnostics
- On-site service and extended warranties available

Compaq SystemPro 486

Product Summary

- Upgradable 33MHz 80486 CPU
- Support for multiple processors
- 8M-byte RAM expandable to 256M bytes using proprietary 80-ns. DRAM modules
- Secondary 512K-byte direct-mapped write-through ServerCache
- Seven 32-bit EISA expansion slots; four proprietary memory and processor slots
- Two 9-pin serial, parallel, and mouse ports
- Integrated VGA controller with graphics accelerator
- 32-bit IDA bus master controller supports up to four drive array pairs
- Accommodates up to 11 mass storage devices
- 1.68G-byte maximum drive array storage capacity
- Chassis lock, server mode, boot and keyboard password protection
- Disk-based EISA configuration utility; RAM disk, EMM, diagnostics, and disk caching software
- On-site service and extended warranties dealer dependent

Dell PowerLine 433SE

Product Summary

- Upgradable 33MHz 80486 CPU
- Excellent performance when configured for independent seeks
- 4M-byte RAM expandable to 128M bytes using 80-ns. DRAM SIMMs
- Secondary 128K-byte direct-mapped write-through memory cache
- Eight 32-bit EISA expansion slots; proprietary processor and dedicated video slots
- Two 9-pin serial, parallel, and mouse ports
- Standard high-resolution VGA adapter
- SmartVu LED display for error and status information
- Accommodates 11 half-height or 5 full-height mass storage devices
- 2G-byte maximum drive array storage; 5G-byte maximum internal storage capacity
- Chassis lock, boot and keyboard password protection
- Disk-based EISA configuration utility; diagnostics
- 12 month on-site service included in the system price; extended warranties available

Dell PowerLine 450SE

Product Summary

- Upgradable 50MHz 80486 CPU
- 4M-byte RAM expandable to 128M bytes using 80-ns. DRAM SIMMs
- Secondary 128K-byte direct-mapped write-through memory cache
- Eight 32-bit EISA expansion slots; proprietary processor and dedicated video slots
- Two 9-pin serial, parallel, and mouse ports
- Standard high-resolution VGA adapter
- SmartVu LED display for error and status information
- Accommodates 11 half-height or 5 full-height mass storage devices
- 2G-byte maximum drive array storage; 5G bytes maximum internal storage capacity
- Chassis lock, boot and keyboard password protection
- Disk-based EISA configuration utility; diagnostics
- 12 month on-site service included in the system price; extended warranties available

Digital Equipment DECpc 433T

Product Summary

- 33MHz 80486 CPU
- 4M-byte RAM expandable to 64M bytes using 70-ns. DRAM SIMMs
- Secondary 128K-byte (expandable to 256K bytes) direct-mapped write-through memory cache
- Eight 32-bit EISA expansion slots
- Two 9-pin serial, parallel, and mouse ports
- Accommodates nine half-height or four full-height mass storage devices
- 5.9G-byte maximum internal storage capacity
- Chassis lock and boot password protection
- Programmable 40-character LCD display panel
- Large 380-watt power supply
- Disk-based EISA configuration utility, diagnostics
- On-site service and extended warranties available

Hewlett-Packard Vectra 486/33T

Product Summary

- 33MHz 80486 CPU
- 4M-byte RAM expandable to 64M bytes using 80-ns. DRAM SIMMs
- Secondary 128K-byte two-way set-associative write-through memory cache
- Eight 32-bit EISA expansion slots; proprietary processor and memory slots
- Two 9-pin serial, parallel, and mouse ports
- Accommodates four half-height or two full-height mass storage devices
- 2G-byte maximum internal storage capacity
- Keyboard and chassis locks, server mode, and boot password protection
- Optional SCSI-2 bus master controller with onboard 16MHz processor
- Optional system diagnostics
- Disk-based EISA configuration utility; HP Memory Manager
- 12 month on-site service included in the system price; extended warranties available

IBM PS/2 Model 95 XP 486

Product Summary

- Upgradable 33MHz 80486 CPU
- 8M-byte RAM expandable to 64M bytes using 70-ns. DRAM SIMMs
- Optional secondary 256K-byte two-way set-associative write-through memory cache
- Eight 32-bit MCA expansion slots; proprietary processor slot
- Parallel, 25-pin serial, SCSI, and mouse ports
- Integrated high-resolution XGA video adapter
- SCSI bus master controller with cache and 320M-byte SCSI drive included with the base model
- Five available 5.25-inch mass storage bays
- 1.6G-byte maximum internal storage capacity
- Chassis lock, server mode, boot and keyboard password protection
- Hard disk-based MCA configuration utility; diagnostics and disk caching software
- On-site service available, extended warranties dealer dependent

NCR System 3445

Product Summary

- Very large footprint
- 33MHz 80486 CPU; socket for a Weitek 4167 coprocessor
- RAM expandable to 128M bytes using proprietary 80-ns. DRAM memory boards
- No secondary memory cache
- Six 32-bit slots and one 16-bit MCA expansion slot
- One intelligent SCSI host adapter slot and four dedicated memory slots
- Standard SCSI-2 controller with onboard RISC processsor
- Parallel, 25-pin serial, SCSI and mouse ports
- Integrated high-resolution VGA adapter
- Accommodates seven half-height or five full-height mass storage devices
- All drives plug into a "cableless" SCSI bus board
- 2.1G-byte maximum drive array storage; 7G-byte maximum internal storage capacity
- Chassis lock, server mode, boot and keyboard password protection
- Disk-based MCA configuration utility; diagnostic and demonstration software
- On-site service and extended warranties available

Olivetti LSX 5020

Product Summmary

- Excellent file server performance
- 33MHz 80486 CPU
- Supports an Intel i860 application processor
- 8M-byte RAM expandable to 64M bytes using 70-ns. DRAM SIMMs
- No secondary memory cache
- System control panel with 24-character LCD display
- Eight 32-bit EISA expansion slots
- 25-pin serial, parallel, SCSI and mouse ports
- Paradise 16-bit VGA adapter standard
- 32-bit SCSI bus master controller and 150M-byte SCSI hard drive included with the base system
- Accommodates three half-height or two full-height mass storage devices
- 2.8G-byte maximum internal storage capacity
- Chassis lock, server mode, boot and keyboard password protection
- Disk-based EISA configuration utility; diagnostics and EMM
- On-site service and extended warranties available

Product Recommendations

Dell PowerLine 433SE

The EISA-based Dell provides exceptional file server performance when its disk array subsystem is configured for "independent seeks," rather than hardware striping. Its removable processor card provides an upgrade path, and the system chassis provides 5G bytes of storage capacity, including 2G bytes of drive array storage. System RAM expands to 128M bytes, and a 128K-byte secondary memory cache reduces wait states on memory accesses. Dell also excels in terms of its warranty and support, which includes one year of on-site service.

Olivetti LSX 5020

The EISA-based Olivetti's SCSI hard disk subsystem provides excellent file server performance. The system chassis supports three half-height or two full-height devices for a maximum internal storage capacity of 2.8G bytes, and system RAM expands to 64M bytes. Olivetti's control panel features a programmable LCD message display, function buttons, and numerous LED indicators. On-site service and extended warranties are available.

IBM PS/2 Model 95 XP 486

The Model 95 XP 486 represents an obvious choice for users standardizing on Micro Channel Architecture. The system is well equipped for network server environments when configured with its SCSI bus master adapter and optional 256K-byte memory cache. Memory expands to 64M bytes on the motherboard, and an integrated XGA video adapter is provided for video-intensive applications. The tower case provides 1.6G bytes of storage capacity. An optional secondary storage case for SCSI devices increases mass storage options. On-site service is available.

Rating Summaries

Overall Evaluation

The Dell PowerLine 433SE is attractively priced and backed by one year of on-site service. The Dell Drive Array (DDA), provides the best performance among the EISA-based systems in cc:Mail and WordPerfect tests when configured for independent drives. In this configuration, the DDA processes multiple NetWare disk commands by simultaneously seeking on all drives. The 33MHz and 50MHz Dell systems are indistinguishable except for their upgradable processor board. Standard features include support for up to 128M bytes of RAM and a 128K bytes memory cache. Drive array storage expands to 2G bytes; the chassis provides 5G bytes of internal storage capacity. Dell's clear and comprehensive documentation makes it one of the easiest systems to use.

The Olivetti LSX 5020 provides the best file server performance among the EISA-based systems. Its SCSI hard disk subsystem is efficient at random reads, providing excellent performance in the FoxPro benchmark. The system

Figure 1.
ALR PowerCache 33/4 Ratings

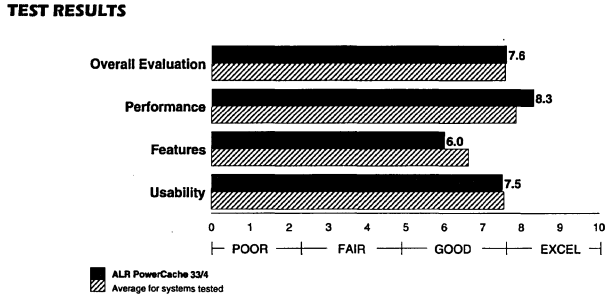


Figure 2.
ALR PowerPro Array Ratings

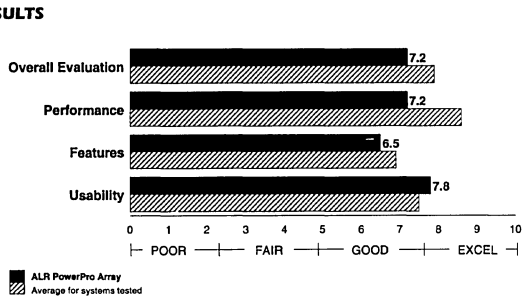


Figure 3.
Compaq SystemPro 486 Ratings

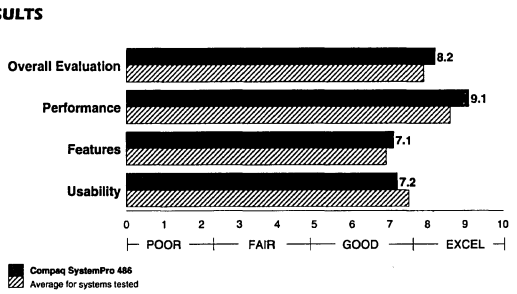


Figure 4.
Dell PowerLine 433SE Ratings

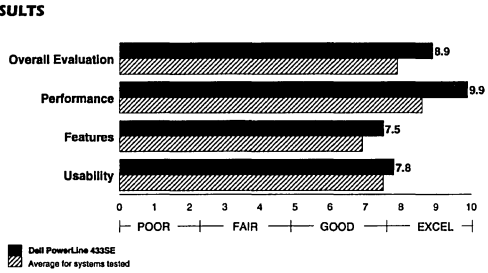


Figure 5.
Dell PowerLine 450SE Ratings

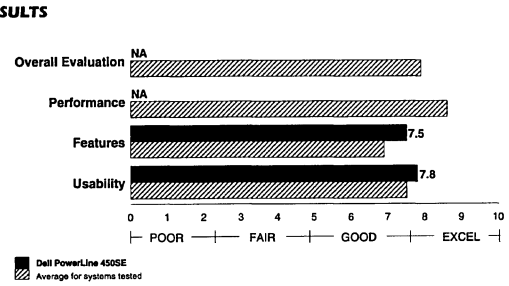


Figure 6.
Digital Equipment DECpc 433T Ratings

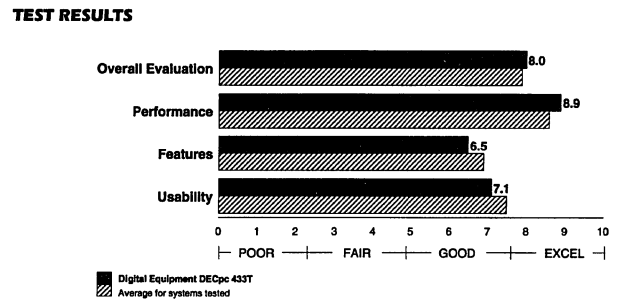


Figure 7.
Hewlett-Packard Vectra 486/33T Ratings

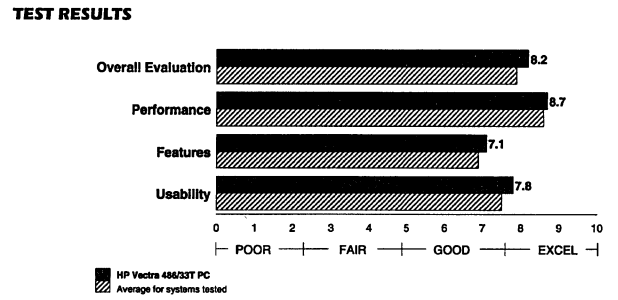


Figure 8.
IBM PS/2 Model 95 XP 486 Ratings

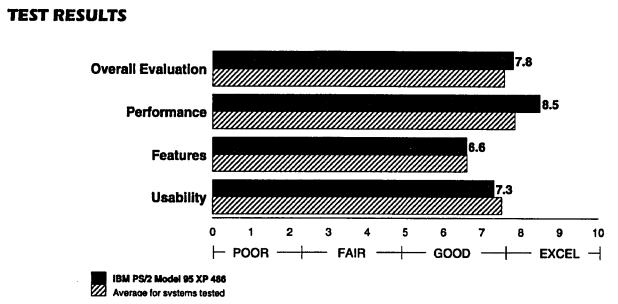


Figure 9.
NCR System 3445 Ratings

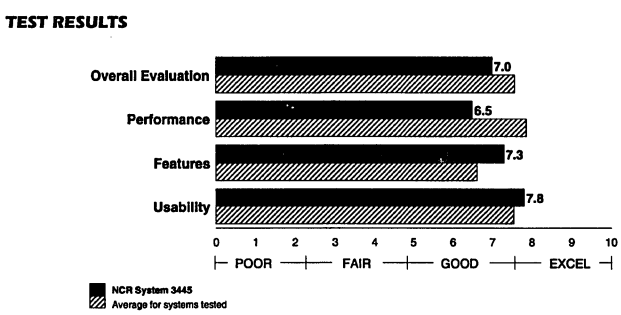
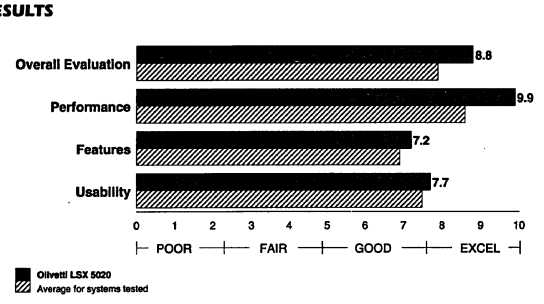


Figure 10.
Olivetti LSX 5020 Ratings



supports up to 64M bytes of RAM and provides 2.8G bytes of internal storage capacity. The front system control panel contains a programmable LCD message display, function buttons, and numerous LED indicators. Comprehensive system documentation includes helpful illustrations and feature descriptions.

The Compaq SystemPro Model 486-420 contains a 32-bit EISA Intelligent Drive Array (IDA) controller that increases throughput by simultaneously responding to multiple requests for user data. The Compaq supports symmetric processing and up to 256M bytes of RAM, using proprietary memory modules. The SystemPro supports up to 1.6G bytes of drive array storage. Users must alternate between the system setup, overview, drive arrays, and user programs manuals to find required information.

The Hewlett-Packard (HP) Vectra 486/33T PC comes with comprehensive documentation. The unit offers above average file server performance due in part to the efficiency of its SCSI hard disk at performing sequential reads. Its SCSI-2 drives support tagged-command queuing, zero latency read, and disk caching. A 128K-byte memory cache reduces wait states. System RAM expands to 64M bytes, and the chassis supports up to 2G bytes of internal storage. The EISA-based system is backed by one year of on-site service.

The Digital Equipment DECpc 433T reduces wait states with its 128K-byte direct-mapped write-through memory cache; the SCSI hard disk subsystem performs random reads proficiently. The system features a unique programmable status window which displays error messages during boot-up. Digital's expansive chassis supports 5.9G bytes of internal storage capacity. System memory upgrades to 64M bytes by installing SIMMs on the motherboard.

ALR PowerCache 33/4s primary hard drive mounts on a shock-mounted "swing out" door. Internal mass storage capacity is limited to 1.2G bytes, and only one 32-bit and three 16-bit MCA expansion slots are available with the hard drive controller and video adapter installed. The ALR comes configured with a 128K-byte direct-mapped write-back memory cache and supports up to 32M bytes of RAM. System documentation lacks diagrams, and the installation instructions are insufficient.

The IBM PS/2 Model 95 XP 486 tops MCA-based systems in file server performance. The unit's SCSI hard disk subsystem performs efficient sequential reads and excels in the cc:Mail and WordPerfect benchmarks. The test configuration includes an optional 256K-byte memory cache.

System memory expands up to 64M bytes on the motherboard, and a built-in XGA video controller supports resolutions up to 1,024 x 768. Five available 5.25-inch drive bays support up to 1.6G bytes of mass storage. Documentation provides detailed diagrams but lacks extensive specifications and feature descriptions.

The ALR PowerPro Array's poor random/sequential read performance lowered the overall file server rating. The system's "swing out" chassis design accommodates a 1.36G-byte, four-drive array. A standard EISA bus master controller, with 2M bytes of cache, supports data striping, disk spanning, and mirroring. The system supports multiple upgradable processors, each containing 512K bytes of cache memory. System RAM upgrades to 49M bytes using DRAM SIMMs. The PowerPro's documentation is poorly organized and does not include sufficient diagrams.

The NCR System 3445's below average overall rating directly corresponds to the inefficiency of its SCSI hard disk subsystem in performing random and sequential writes. The MCA-based system features an intelligent RISC-based SCSI controller. The 33MHz processor can be replaced with a 50MHz 486 CPU. The NCR's spacious case supports up to 7G bytes of mass storage. SCSI connectors at the rear of each drive bay provide direct connections to drives. System RAM expands to 128M bytes with the installation of proprietary 4M-byte or 16M-byte memory cards. Comprehensive documentation includes numerous tables and diagrams.

Methodology

The Overall Evaluation Score is the weighted averages of scores for the individual rating categories.

Overall Evaluation Score = (5 x Performance Score) + (2 x Features Score) + (2 x Usability Score) ÷ 9.

Performance

NSTL tested network file server performance using application-based tests that measure the speed of network server responses to such commonly performed operations as looking up a record in a FoxPro transaction file. Additionally, a series of low-level read/write tests isolated the performance of each file server's hard disk subsystem.

Each system was configured as a Novell NetWare file server with two Madge token-ring network adapters. In comparing EISA and MCA file server performance, it should be noted that subtle differences between Madge's EISA and MCA token-ring adapter implementation may account for performance differences. The servers each contain two spindle hard disk subsystems facilitating direct comparison between the SCSI and arrayed subsystems.

The Dell Drive Array (DDA) is built around an EISA bus master controller containing a 16MHz Intel 960 RISC processor. Physical drives can be hardware striped or configured independently. The benefits of hardware striped drives diminish with applications that perform many small read/write operations. For NetWare file server applications, Dell recommends configuring its system for independent drives. When so configured, the DDA processes multiple NetWare disk commands by simultaneously seeking on all drives. This configuration pushes Dell to the best performance among the EISA-based systems in the cc:Mail and WordPerfect tests.

The Olivetti LSX 5020 includes two Seagate 320MB SCSI drives, providing similar overall performance to the Dell. It demonstrates the best performance among EISA-based systems, in the FoxPro transaction test. Low-level testing indicates the Olivetti's efficient random reads and 512-byte sequential writes. The Dell contains a more efficient memory architecture than the Olivetti, as shown by the systems sequential read from cache performance. The Dell contains a secondary 128K-byte direct-mapped memory cache; the Olivetti relies on the efficiency of the 486's built-in 8K-byte memory cache.

The Compaq SystemPro provides the best overall performance among the remaining EISA-based systems. The SystemPro contains a 32-bit EISA Intelligent Drive Array (IDA) controller that increases throughput by simultaneously responding to multiple requests for user data. Data distributed across synchronized drives, is transferred on four high-speed channels (two channels are used in the comparative rating). Response rate is improved through intelligent management of user requests for data. The SystemPro is particularly proficient in the Lotus 1-2-3 benchmark.

The Digital Equipment DECpc 433T and Hewlett-Packard Vectra 486/33T PC run efficient SCSI hard disk and memory subsystems. The Digital's hard disk subsystem is proficient at performing random reads, and its 128K-byte (expandable to 256K bytes) memory cache reduces wait states. The Hewlett-Packard disk provides impressive sequential read performance, and the unit features a 128K-byte two-way set-associative memory cache.

The ALR PowerPro test model offers an array consisting of two 380M-byte Maxtor hard drives. The system's 32-bit EISA bus master caching controller contains a 2M-byte disk cache that is expandable to 8M bytes. The ALR stripes data across multiple drives at the byte level and appears to be optimized for random and sequential writes. The relative inefficiency of the ALR disk array at performing random/sequential reads hinders the system's performance in the application-based benchmarks. The IBM PS/2 Model 95, ALR PowerCache 33/4, and NCR System 3445 use MCA expansion buses.

IBM and ALR offer similar overall file server performance. The IBM's SCSI hard disk subsystem performs sequential reads more efficiently, outperforming the ALR in the cc:Mail and WordPerfect tests. ALR's SCSI hard disk subsystem strength in random reads is evident in the FoxPro benchmark. The ALR Micro Channel-compatible system comes configured with a 128K-byte direct-mapped write-back memory cache. The IBM test model contains an optional 256K-byte two-way set-associative write-through memory cache.

The NCR's relatively poor overall performance is due in part to the inefficiency of its hard disk subsystem at performing random and sequential writes. The NCR disk performance results were worse than projected for a system with an intelligent RISC-based SCSI controller and two large Maxtor SCSI drives. The NCR only relies on the 8K-byte memory cache built into its 33MHz 486 processor.

Methodology

Performance ratings are based on indexes calculated from individual performance scores for the weighted benchmarks. A particular file server's performance rating for a single benchmark is calculated by dividing the fastest system's results (the largest number of runs or best time for the disk read/write test) by the file server's result. The overall Performance Score is the weighted average of the indexes for the individual tests.

Performance Score = (cc:Mail Index) + (FoxPro Index) + (Lotus 1-2-3 Index) + WordPerfect Index) + (Disk Read/Write Index) ÷ 5.

Features

The 33MHz and 50MHz Dell systems differ only in their processor boards, which include different CPUs. The chassis, software warranty, and support features are identical. Seven EISA expansion slots are available in the test configurations, and a built-in, high-resolution VGA adapter is standard. System memory expands to 128M bytes of RAM using DRAM SIMMs. A 128K-byte secondary direct-mapped memory cache is utilized. The expansion chassis accommodates 11 half-height or 5 full-height devices. Mass storage option maximums include 650M-byte hard drives and drive arrays up to 2G bytes. Dell includes one year of on-site service and extended warranties are available.

Compaq's advanced features include drive arrays and support for multiple processors. The SystemPro supports up to four drive array pairs, providing 1.68G bytes of storage. Symmetric processing is supported in the following CPU combinations: two 33MHz 486s, two 33MHz 386s, or one of each type. The EISA expansion bus supports six available expansion slots; the integrated VGA adapter frees an expansion slot. System memory expands to 256M bytes by adding proprietary modules to its 32-bit memory expansion board.

The Micro Channel Architecture-based NCR expands to 128M bytes of RAM by installing 4M-byte and 16M-byte memory expansion boards in the system's four dedicated memory slots. The NCR does not utilize secondary memory caching, relying on the efficiency of the 486's internal 8K-byte memory cache. It supports SCSI drives with maximum capacities of 1.4G bytes; a 2.1G-byte drive array is also available. The NCR's spacious case offers room for seven half-height or five full-height mass storage devices. The NCR contains a built-in, high-resolution VGA port.

The EISA-based Olivetti provides six available 32-bit expansion slots, two full-height drive bays, or three half-height bays. Up to 1.4G-byte hard drives are supported. The system board contains eight memory slots, allowing up to 64M bytes of SIMMs to be installed. Memory caching is limited to the 486's 8K-byte internal cache, but sockets are available for the Weitek 4167 co-processor and Intel i860 application processor. The front system control panel contains a programmable LCD message display, function buttons, and numerous LED indicators. Warranty service is provided directly with extended warranties available.

Hewlett-Packard provides two 32-bit memory adapter slots for installing up to 64M bytes of SIMM memory. Mass storage expansion includes two full-height drive bays allowing up to 2G bytes of internal storage. The EISA expansion bus provides six available 32-bit slots. A secondary 128K-byte two-way set-associative write-through memory cache reduces wait states. Hewlett-Packard bundles one year of on-site service in the list price; extended warranties are available.

The IBM model provides a built-in XGA video controller that supports resolutions up to 1,024 x 768. System memory expands to 64M bytes by installing SIMMs on the motherboard. An optional 256K-byte two-way set-associative memory cache module attaches to the system's upgradable i486 processor complex. Up to five devices can be installed in the available 5.25-inch storage bays. The Micro Channel expansion bus provides six available 32-bit expansion slots. On-site service and extended warranties (dealer-dependent) are available.

ALR PowerPro's drive array subsystem supports up to 1.36G bytes of storage. The EISA-based system supports multiple processors; each upgradable processor supports 512K bytes of direct-mapped write-back memory cache. System memory upgrades to 49M bytes by installing SIMMs on the system board. The expansion bus provides five available slots. On-site service and extended warranties are available.

Digital's expansive chassis accommodates a maximum of four full-height drives or nine half-height drives. The EISA expansion bus provides five available slots after installing a video adapter (not included) and disk controller. System memory upgrades to 64M bytes by installing SIMMs on the motherboard. The secondary 128K-byte direct-mapped write-through cache expands to 256K bytes. An LCD display provides boot-up messages without requiring a standard video system to be installed. On-site service and extended warranties are available.

The ALR PowerCache's Micro Channel expansion bus provides four open expansion slots. Limited memory expansion allows up to 32M bytes of SIMMs to be installed. The system features a secondary 128K-byte direct-mapped write-back memory cache. Three half-height, one full-height, and one 3.5-inch drive are installable. The drive subsystem supports a 1.2 G-byte hard drive. On-site service and extended warranties are available.

Methodology

NSTL verified each system's features against a master list, noting which features are standard and which are optional. The Features Score is a weighted average of scores for individual features, rescaled from 1 to 10.

Usability

The ALR PowerPro's documentation is poorly organized and lacks sufficient diagrams. The index refers to incorrect locations and omits key titles (memory is only listed as a subsection under options). The system automatically reconfigures itself when memory is installed on the system board. Accessing the system board does not require the removal of any fixed components. Drive arrays are located on a swing-out door. The ROM-based setup utility features a flowing menu structure and detailed help.

The Dell 433SE and 450SE are identical except for the interchangeable processor board. Dell's disk-based EISA configuration utility features menu options for copying configuration files and for basic and advanced setup. The side cover is firmly held in place by ball-end studs. Memory upgrades require installing SIMMs on the system board; the setup program must be run to complete the reconfiguration. A metal cover protects the forward facing drive bays. Three manuals cover different models and often refer to other parts of the documentation to complete a feature description.

The Hewlett-Packard Vectra comes with comprehensive documentation, including manuals covering the SCSI drive and NetWare installation. The tabbed user's manual is well organized and features helpful index and glossary sections. The slow-loading EISA configuration utility allows passwords, operating systems, and other utilities to be installed. The adapter slot bracket must be removed to access the system board. The drive bay provides adequate

space for installing hard drives; the power supply and controller wiring area, however, is tight. SIMMs install on the memory card.

The cover of the large NCR system slides forward on tracks to expose internal subsystems. Dedicated memory slots support 4M-byte or 16M-byte memory cards, and NCR recommends installing pairs of equivalent size boards to maximize interleaving. SCSI connectors at the rear of each drive bay provide direct connections. A front cover closes to protect the power button and LCD display. Comprehensive documentation includes numerous tables and diagrams. The disk-based Micro Channel configuration utility includes on-line, context-sensitive help.

The front and side covers of the IBM Model 95 pull off easily. The reference diskette, used to reconfigure the system, contains context-sensitive help. Error messages generated on boot-up must be translated using the manual inside the cover. The system's large power supply swings out from the unit to provide access to the system board, and SIMMs are easily installed on the system board. Documentation provides detailed diagrams although extensive specifications and feature descriptions are omitted.

On the Olivetti system, the mouse, keyboard, and I/O ports are placed on top in a narrow row near the power supply. Molded top, side, and front covers are removed to provide access the system components. The disk-based EISA setup utility includes context-sensitive help and clear menu options. Memory upgrades use SIMM slots on the system board. Hard drive installation requires removing the front cover. The comprehensive documentation includes helpful illustrations and feature descriptions.

The ALR PowerCache's configuration disk is not bootable, requiring the user to first load an operating system. The primary hard drive is installed on a swing-out door; additional hard drives require an additional drive bay support bracket. A memory card installs SIMMs. The documentation lacks diagrams, and the installation instructions are inadequate.

Compaq's disk-based EISA configuration utility's online help only offers technical descriptions. Proprietary memory modules install easily on a memory expansion adapter. The drive array pairs install by removing the rear cover and passing the wiring through a lower storage area. A plastic cover slides over the power button to prevent accidental power-offs. Users must alternate between the system setup, overview, drive arrays, and user programs manuals to find required information.

The Digital model features a programmable status window which displays error messages during boot-up. The disk- and ROM-based setup utilities feature clear menu and help options. Detaching the controller wiring allows SIMMs to be installed on the system board. Internal options are accessed by removing a top cover and side panel. The documentation provides helpful reference materials.

Methodology

The Usability Score is a weighted average of scores for individual criteria. Usability criteria are scored from 0 to 5; the results are rescaled from 0 to 10.

Usability Score = (3 x System Setup Score) + (2 x Cover Removal Score) + (3 x Memory Installation Score) + (3 x Hard Disk Installation Score) + (2 x System Teardown Score) + (2 x Manual Organization Score) + (2 x Manual Clarity Score) + (3 x Manual Comprehensiveness Score) ÷ 20.

Performance Results

NSTL measured network file server performance using application programs running on eight network workstations. These application-based tests measured the speed of network server responses to commonly performed operations. The programs, cc:Mail, Lotus 1-2-3, WordPerfect, and FoxPro, represent the business software most commonly used on personal computer networks. Specific software packages were chosen based on their visibility and importance in the marketplace and their capabilities. Additionaly, a series of low-level read/write tests isolated the performance of the file servers' hard disk subsystems.

Each network workstation executed a series of transactions like load and save a WordPerfect document or look up a record in a FoxPro transaction file. Transactions were timed by a transaction manager, an NSTL program that initiates and records the results of the transaction benchmarks. Prior to executing each transaction, the transaction manager randomly changed to a disk subdirectory containing transaction source data on the network server. The subdirectory was selected from a range of predefined server directories assigned to the workstation. Such random choice minimizes the chances that a given disk read will already be in the server's cache. The directory ranges do

Figure 11.
cc:Mail

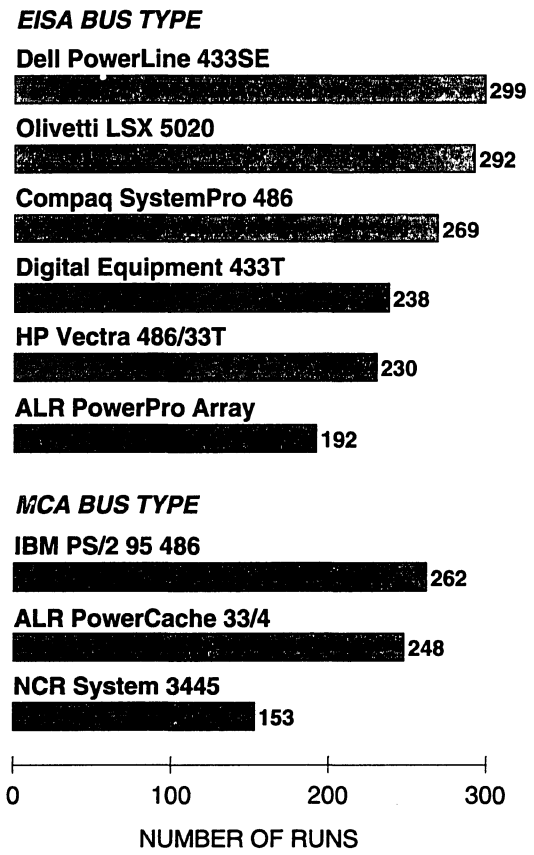


Figure 12.
Lotus 1-2-3

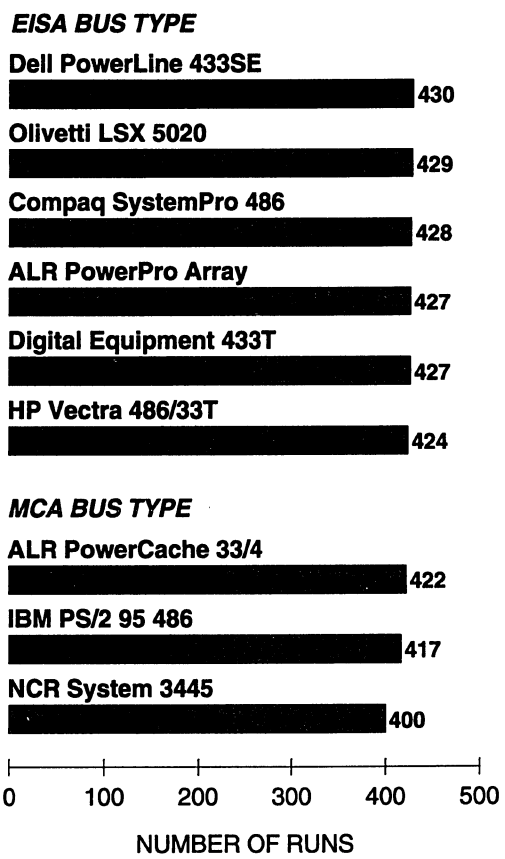
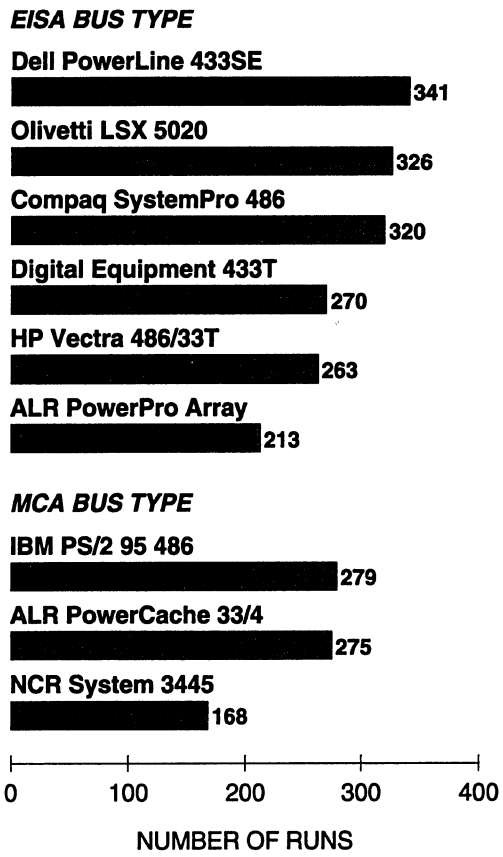


Figure 13.
WordPerfect



not overlap with other workstations for most transactions executed on a workstation; but others, like the FoxPro transaction, have many workstations sharing the same directory. All transactions, except for FoxPro, executed on different copies of the same test files. Each workstation chooses a directory in its nonoverlapping range and changes to that directory before executing transactions.

A single application transaction test measured the number of transaction operations that can be completed in 10 minutes. A server's performance for a particular application was determined by the total number of transactions that the workstations were capable of completing in the given time. For example, the Lotus test measured the number of spreadsheet loads and saves that can be executed from all workstations in 10 minutes with no wait time between the individual transaction runs. For each measured test, the same transaction type ran on each workstation. Application programs and test data were stored on the network file server's disks.

Configuration

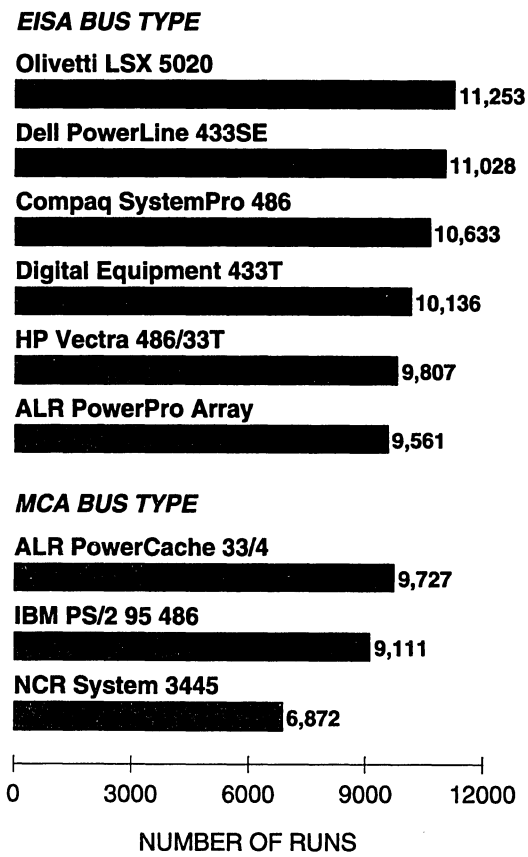
Each system ran as a network file server under Novell NetWare Version 3.11. The systems contained 8M bytes of RAM (the ALR PowerPro Array contained 9M bytes) and featured either SCSI or arrayed hard disk subsystems. Each hard disk subsystem contained two disk spindles facilitating direct comparison between the SCSI and arrayed subsystems. The ALR PowerCache 33/4, IBM, and NCR offer Micro Channel Architecture (MCA) expansion buses and were configured with two Madge Smart 16/4 MC Ringnode token-ring network adapters. The remaining systems were built around EISA expansion buses and are configured with two Madge Smart 16/4 EISA Ringnode token-ring network adapters. Differences between Madge's implementation of the EISA and MCA specifications change the performance differences between file servers built around the two bus architectures. As a result, the data is not directly comparable. The Madge EISA token-ring adapter contains 32 data lines and 32 address lines. The Madge MCA token-ring adapter also contains 32 address lines, but uses 16 data lines.

The file servers' disk subsystems were either hardware striped (arrays) or NetWare striped (SCSI) and partitioned into two volumes in order to control the amount of server disk head movement. Test files for a given transaction were spread across the partitions in a directory tree.

The network test bed operated at 16M bps and consisted of the file server, eight workstations, and a control station. The workstations were diskless 16MHz 286-based systems configured with 1M byte of RAM and IBM 16/4 token-ring adapters. An AST Premium 386SX/16 with 4M bytes of RAM and an IBM 16/4 Token-Ring adapter functioned as a control station. Four workstations attached to each of the file server's Madge token-ring adapters—two accessing Volume1 and two accessing Volume2—ensuring maximum disk activity.

Low-level disk tests ran with four workstations and comprised a series of random and sequential read/writes of

Figure 14.
FoxPro

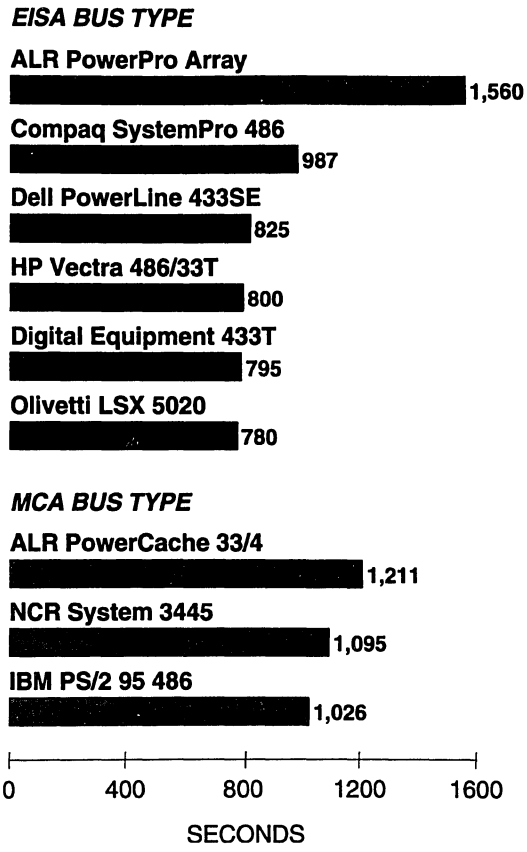


512-byte and 4K blocks from 80M-byte files. The test copied two 80M-byte files to each of the NetWare volumes; each workstation accessed its own file. Each of the file server's Madge token-ring adapters handled requests for Volume1 and Volume2.

The Dell Drive Array (DDA) can be hardware striped or configured as independent drives. Hardware striping is a method of spreading data across multiple disks and is implemented at the sector level with the DDA. The array's drives are synchronized and can perform parallel data transfers resulting in high sequential transfer rates. When configured as independent drives, the DDA can process multiple NetWare disk commands by simultaneously seeking on all drives. The disadvantage of the DDA's hardware striping is that the controller can only process a single NetWare disk command at one time. Per Dell's hot line recommendation, NSTL tested and scored the PowerLine 433SE based on its independent configuration using NetWare striping.

Dell and ALR PowerPro Array support posted writes, which can improve performance by acknowledging data as soon as it is transferred to the host adapter, before it is physically written to the drive. However, there is no guarantee that a particular write will be completed. NSTL disabled posted writes for testing because of the inherent risk of data loss with database applications.

Figure 15.
Disk Read/Write



cc:Mail

The cc:Mail transaction consists of two parts. First, a 100K file is copied from a directory on the server into the same directory on the server. Second, the cc:Mail import program imports a 100K mail message into the mail database.

Performance Factors

The hard disk subsystem has the most impact on this test; other performance factors include the token-ring network adapter and memory subsystem.

Lotus 1-2-3

The Lotus 1-2-3 transaction loads a macro that combines a (39K) worksheet into the current worksheet and saves the worksheet. Lotus 2.2 Server Edition is used; all workstations execute the same copy of the program.

Performance Factors

This test primarily exercises the hard disk subsystem; secondary influences include the token-ring network adapter and memory subsystem.

WordPerfect

The WordPerfect transaction runs a macro that loads a 135K document and saves it under a different name. A network copy of WordPerfect (Version 5.1) is used; all workstations execute the same copy of the program.

Performance Factors

This test measures the hard disk subsystem with some impact from the token-ring network adapter and memory subsystem.

FoxPro

The FoxPro transaction looks up a record in a transaction file; locks a corresponding record in the accounts, teller, and branch files; and adds a record into the history file. A network version of FoxPro is used (FoxPro/LAN 1.02).

Performance Factors

This test primarily stresses the hard disk subsystem; secondarily, the token-ring network adapter and memory subsystem are measured.

Disk Read/Write

Four workstations make concurrent file I/O requests for 512-byte and 4K blocks from the server. Each workstation opens and accesses a separate 80M-byte file; makes 1,000 requests that seek and read from records scattered throughout the target files; and writes the same blocks. Sequential reads/writes perform 1,000 requests in record order starting at the beginning of each file. Sequential reads (1,000) are also performed from cache to assess the efficiency of the servers' memory subsystems.

Performance Factors

This test primarily stresses the hard disk subsystem; the token-ring network adapter and memory subsystem also are stressed.

Vendors

Advanced Logic Research, Inc. (ALR)
9401 Jeronimo
Irvine, CA 92718 (800) 444-4ALR

Compaq Computer Corp.
20555 State Highway 249
Houston, TX 77070 (713) 370-0670

Dell Computer Corp.
9505 Arboretum Boulevard
Austin, TX 78759 (800) 289-3355

Digital Equipment Corp.
305 Foster Street
Littleton, MA 01460 (800) DIGITAL

Hewlett-Packard Co.
3000 Hanover Street
Palo Alto, CA 94304 (800) 752-0900

IBM Corp.
1133 Westchester Avenue
White Plains, NY 10604
Contact your local IBM representative.

NCR Corp.
1700 South Patterson Boulevard
Dayton, OH 45479 (800) 544-3333

Olivetti Systems and Networks
ISC-Bunker Ramo
2 Enterprise Drive
Shelton, CT 06484 (800) 243-9737

Specifications

Features/Functions

Features	ALR PowerCache 33/4	ALR PowerPro Array	Compaq SystemPro 486	Dell PowerLine 433SE	Dell PowerLine 450SE
Microprocessor	33MHz 80486	33MHz 80486; socket for a Weitek 4167 co-processor (support for multiple system processors)	33MHz 80486 (support for multiple system processors)	33MHz 80486; socket for a Weitek 4167 co-processor	50MHz 80486
Memory	Base Memory: 8MB system RAM expandable to 32MB on the system board using 80-ns. DRAM SIMMs; 128KB secondary direct-mapped write-back memory cache	Base Memory: 17MB system RAM expandable to 49MB on the system board using 80-ns. DRAM SIMMs; 512KB secondary direct-mapped write-back memory cache	Base Memory: 8MB expandable to 256MB using proprietary 80-ns. memory modules; 512KB secondary direct-mapped write-through memory cache	Base Memory: 4MB expandable to 128MB on the system board using 80-ns. DRAM SIMMs; 128KB secondary direct-mapped write-through memory cache	Base Memory: 4MB expandable to 128MB on the system board using 80-ns. DRAM SIMMs; 128KB secondary direct-mapped write-through memory cache
Hardware Included	1.44MB diskette drive; 25-pin serial, parallel, and mouse ports; four 16-bit and two 32-bit Micro Channel expansion slots; one proprietary memory slot; ESDI hard disk controller; 200-watt power supply; 101-key enhanced keyboard	1.2MB diskette drive; 420MB drive array; 9-/25-pin serial, parallel, and mouse ports; Super VGA video adapter; eight 32-bit EISA expansion slots; two proprietary processor slots; advanced disk array controller with 2MB cache (expandable to 8MB); 300-watt power supply; 101-key enhanced keyboard	1.44MB diskette drive; 240MB 2-drive array; 32-bit Intelligent Drive Array (IDA) controller; two 9-pin serial, parallel, and mouse ports; four proprietary processor/memory slots; seven 32-bit EISA expansion slots; integrated VGA adapter; 101-key enhanced keyboard; 355-watt power supply	1.2MB or 1.44MB diskette drive; 80MB IDE hard drive; eight 32-bit EISA expansion slots; proprietary processor and dedicated video slots; two 9-pin serial, one parallel, and mouse ports; high-resolution VGA adapter; high-resolution VGA monitor; 101-key enhanced keyboard; 300-watt power supply	1.2MB or 1.44MB diskette drive; 80MB IDE hard drive; eight 32-bit EISA expansion slots; proprietary processor and dedicated video slots; two 9-pin serial, one parallel, and mouse ports; high-resolution VGA adapter; high-resolution VGA monitor; 101-key enhanced keyboard; 300-watt power supply
Software Included	Diagnostic software, MCA setup/configuration utilities	Diagnostic software, EISA setup/configuration utilities	Disk cache, RAM disk, EMM, diagnostic, EISA setup/configuration utilities	Diagnostic software, EISA setup/configuration utilities	Diagnostic software, EISA setup/configuration utilities
Operating System Support	MS-DOS 3.30-5.0; OS/2 1.1-1.2; Novell NetWare; IBM LAN Server; Microsoft LAN Manager; SCO Xenix	MS-DOS 3.30-5.0; OS/2 1.1-1.2; Banyan VINES; IBM PC LAN Program; IBM LAN Server; 3Com 3+Open; Microsoft LAN Manager; TCP/IP; SCO UNIX	MS-DOS 3.30-5.0; OS/2 1.1-1.2; Novell NetWare; Banyan VINES; 3Com 3+Open; Microsoft LAN Manager; SCO Xenix System V, SCO Xenix 386	MS-DOS 3.30-5.0; OS/2 1.2; Novell NetWare; Banyan VINES; IBM PC LAN Program; IBM LAN Server; 3Com 3+Open; Microsoft LAN Manager; TCP/IP; Dell UNIX System v4.0	MS-DOS 3.30-5.0; OS/2 1.2; Novell NetWare; Banyan VINES; IBM PC LAN; IBM LAN Server; 3Com 3+Open; Microsoft LAN Manager; TCP/IP; Dell UNIX System v4.0

Features/Functions (Continued)

Features	ALR PowerCache 33/4	ALR PowerPro Array	Compaq SystemPro 486	Dell PowerLine 433SE	Dell PowerLine 450SE
Warranty/Service/Support	One year parts and labor; warranty service through vendor, authorized dealers, and Intel; on-site service and extended warranties are available; telephone support	One year parts, labor, and return shipment; warranty service through vendor, authorized dealers, and Intel; on-site service and extended warranties available; telephone support	One year, parts and labor; shipping coverage, on-site service, and extended warranties dealer dependent; toll-freetelephone help	One year, parts, labor, return shipment; service through Xerox Corp.; one year on-site service included in list price; extended warranties available; toll-free telephone support	One year, parts, labor, return shipment; service through Xerox Corp.; one year on-site service included in list price; extended warranties available; toll-free telephone support

Features	Digital DECpc 433T	Hewlett-Packard Vectra 486/33T	IBM PS/2 Model 95 XP 486	NCR System 3445	Olivetti LSX 5020
Microprocessor	33MHz 80486; socket for a Weitek 4167 co-processor	33MHz 80486; socket for a Weitek 4167 co-processor	33MHz 80486	33MHz 80486; socket for a Weitek 4167 co-processor	33MHz 80486; socket for a Weitek 4167 co-processor
Memory	Base Memory: 4MB expandable to 64MB on the system board using 70-ns. DRAM SIMMs; 128KB (expandable to 256KB) secondary direct-mapped write-through memory cache	Base Memory: 4MB expandable to 64MB on the system board using 80-ns. DRAM SIMMs; 128KB secondary two-way set-associative write-through memory cache	Base Memory: 8MB expandable to 64MB on system board using 70-ns. DRAM SIMMs (optional secondary 256KB two-way set-associative write-through memory cache)	Base Memory: 16MB expandable to 64MB on the system board with proprietary 80-ns. DRAM modules	Base Memory: 8MB expandable to 64MB on the system board using 70-ns. DRAM SIMMs
Hardware Included	1.2MB diskette drive; two 9-pin serial, parallel, and mouse ports; eight 32-bit EISA expansion slots; serial mouse; 101-key enhanced keyboard; 380-watt power supply	1.2MB or 1.44MB diskette drive; two 9-pin serial, one parallel, and mouse ports; diskette/hard disk controller; eight 32-bit EISA expansion slots; proprietary memory and processor slots; 101-key enhanced keyboard; 360-watt power supply	1.44MB diskette drive; 320MB SCSI hard drive; 25-pin serial, parallel, SCSI, and mouse ports; eight 32-bit Micro Channel expansion slots; proprietary processor slot; integrated XGA video adapter; SCSI controller with cache; 101-key enhanced keyboard; 329-watt power supply	1.44MB diskette drive; 670MB SCSI hard drive; SCSI II controller with onboard RISC processor; 25-pin serial, parallel, SCSI, and mouse ports; integrated high-resolution VGA adapter; one 16-bit and six 32-bit Micro Channel expansion slots; one intelligent SCSI host adapter slot and four dedicated memory slots; 385-watt power supply; enhanced keyboard	1.44MB diskette drive; 150MB SCSI hard drive; 32-bit SCSI bus master contoller; 25-pin serial, parallel, SCSI, and mouse ports; 16-bit Paradise VGA adapter; eight 32-bit EISA expansion slots; 295-watt power supply; enhanced keyboard

Features/Functions (Continued) (Continued)

Features	Digital DECpc 433T	Hewlett-Packard Vectra 486/33T	IBM PS/2 Model 95 XP 486	NCR System 3445	Olivetti LSX 5020
Software Included	EISA setup/ configuration utilities; system diagnostics	EISA setup/ configuration utilities; HP Memory Manager	Disk cache, diagnostics, Micro Channel setup/configuration utilities	Diagnostic and demonstration software; Micro Channel setup/ configuration utilities	Diagnostic and expanded memory management software; EISA setup/configuration utilities
Operating System Support	MS-DOS 3.30-5.0; OS/2 1.2 with Presentation Manager; Novell NetWare; Microsoft LAN Manager; TCP/IP; SCO UNIX V 3.2.2 PathWorks, Digital's PC networking products	MS-DOS 3.30-5.0; OS/2 1.2-1.3; Novell NetWare; Banyan VINES; 3Com 3+Open; Microsoft LAN Manager; UNIX 3.2.2	MS-DOS 3.30-5.0; OS/2 1.2-1.3; OS/2 LAN Server 1.3; Novell NetWare; IBM PC LAN Program; IBM LAN Server; Microsoft LAN Manager; AIX	MS-DOS 3.30-5.0; OS/2 1.2 with Presentation Manager; Novell NetWare; Microsoft LAN Manager; TCP/IP; SCO UNIX	MS-DOS 3.30-5.0; OS/2 1.2 with Presentation Manager; Novell NetWare 3.0-3.1; IBM PC LAN Program, IBM LAN Server 1.2; 3Com 3+Open; Microsoft LAN Manager; TCP/IP; UNIX SV 5.0
Warranty/Service/Support	One year, parts, labor, and return shipment; on-site service and extended warranties available; toll-free telephone help	One year, parts, labor, return shipment; next business day on-site service through vendor and authorized dealers; extended warranties available ($300/year); toll-free telephone support ($45/call; approximately $720/year for a hardware support contract)	One year, parts, labor, and return shipment; service through supplier/dealers; on-site warranty service available; extended warranties dealer dependent; telephone support	One year parts; on-site service and extended warranties available; telephone support	One year parts, labor, and return shipment; on-site service and extended warranties available; telephone support

286 Diskless Workstations

A Report from NSTL

In this report:

Synopsis

Focus
The market for diskless workstations is expected to double over the next year as businesses look for low-cost, secure network systems. NSTL evaluated seven diskless workstations based on the Intel 80286 microprocessor. (The 80386SX-based Compaq Deskpro 386N was included in the performance, usability, and features evaluations for comparison with the 286 workstations.) Ratings are based on the systems' performance, features, usability, and price.

Products Tested
EarthStation IIe
Alloy Computer Products
PowerFlex 286
Advanced Logic Research, Inc. (ALR)
MiStation MI212
American Mitac Corp.
Bravo/286
AST Research Inc.
6286/EL WGS
AT&T
Deskpro 386N
Compaq Computer Corp.
PC 286
NCR Corp.
PW2 LAN Workstation/286
Unisys Corp.

Product Recommendations
- Alloy EarthStation IIe
- ALR PowerFlex 286
- Unisys PW2 LAN Workstation/ 286

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

Chart 1.
Rating Chart

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

Overall Rating	Product Name	Performance	Usability	Features	Price
8.2	Alloy EarthStation IIe	●	●	▨	$1,295 ★
7.2	ALR PowerFlex 286	●	●	○	$1,522 ★
7.0	AT&T 6286/EL WGS	○	●	○	$1,827
6.9	American Mitac MiStation MI212	○	●	○	$1,623
6.4	NCR PC 286	○	○	○	$2,023
6.2	Unisys PW2 LAN Workstation/286	○	●	▨	$2,090 ★
5.7	AST Bravo/286	○	○	▨	$1,652

Overview

Traditionally, the market for diskless workstations has been a niche market confined almost exclusively to financial institutions. Recently, however, that market has expanded to include many business networking environments, and the market is expected to double over the next year. Until recently, network administrators chose personal computers with diskette and hard disk drives to serve as network workstations, but diskless workstations offer advantages over traditional PCs including security, price, size, and adaptability in harsh environments.

Diskless workstations become increasingly popular as businesses decentralize information and search for cost-effective ways to distribute data. Diskless workstations are smaller than standard desktop systems and do not incur the additional cost of diskette and hard disk drives. A small footprint makes the diskless workstation ideal for environments with limited work space, and because they do not use disk drives (which are prone to failure in harsh environments), diskless workstations are much better suited to "dirty" industrial environments than are standard PCs.

Businesses commonly choose diskless workstations for their security. Systems without local disk drives make it more difficult to unintentionally introduce a virus onto a network or to steal confidential information, and they reduce the risk of users introducing unlicensed software. Diskless workstations are not without problems, but the cost and security advantages often outweigh the disadvantages.

Diskless workstations present unique maintenance problems in that operating system software must be downloaded from a network server. An internal failure may render the workstation unable to download its boot software. Standard PCs that experience similar failures can be booted from diskette-based diagnostic software that pinpoints the cause of failure.

User resistance to diskless workstations arises primarily from reluctance to having to store personal or confidential files (i.e., company financial or personnel data) on the network file server rather than on a local hard or diskette drive. Users may have difficulty accessing data on a network because of network operating system security features, and they may perceive the installation of a diskless workstation as a demotion or as a lack of trust.

Evaluation Criteria

NSTL tested 286 diskless workstations configured with at least 1M byte of RAM and a VGA monitor. The base model ALR comes configured with a 1.44M-byte diskette drive that can be disabled. Diskless models of the Compaq and NCR are available, but the Compaq test model contains a 1.44M-byte diskette, and the NCR contains a 1.44M-byte diskette and a 40M-byte AT hard drive. The Alloy and Unisys come with proprietary 8-bit network adapters that emulate the Novell NE1000 Ethernet adapter. All the other systems are tested with 16-bit CNet 200E Ethernet cards that emulate the Novell NE2000.

The workstations were tested on a Novell NetWare 386 3.10 network using Ethernet over thin coaxial cabling. The workstations were connected to an AST Premium 386/25 server equipped with 4M bytes of RAM, 16K-byte external memory cache, Novell NE2000 Ethernet card, 110M-byte IDE hard drive, and VGA monitor. A Hewlett-Packard Vectra 386/25 served as a control station with 4M bytes of RAM, 32K-byte external memory cache, 1.2M-byte diskette, Novell NE2000 Ethernet card, 84M-byte AT hard disk, and VGA monitor.

The new 16MHz 80386SX Compaq 386N diskless workstation was included in the performance, usability, and features evaluations for comparison with the 286 workstations. IBM's new diskless PS/2 Model 55 LS was not available for comparison testing. The Model 55 LS uses a 16MHz 386SX processor and comes bundled with an IBM 16/4 Token-Ring adapter.

Configurations

Diskless workstations come in keyboard, notebook, and modified PC configurations. The Alloy is typical of the keyboard configuration, which consists of an AT-style keyboard with the system components embedded in the keyboard housing. The Unisys uses the notebook configuration, which consists of a box about the size of a three-ring binder with an external keyboard. All the other test systems were modified PCs without diskette or hard disk drives.

Adapter Cards

NSTL tested the diskless workstations using Ethernet adapters. The Ethernet architecture boasts a large installed base and remains one of the most popular network architectures. Ethernet is widely supported by diskless workstation vendors, and it remains popular in large-scale environments that mix several types of terminals (e.g., Sun and Digital Equipment workstation environments) with personal computers. Ethernet adapters come bundled with the Alloy and Unisys systems. ALR supplies an optional Western Digital Ethernet card, and American Mitac provides an optional CNet 200E Ethernet card. AT&T supplies a Starlan 10 network card that was not used for testing because drivers are not available for NetWare 386 3.10. The other manufacturers do not supply Ethernet cards.

IBM's 16M bps Token-Ring Network provides a high-performance alternative to Ethernet networks. Although Ethernet still outranks token-ring in number of installations, current market studies show token-ring overtaking Ethernet in the PC LAN market. Token-ring topology is more receptive to adding and deleting nodes and recabling during operation. Token-ring arbitrates contention among nodes more efficiently because token passing enforces sharing of the network. Alloy bundles a proprietary token-ring adapter with its EarthStation IIIt, and NCR sells an optional token-ring adapter for its PC 286.

Arcnet LAN architecture provides a flexible and low-cost alternative to token-ring and Ethernet. Arcnet does not provide the performance or IEEE standardization of the token-ring and Ethernet architectures, but it owns a respectable 10 to 15 percent share of the LAN market and is considered one of the easiest network architectures to install and maintain. Alloy bundles a proprietary Arcnet adapter with its EarthStation IIa. ALR supplies an optional Arcnet adapter.

Installation

The Unisys and Alloy systems come configured with proprietary network adapters. The other systems require network adapter installation in an open expansion slot. All require cable connections to the network. The Alloy workstation's external satellite box provides power, TTL, and analog video connections. The Unisys external Medium Attachment Unit provides two Ethernet BNC connectors for coaxial cable; a terminator must be attached to an unused connector. Lights on the Medium Attachment Unit indicate whether the system is transmitting and receiving data.

The Alloy system setup is easy except for the monitor configuration, which is done before the monitor is connected. The user must type a one-character monitor code indicating the type of monitor being used within four seconds of turning on the system.

Network installation consists of installing server software and adapter boards and cabling the workstations and server(s). All the Ethernet adapters are configured with remote boot PROMs that boot the systems from the server. Instructions for inserting the PROM and installing the board are generally found in the network adapter documentation.

Network Operating System

(The following setup information is specific to Novell NetWare 386 3.10, but the same basic procedures apply to all LAN operating systems.)

Novell's SHGEN (Shell Generator) file utility is used to create a driver file (Ipx.com) that enables the workstation to communicate with a specific network adapter. The user selects the appropriate network adapter, memory address, and interrupt levels for the workstation. A second driver, called NETx.com (x signifies the DOS version), is required to redirect operating system and application disk requests through the network adapter (using Ipx.com) to the network server.

Remote Boot File

Because diskless workstations have no disks to store the workstation operating system and LAN drivers, a remote boot file is created and stored on the file server. The remote boot file contains the instructions necessary to boot the system to DOS and attach it to the network (NetWare shell). Setting up a remote boot file is relatively simple with NetWare's DOSGEN utility. The Remote Boot image file stored on the server must be generated on a workstation that boots from a diskette or hard disk.

With a remote boot diskette containing the DOS system and network shell configuration files inserted in the diskette drive, NetWare's DOSGEN program (requires supervisory access rights) creates a DOS boot image file (called Net$dos.sys) in the Sys:Login directory and copies the Autoexec.bat file from the boot diskette into the Sys:Login directory. At this point, the remote boot file on the server is complete.

On rebooting the workstation, the adapter's remote boot PROM connects to the file server and downloads the remote boot file (DOS image) to the workstation. (A remote boot PROM is programmed to communicate with a particular network operating system and protocol prior to network installation.) Once loaded, the boot image is executed, providing full DOS and networkable workstation functionality with the network file server acting as the workstation hard drive.

A unique boot image file must be generated on the server for each workstation type and DOS version. A Bootconf.sys file in the Sys:Login directory tells the server which boot image file a workstation needs. Installing multiple remote boot files is slightly different from the DOSGEN procedure described above.

Security

Diskless workstations make it difficult for network users to copy strategic data or introduce unauthorized software. They also give the network administrator much better control over data. Computer viruses represent a growing concern for PC administrators, and diskless workstations help prohibit their growth. The base model ALR 1.44M-byte diskette drive compromises network security to give the user greater flexibility. The ALR diskette drive can be disabled using the system's ROM-based setup utility.

Physical security features on the 286 workstations are generally nonexistent. The AT&T supports a boot password that can be cleared by the administrator via a jumper on the system board. A cover lock on the AT&T prevents opening the unit; in contrast, the Alloy pries open easily, exposing internal system components to theft.

The Compaq 386N is designed with security in mind. When configured with a diskette drive, a security option can limit users to read-only access to the drive to prevent copying data to the network server. A Quicktest utility lets LAN managers determine the PC's memory, configure or lock ports, change system parameters, and determine the status of password options. Drive security can be disabled via DIP switches, and a system hood lock is provided. A mechanical key lock prevents tampering with the security configuration.

Workstation Performance

NSTL's workstation benchmarks demonstrate system performance with standard DOS applications running on a Novell NetWare 386 3.10 network. The Alloy and ALR access main memory with close to 0 wait states and consistently outperform the other 286 systems in tests stressing CPU and memory speed. The 8MHz AST and 10MHz Unisys perform poorly with CPU-intensive applications such as Lotus 1-2-3. The American Mitac, AT&T, and NCR operate at 12.5MHz and provide similar overall performance.

The systems all provide Intel 80287 coprocessor sockets. The co-processor can significantly improve performance of floating-point calculations. The AT&T and Unisys perform by an average of 13 percent faster in the Lotus 1-2-3 test with an 8MHz 80287 co-processor installed.

Except for the Alloy and Unisys, the systems are tested with 16-bit CNet Ethernet adapters that emulate Novell's NE2000 board. The Alloy and Unisys come with proprietary 8-bit Ethernet network adapters that emulate the Novell NE1000 and produce relatively low throughput. NCR's throughput is approximately 5 percent less than that of similarly configured systems.

The Unisys workstation is particularly proficient at the Microsoft Word graphics mode scroll, where the processor is forced to wait while the video adapter updates the screen. The system's

Western Digital VGA controller is located in the Personality module attached to the back of the display. The American Mitac and NCR use built-in Paradise VGA adapters and perform sluggishly in the graphics mode scroll (which is not necessarily the case for all video operations).

Interestingly, the NCR performs the dBASE III Plus benchmark twice as fast across the network using the server hard disk (AST Premium 386/25 server) instead of its internal 40M-byte Conner Peripherals AT hard drive. Diskless workstations can take advantage of the enhanced processing power of network file servers, which are typically configured with fast hard disks, advanced hard disk controllers, large disk caches, and fast CPUs.

Performance advantages of the Compaq's 386SX processor are negligible in comparison to a 286 system operating with close to 0 wait states. The Compaq outperforms the Alloy by only 9 percent in the CPU- and memory-intensive Lotus 1-2-3 benchmark. The 286 workstations are adequate for most standard DOS applications (i.e., word processing, spreadsheets, etc.) when attached to a powerful server. The virtual memory management capabilities of the 386SX processor and the enhanced numeric processing power of an installed 387-SX co-processor may be preferable for multitasking environments such as Microsoft Windows 3.0. or for CAD workstations.

Shadow RAM

Shadow RAM uses the system RAM to overcome the slowness of the ROM BIOS. System BIOS executes slowly compared to RAM, and many adapters have BIOS on-board to handle tasks not included in the original system BIOS. Programs that are heavily dependent on BIOS calls executed from ROM (i.e., CAD/CAM, desktop publishing) run slower than they should, negating the advantages of a fast processor. Shadow RAM eliminates the slowdown by loading copies of the system BIOS and/or video BIOS into fast RAM on the system board. Shadow RAM is physically located on the system board, and its logical address is the reserved memory between 640K bytes and 1M byte. Most of the 286 workstations support user-selectable shadowing of system and video ROM. Shadowing cannot be disabled on the Compaq 386N, which reserves 128K bytes of RAM for copying the system and video BIOS.

System Expansion

Expansion options are a function of the design and physical size of the workstation. The Alloy and Unisys are true diskless workstations with 4M-byte and 5M-byte RAM limitations, respectively. The Alloy's internal components are located within the keyboard housing, and a thick cable attaches the keyboard to a tiny satellite box that houses the video, LAN, and power connectors. Using the satellite box to host most of the connectors keeps the required desktop space to a minimum. Most of the Unisys system is contained in a Personality Pack that snaps onto the back of the PW2 VGA monitor. The Personality Pack is a busless, single-board system about the size of a three-ring notebook. Video and Ethernet adapters are integrated into the Personality Pack. The system board draws its power from the monitor. The Alloy and Unisys are each configured with 9-pin serial and parallel ports.

The modified PC workstations generally come void of mass storage options. The ALR contains a 1.44M-byte diskette drive. The modified PC workstations contain embedded hard drive and diskette controllers and provide at least one serial and one parallel port. American Mitac, AT&T, Compaq, and NCR save an expansion slot by supplying built-in VGA adapters; mouse ports are standard on the AT&T, American Mitac, and Compaq. The American Mitac, AST, Compaq, and NCR are left with one open 16-bit expansion slot when attached to a network.

The modified PCs ship with 1M byte of RAM and support up to 16M bytes of RAM (the maximum addressable by the 286 processor). The AST ships with 640K bytes of RAM. Workstation memory is expandable to 4M bytes or 5M bytes on the system board using DRAM SIMMs. Additional memory must be installed through the expansion bus. The 386SX Compaq supports up to 8M bytes on the system board; an additional 8M bytes can be added via a 16-bit high-speed memory slot.

The ALR features a unique 108-pin 386/i486 Feature Connector that enables CPU upgrades with plug-in modules (16MHz 386SX or 25MHz i486). The modular upgrade path makes the ALR a good hedge against processor obsolescence.

Reliability and Customer Support

Reliability and quality engineering are major concerns when purchasing any microcomputer system. System reliability often depends on a number of components bearing different Mean-Time-Between-Failure (MTBF) statistics and quality assurance methods applied during assembly. Vendors generally do not disclose component purchasing procedures, quality testing and component inspection methods, or the names of component manufacturers and distributors.

Users will generally find a direct correlation between the manufacturer's size and its commitment to quality engineering. Users who opt for low-cost or mail order systems may experience problems with parts availability and timely on-site service. All the tested systems except the Alloy offer a standard one-year warranty. Alloy provides a two-year warranty covering everything except physical damage due to misuse; Alloy does not offer on-site service.

Summary

Diskless workstations come in a variety of sizes and configurations. They provide excellent data security, work well in harsh environments, and prevent the spread of computer viruses. Most of the systems accommodate optional diskette and hard disk drives.

The Compaq 386N uses a 16MHz 80386SX processor. Unique security features include read-only rights for diskettes, Quicktest security software, a mechanical key lock, and security setup via DIP switches. The 386N features a built-in VGA adapter and leaves one open 16-bit expansion slot when attached to a network.

The Alloy EarthStation is a true diskless workstation with an embedded proprietary 8-bit network adapter; it supports a maximum 4M bytes of RAM and no other expansion options. The entire system is embedded within the keyboard housing. The proprietary Ethernet adapter emulates the Novell NE1000 and produces relatively low throughput, but the Alloy accesses main memory with close to 0 wait states and performs well in tests of CPU and memory speed.

The ALR PowerFlex comes configured with a 1.44M-byte diskette drive that compromises data security but gives the user greater flexibility. The ALR accesses main memory with close to 0 wait states and performs well in tests of CPU and memory speed. The ALR offers businesses the advantage of CPU upgrades to a 16MHz 386SX or 25MHz i486 with plug-in modules.

AT&T's 6286/EL WGS and NCR's PC 286 operate at 12.5MHz and come with built-in VGA adapters. AT&T security features include a boot password that can be cleared by the administrator (jumper setting on the system board) and a cover lock. When attached to the network, the NCR is left with one open 16-bit expansion slot. The PC 286 performs the graphics mode scroll benchmark slowly.

American Mitac offers an optional CNet 200E Ethernet card for its MiStation II. The workstation performs poorly in the graphics mode scroll test, indicating a relatively slow video subsystem. It comes with a built-in VGA adapter and leaves one open 16-bit expansion slot when connected to a network.

Like the Alloy, the Unisys PW2 comes bundled with a proprietary 8-bit network adapter that emulates the Novell NE1000. The PW2 runs at 10MHz and performs poorly in CPU-intensive tests. The Unisys system design bundles all system components into a Personality Pack that fits on the back of a standard Unisys workstation. Memory is expandable to 5M bytes but offers no mass storage expansion options, making it an excellent choice for users who require extensive security.

The 8MHz AST Bravo/286 is slow in CPU-intensive tests; it leaves one open 16-bit expansion slot when connected to a network and ships with 640K bytes of RAM.

Product Evaluations

Alloy EarthStation IIe

Product Summary

- Excellent overall performance
- 12MHz 80286 processor
- Maximum 4M bytes of RAM on system board

- 80-ns. DRAM main system memory
- Compact design combines system board into 101-key keyboard
- VGA, proprietary 8-bit Ethernet adapters included
- No mass storage options
- No industry-standard expansion slots
- Supports Intel 80287
- Parallel, 9-pin serial ports
- Alternate Token-Ring, Arcnet models

ALR PowerFlex 286

Product Summary

- Good overall performance
- 12.5MHz 80286 processor
- Maximum 5M bytes of RAM on system board
- 80-ns. DRAM main system memory
- 1.44M-byte diskette standard
- Embedded diskette/hard disk controller
- Upgrade path to 16MHz 386SX or 25MHz i486
- Five 16-bit, one 8-bit ISA expansion slots
- Supports Intel 80287
- Holds two 3.5-inch, two 5.25-inch devices
- Parallel, 25-pin serial ports
- Optional Ethernet, Arcnet network adapters

American Mitac MiStation MI212

Product Summary

- Average overall performance
- 12.5MHz 80286 processor
- Maximum 4M bytes of RAM on system board
- 80-ns. DRAM main system memory
- Embedded diskette/hard disk controller
- Two 16-bit ISA expansion slots
- Supports Intel 80287
- Holds one 3.5-inch, one half-height device
- Parallel, 9-pin serial, mouse ports
- Built-in VGA adapter
- Optional Ethernet network adapter

AST Bravo/286

Product Summary

- Poor overall performance
- 8MHz 80286 processor
- Maximum 4M bytes of RAM on system board
- 100-ns. DRAM main system memory
- Embedded diskette/hard disk controller
- Three 16-bit, one 8-bit ISA expansion slots
- Supports Intel 80287
- Holds two half-height, one third-height 3.5-inch devices
- Parallel, 25-pin serial ports
- No optional network adapters
- No shadow RAM

AT&T 6286/EL WGS

Product Summary

- Average overall performance
- 12.5MHz 80286 processor
- Maximum 4M bytes of RAM on system board
- 100-ns. DRAM main system memory
- Embedded diskette/hard disk controller
- Three 16-bit ISA expansion slots
- Supports Intel 80287
- Holds one half-height, and one 3.5-inch device
- Parallel, two 9-pin serial, mouse ports
- Built-in VGA adapter
- Chassis lock, boot password security
- Optional Starlan network adapter

Compaq Deskpro 386N

Product Summary

- 16MHz 80386SX processor
- Maximum 8M bytes of RAM on system board
- 80-ns. DRAM main system memory
- Embedded diskette/hard disk controller
- Two 16-bit ISA expansion slots
- Supports Intel 80287SX

- Holds 3.5-inch diskette, hard disk drive
- Parallel, 9-pin serial, mouse ports
- Built-in VGA adapter
- ROM-based diagnostics
- Most security features
- No optional network adapters

NCR PC 286

Product Summary

- Below-average overall performance
- 12.5MHz 80286 processor
- Maximum 5M bytes of RAM on system board
- 100-ns. DRAM main system memory
- Embedded diskette/hard disk controller
- Two 16-bit ISA expansion slots
- Supports Intel 80287
- Holds 3.5-inch diskette, hard disk drive
- Parallel, 9-pin serial, 25-pin serial ports
- Built-in VGA adapter
- Combination keyboard, system cover lock
- No optional network adapters

Unisys PW2 LAN Workstation/286

Product Summary

- Below-average overall performance
- 10MHz 80286 processor
- Maximum 5M bytes of RAM on system board
- 100-ns. DRAM main system memory
- Personality module attaches behind VGA display
- VGA, proprietary 8-bit Ethernet adapters included
- No mass storage options
- No industry-standard expansion slots
- Supports Intel 80287
- Parallel, 9-pin serial, mouse ports

Product Recommendations

Alloy EarthStation IIe

The EarthStation IIe's compact design combines the system board (CPU, RAM, ROM, and I/O ports) into a 101-key keyboard. A thick cable attaches the keyboard to a small satellite box that houses the video, LAN, and power connectors. All configuration settings are stored in ROM, eliminating the need for switches and jumpers on the system's proprietary Ethernet network adapter. The EarthStation IIe offers excellent performance and is well suited for harsh and customer transaction environments.

ALR PowerFlex 286

The ALR PowerFlex 286 can be classified as a modified PC workstation. A standard 1.44M-byte diskette drive adds flexibility but compromises the network security afforded with truly diskless workstations. A proprietary connector enables system upgrades from a 286 CPU to a 16MHz 386SX or 25MHz i486 using plug-in CPU modules. An optional Western Digital Ethernet adapter provides good overall performance.

Unisys PW2 LAN Workstation/286

Unisys markets the PW2 as a diskless workstation for secure or sensitive government applications. The system resembles the dumb terminals common in mainframe computing environments. The heart of the Unisys system is a diskless, busless, single-board module that snaps onto the back of the PW2 VGA monitor. Video and proprietary Ethernet adapters are integrated into the external module along with serial, parallel, and mouse ports. Performance is generally unimpressive owing to the system's relatively slow 10MHz processor.

Rating Summaries

Figure 1.
Alloy EarthStation IIe Ratings

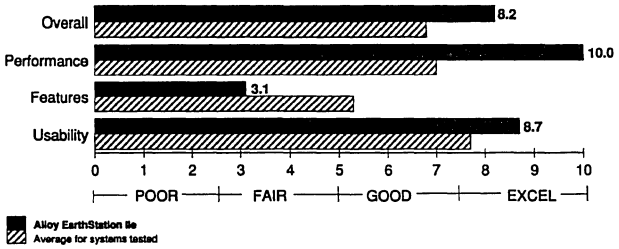


Figure 2.
ALR PowerFlex 286 Ratings

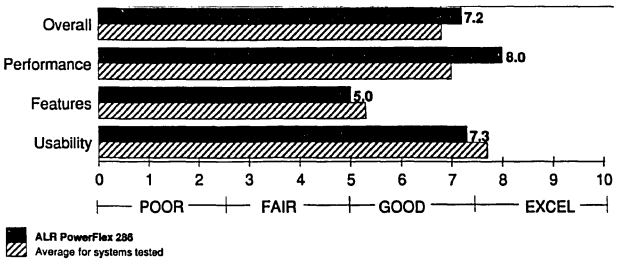


Figure 3.
American Mitac MiStation MI212 Ratings

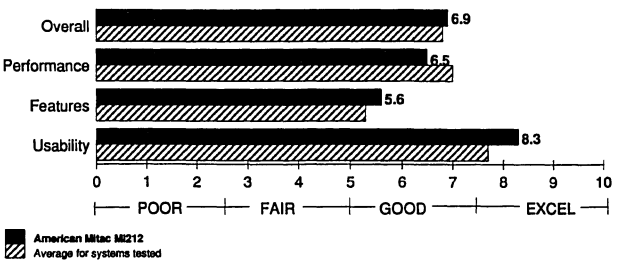


Figure 4.
AST Bravo/286 Ratings

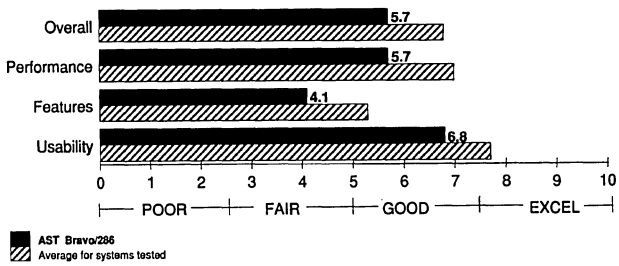


Figure 5.
AT&T 6286/EL WGS Ratings

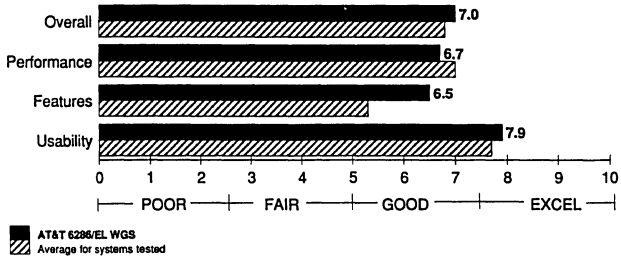


Figure 6
Compaq Deskpro 386N Ratings

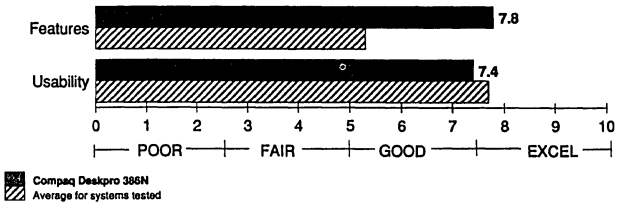


Figure 7.
NCR PC 286 Ratings

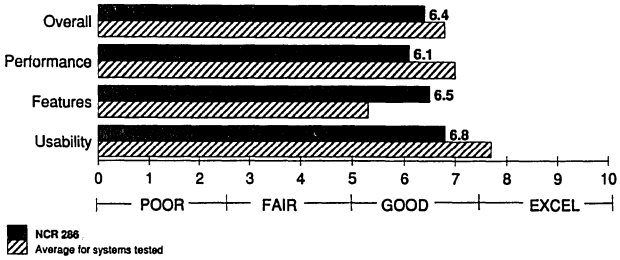
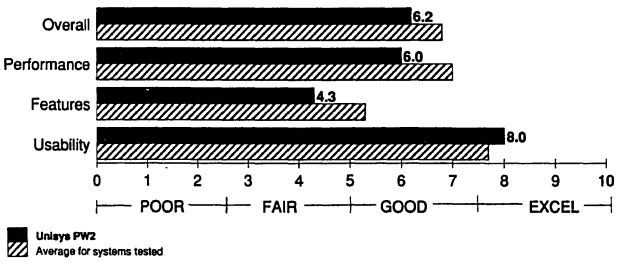


Figure 8.
Unisys PW2 LAN Workstation/286 Ratings



Overall Evaluation

The Alloy and ALR systems access memory with close to 0 wait states and feature 80-ns. memory to provide excellent overall performance. The Alloy and Unisys are true diskless workstations designed for network use, and neither supports the range of expansion options offered by the modified PCs. Both systems come configured with proprietary Ethernet adapters, making them simple to attach to the network. The other systems must be configured with optional or third-party network adapters.

The Compaq comes with several unique security features and provides excellent expansion options. The Compaq uses a 386SX processor and is included with the 286 diskless workstations purely for comparison. The faster processor provides insignificant performance gains over the 286 systems operating with close to 0 wait states.

The American Mitac, AT&T, and NCR are configured with 12.5MHz processors and provide similar overall performance. The American Mitac and NCR have built-in Paradise VGA adapters and perform graphics scrolls slowly. The AT&T keyboard can be adjusted for comfort.

The AST comes with well-organized, clear documentation. The AST's comparatively slow 8MHz processor yields disappointing performance, and the system lacks some of the standard features provided by the other modified PCs, such as a keyboard or chassis lock.

Methodology

The overall evaluation score is a weighted average of scores for individual criteria.

Overall Evaluation Score = (5 x Performance Score) + (3 x Usability Score) + (2 x Features Score) ÷ 10.

Performance

The Alloy and ALR systems provide the best overall performance. These systems access main memory with close to 0 wait states, use 80-ns. memory, and operate at 12MHz and 12.5MHz, respectively. The AST and Unisys use slow 8MHz and 10MHz processors and 100-ns. memory, and both perform poorly with CPU-intensive applications such as Lotus 1-2-3. The American Mitac, AT&T, and NCR are configured with 12.5MHz CPUs, and all perform similarly. The NCR and AT&T use slower 100-ns. memory, and the American Mitac uses 80-ns. memory. The 386SX-based Compaq 386N provides relatively little performance gain over the 286 ALR and Alloy systems.

The NCR performs the dBASE III Plus benchmark twice as fast across the network than locally using its internal 40M-byte Conner Peripherals hard drive because of the network server's processing power, advanced hard disk controller, and fast CPU.

In the Microsoft Word 5.0 graphics mode scroll (where the processor is forced to wait for the video adapter to update the screen), the Unisys is fastest. The Western Digital VGA adapter bundled with the Unisys is located in the Personality Pack attached to the back of the monitor. American Mitac and NCR perform the graphics scroll slowly, indicating slow video subsystems; both use built-in Paradise VGA adapters.

The Unisys and Alloy perform slowly in tests measuring the throughput of the Ethernet adapters. The Unisys and Alloy use proprietary 8-bit Ethernet adapters designed to emulate the Novell NE1000. NCR's throughput is approximately 5 percent less than other systems using the CNet Ethernet adapter. The Compaq's throughput benefits from the 16MHz clock speed of its 386SX CPU.

Methodology

Performance ratings are based on the System Performance Index calculated from individual performance scores for the weighted benchmarks. A system's performance rating for a single benchmark is the AT&T 6286/EL WGS time divided by the system's time. (The AT&T 6286/EL WGS is used as the standard of comparison.) The Overall Performance Index is the sum of the indexes for the weighted tests divided by the sum of the weights.

Performance Score = (System Index - Average Index)/(Highest Index - Average Index) x 3 + 7. Weights: Lotus 1-2-3 = 1; dBase III Plus = 1; Microsoft C = 1; Microsoft Word = 2.

Features

The Alloy and Unisys are marketed as true diskless workstations that offer very little expandability. Features such as embedded diskette or hard disk

controllers, which can be important in a modified PC, are not applicable to the Unisys and Alloy workstations.

Security features safeguard data and internal system components in diskless workstations. The AT&T and Compaq offer boot password protection that can be disabled via a jumper or switch on the system board. Compaq provides unique parallel/serial interface control, diskette boot control, and diskette write control security features. NCR provides keyboard and chassis locks.

The base model systems come with one parallel port and at least one serial port. The AT&T, American Mitac, Compaq, and Unisys have dedicated mouse ports. All except the AST and ALR come with VGA adapters.

CPU speed can be slowed on all the systems except the Alloy, AST, and Unisys to ensure compatibility with software written for slower processors. CPU speed adjustments are keyboard activated on all but the AT&T, Compaq, and NCR.

Alloy systems come in Ethernet, Token-Ring, and Arcnet configurations. The Unisys system comes bundled with an Ethernet adapter. All the other systems must be configured with third-party network adapters to access a LAN.

Methodology

NSTL verifies each system's features against a master list, noting which features are standard and which are optional. A detailed comparison of the system's features and their methodology weights appears in Table 4.

Usability

Cover removal for some of the workstations involves procedures as simple as removing AT&T's single hand-turned screw. The Alloy cover simply pries open; lifting the keyboard exposes the system's internal components. The Unisys system board is located in the Personality Pack attached to the back of the PW2's VGA monitor; opening the Personality Pack involves removing a series of variable-length screws.

Numeric co-processor installation is relatively straightforward on all the systems except the AST and Unisys. The AST's VGA adapter must be removed to access the co-processor socket, and a protective metal shield blocks access to the Unisys co-processor socket.

The Alloy and Unisys systems come bundled with preconfigured, proprietary 8-bit Ethernet adapters. The remaining systems use third-party network adapters configured using DIP switches and jumper block settings. Only AT&T provides an adjustable keyboard.

The AST and AT&T manuals are clearly written and well organized, but neither covers network connection at all. American Mitac and AST use colors to differentiate manual sections. The Alloy and NCR manuals lack comprehensive indexes.

Methodology

The usability rating is a weighted average of scores for individual criteria.

Usability Score = (2 x Cover Removal Score) + (3 x Memory Installation Score) + (3 x Co-processor Installation Score) + (3 + Network Configuration Score) + (Optional Diskette Installation Score) + (2 x System Setup Score) + (3 x Keyboard Rating Score) + (2 x Manual Organization Score) + (2 x Manual Clarity Score) + (3 x Manual Comprehensiveness Score) ÷ 24.

Performance Results

NSTL's workstation benchmarks demonstrate system performance using standard DOS business applications running on a Novell NetWare 386 3.10 network. Application-based benchmarks demonstrate the interaction of various subsystems (e.g., memory architecture, processor, display), and their relative importance varies by application. A low-level test measures the throughput of the Ethernet adapters.

Test Configuration

NSTL tested each 286 workstation equipped with at least 1M byte of RAM, a VGA adapter (640 by

480-dpi resolution), and a VGA color monitor. Higher resolution VGA modes (800 by 600) were not tested. NSTL also tested the Compaq Deskpro 386N to provide an 80386SX performance comparison. Additional equipment included a 1.44M-byte diskette drive in the ALR and Compaq workstations and a 1.44M-byte diskette drive and 40M-byte AT hard drive in the NCR. Performance tests were run on the NCR's local hard drive as well as across the network. The AT&T and Unisys were tested with and without an 8MHz Intel 80287 co-processor.

Unisys and Alloy provide proprietary 8-bit Ethernet network adapters that emulate the Novell NE1000 card. The other systems were configured with 16-bit CNet Ethernet adapters that emulate the Novell NE2000. The network adapters use remote boot PROMS that enable the workstations to boot from the server. The AST, AT&T, NCR, and Compaq were tested with proprietary DOS versions, and the others with PC-DOS 3.30.

An AST Premium 386/25 system served as a Novell NetWare 386 3.10 server. The server was equipped with 4M bytes of RAM, a 110M-byte IDE hard drive, and a Novell NE2000 Ethernet adapter. A Hewlett-Packard Vectra 386-25 with 4M bytes of RAM and an NE2000 Ethernet adapter functioned as a control station. Network connections used thin coaxial cable with BNC T-connectors.

Config.sys and Autoexec.bat statements for all the tests were as follows.

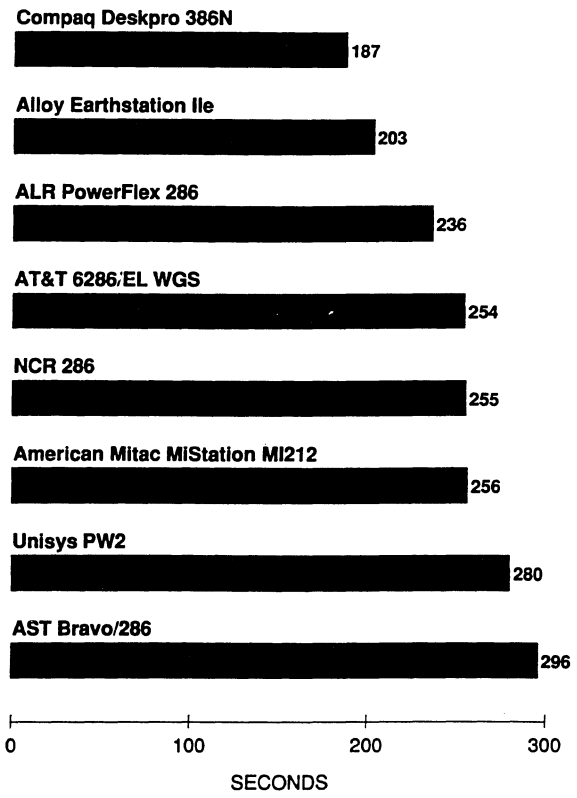
Config.sys: Files=20; Buffers=25; Break=off.

Autoexec.bat: Prompt PG; IPX; Net3 or Net4.

Lotus 1-2-3

A Lotus macro performed a series of recalculations in a 75 by 75 matrix. The macro entered a number in the first cell of the matrix. Subsequently, a formula that used that number was copied to the rest of the matrix. The spreadsheet recalculated three times, each time with a different number entered in the first cell. The procedure was repeated using five different formulas (one each for addition, multiplication, subtraction, division, and exponentation). The macro then executed a block move and erased the entire matrix. The entire sequence was repeated three times.

Figure 9.
Lotus 1-2-3



Performance Factors

Primary components tested:

- processor speed
- memory architecture
- system memory speed

Secondary components tested:

- video subsystem
- Ethernet adapter and driver

Analysis

- Alloy and ALR access main memory with close to 0 wait states, feature 80-ns. memory, and operate at 12MHz and 12.5MHz, respectively.
- American Mitac, AT&T, and NCR are configured with 12.5MHz CPUs and provide similar performance.
- American Mitac uses 80-ns. memory; AT&T and NCR use 100-ns. memory

- AST and Unisys use relatively slow 8MHz and 10MHz processors and 100-ns. memory.
- AT&T and Unisys performance improves by an average of 13 percent with the Intel 8MHz 80287 co-processor.
- Compaq 386N (16MHz 386SX) outperforms the Alloy by only 9 percent.

dBASE III Plus

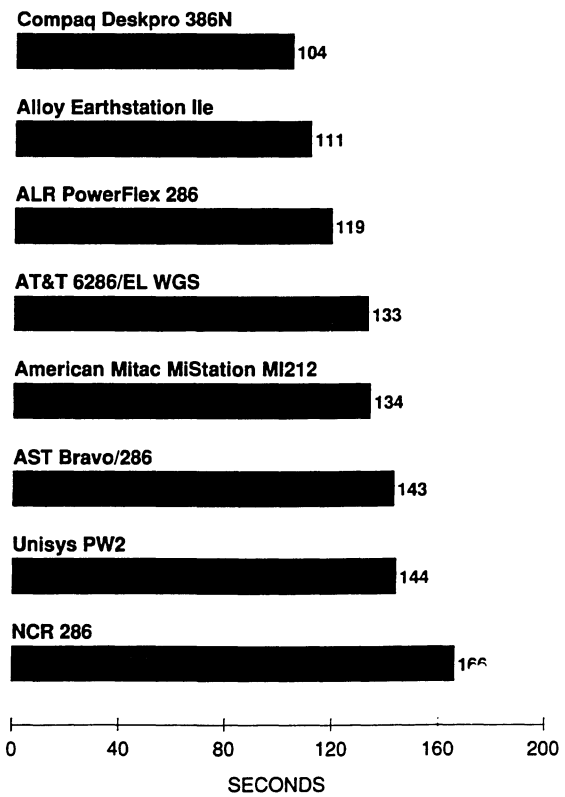
dBASE III Plus produced a report based on a three-file join, select, and sort. The benchmark database consisted of a 500-record Customer file, a 1,000-record Invoice file, and a 2,000-record Item file. The report included calculated fields and subtotals and was printed to a null printer as it was generated.

Performance Factors

Primary components tested:

- Ethernet adapter and driver
- processor speed

Figure 10.
dBASE III Plus



- system memory speed

Secondary components tested:

- video subsystem

Analysis

- Alloy and ALR benefit from their capability to access main memory with close to 0 wait states.
- Alloy and Unisys proprietary 8-bit network adapters emulate the Novell NE1000 Ethernet card.
- AST and Unisys performance is hindered by relatively slow processors (8MHz and 10MHz, respectively).
- NCR is 25 percent slower than the American Mitac and AT&T workstations; each is configured with a 12.5MHz CPU and 16-bit CNet Ethernet adapter.
- NCR performs twice as fast across the network (AST Premium 386/25 server) than locally (using its internal 40M-byte Conner Peripherals AT hard drive).
- Compaq 386N (16MHz 386SX) outperforms the Alloy by only 7 percent.

Microsoft C 5.0

Microsoft C 5.0 compiled and linked XLISP (a public domain program composed of 25 C source files) and generated a working XLISP program.

Performance Factors

Primary components tested:

- Ethernet adapter and driver

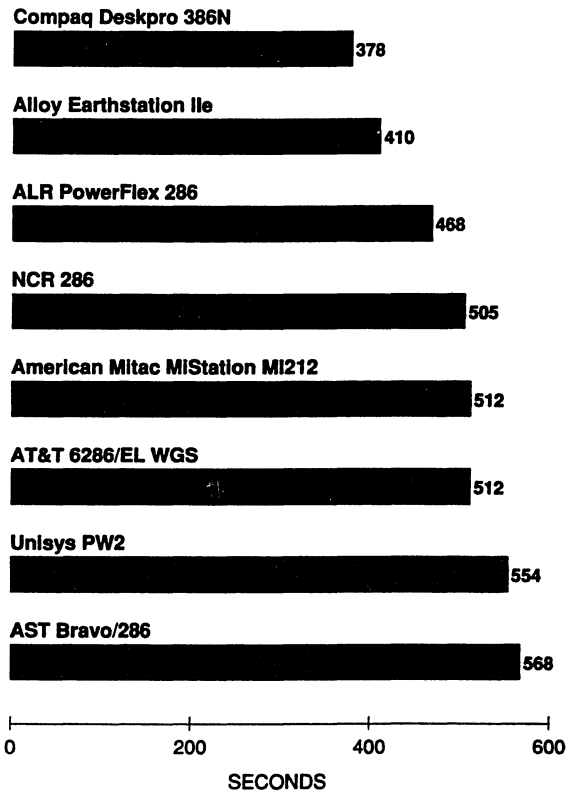
Secondary components tested:

- processor speed
- memory architecture

Analysis

- Alloy is clearly the most proficient, outperforming the ALR (both operate with close to 0 wait states) by 14 percent.
- Alloy and Unisys proprietary 8-bit network adapters emulate the Novell NE1000 Ethernet card; the other systems are configured with 16-

Figure 11.
Microsoft C 5.0



bit CNet Ethernet cards that provide greater throughput.

- AST and Unisys fall behind because of their relatively slow processors (8MHz and 10MHz, respectively).
- American Mitac, AT&T, and NCR operate at 12.5MHz and provide similar performance.
- NCR performs the benchmark 7 percent faster across the network (AST Premium 386/25 server) than locally (using its internal 40M-byte Conner Peripherals AT hard drive).
- The performance advantage of the Compaq 386N's 386SX processor (over 286 systems operating at close to 0 wait states) is negligible for disk-intensive operations.

Low-Level Throughput

NSTL measured the Ethernet adapters' throughput (bytes per second) when sending a 3M-byte block between two workstations using NetWare's IPX transport protocol. Data was transmitted between the test system and the Hewlett-Packard Vectra 386/25 (one conversation). Data was written through IPX with 512-byte buffers, and the adapter drivers independently managed the actual size of the data field within an Ethernet frame, which often ranges from 46 to 1,500 bytes. Throughputs were averaged to derive performance scores.

Performance Factors

Primary components tested:

- Ethernet adapter and driver

Secondary components tested:

- processor speed
- memory speed

Analysis

- The benchmark fairly measures raw hardware and driver performance, but the results are less realistic than application testing because of the static buffer sizes (512 bytes) passed to the IPX drivers and the exclusion of server operations.
- Alloy and Unisys are configured with proprietary 8-bit Ethernet adapters that produce relatively low throughput. The proprietary adapters emulate the Novell NE1000 Ethernet adapter.
- The other systems were tested with the 16-bit CNet Ethernet adapter, which uses NetWare 386 3.10's NE2000 Ethernet driver.

Table 1. Low-Level Throughput

	Throughput (bytes per second)	Time (seconds)
Alloy EarthStation IIe	332,881	9
ALR PowerFlex 286	295,374	11
American Mitac MiStation MI212	335,008	9
AST Bravo/286	339,347	9
AT&T 6286/EL WGS	338,979	9
Compaq Deskpro 386N	371,835	8
NCR PC 286	320,013	10
Unisys PW2 LAN Workstation/286	298,173	11

Table 2. Microsoft Word 5.0 (times in seconds)

	Alloy EarthStation IIe	ALR PowerFlex 286	American Mitac MiStation MI212	AST Bravo/286	AT&T 6286/EL WGS	Compaq Deskpro 386N	NCR PC 286	Unisys PW2 LAN Workstation/286
Load and Exit Word 5.0	3	3	4	4	4	3	4	4
Load File	4	4	5	4	5	3	5	5
Load File (50 times)	58	52	65	68	64	47	62	68
Block Copy (100 times)	57	56	71	72	68	47	71	65
Search/Replace (5 times)	61	51	67	71	67	48	65	71
Spell Check	184	154	206	225	206	149	193	221
Repaginate	70	61	80	88	80	58	77	84
Scroll Text, Graphics Mode	88	81	96	77	87	57	95	65
Scroll Text, Text Mode	33	24	29	29	29	22	29	28
Save File (25 times)	380	332	423	449	428	310	398	451
Print to File	260	216	287	318	287	208	274	309

- NCR's throughput is approximately 5 percent less than similarly configured systems (CNet Ethernet adapters). Compaq's throughput is enhanced by the 16MHz clock speed of its 386SX CPU.

Microsoft Word 5.0

Microsoft Word 5.0 performed a series of typical word processing operations listed in Table 2.

Performance Factors

Primary components tested:

- processor speed

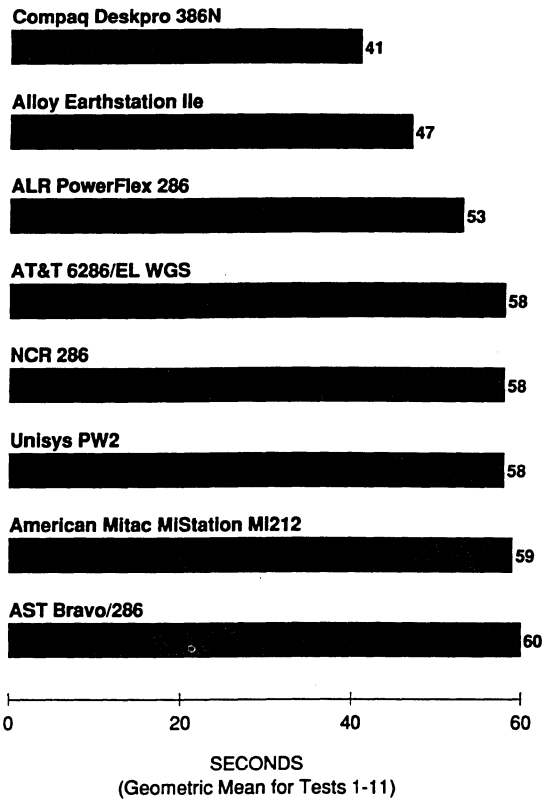
Secondary components tested:

- Ethernet adapter and driver
- video subsystem

Analysis

- Alloy and ALR access main memory with close to 0 wait states and consistently outperform the other workstations in tests that stress CPU and memory speed.
- AST and Unisys are slow in CPU- and memory-intensive tests, such as the Search and Replace and Repagination, because of their relatively slow processors.
- The highly disk-intensive Load File and Spell Check tests stress the Ethernet network adapters and drivers. Most of the systems are configured with 16-bit CNet adapters; the Alloy and Unisys use 8-bit proprietary adapters.
- Unisys performs impressively in the graphics mode scroll, where the processor is forced to wait while the video adapter updates the screen. Its Western Digital VGA controller is located in the Personality module that attaches to the back of the display.
- American Mitac and NCR are sluggish in the graphics mode scroll, indicating relatively slow video subsystems (built-in Paradise VGA adapters).
- Compaq 386N (16MHz 386SX) outperforms the 286 workstations by an average of 34 percent; Compaq is only 15 percent faster than the Alloy.

Figure 12.
Microsoft Word 5.0



Vendors

Alloy Computer Products
165 Forest Street
Marlborough, MA 01752 (508) 481-8500

Advanced Logic Research, Inc. (ALR)
9401 Jeronimo
Irvine, CA 92718 (714) 581-6770

American Mitac Corp.
410 E. Plumeria Drive
San Jose, CA 95134 (408) 432-1160

AST Research Inc.
16215 Alton Parkway, P.O. Box 19658
Irvine, CA 92713 (714) 727-4141

AT&T
295 N. Maple Avenue
Basking Ridge, NJ 07920 (908) 221-8694

Compaq Computer Corp.
20555 State Highway 249
Houston, TX 77070 (800) 231-0900

NCR Corp.
1601 S. Main Street
Dayton, OH 45479 (513) 445-7478

Unisys Corp.
P.O. Box 500
Blue Bell, PA 19424 (800) 448-1424

Characteristics

Table 3. 286 Diskless Workstation Characteristics

	Microprocessor	Memory	Hardware and Software	Network Compatibility	Warranty and Support
Alloy EarthStation IIe	12MHz 80286; socket for 80287	1MB expandable to 4MB using DRAM SIMMs	9-pin serial, parallel ports; VGA adapter; Alloy 8-bit Ethernet adapter; enhanced keyboard	Novell NetWare 286, 386	Two years, parts, labor, and return shipment; service by Alloy; telephone support
ALR PowerFlex 286	12.5MHz 80286; socket for 12- or 8MHz 80287	1MB expandable to 16MB using DRAM SIMMs; maximum 5MB on system board	25-pin serial, parallel ports; five 16-bit, one 8-bit expansion slots; 1.44MB diskette/controller; enhanced keyboard; EMM	Novell NetWare 286, 386; Banyan VINES; IBM PC LAN Program; IBM LAN Server; 3Com 3+Open; Microsoft LAN Manager	One year, parts, labor, and return shipment; on-site service through ALR, dealers, and Intel; extended warranty available; telephone support

Table 3. 286 Diskless Workstation Characteristics (Continued)

	Microprocessor	Memory	Hardware and Software	Network Compatibility	Warranty and Support
American Mitac MiStation MI212	12.5MHz 80386; socket for 80387	1MB expandable to 16MB using DRAM SIMMs; 4MB maximum on system board	9-pin serial, parallel ports; VGA adapter; two 16-bit expansion slots; enhanced keyboard; EMM; diagnostic software	Novell NetWare 286, 386; 3Com 3+Open; Banyan VINES; IBM PC LAN Program; IBM LAN Server	One year parts, labor, and return shipment; on-site service through American Mitac, Bell Atlantic Business Systems Services; extended warranties available; telephone support
AST Bravo/286	8MHz 80286; socket for 80287	640KB expandable to 16MB using DRAM SIMMs; 4MB maximum on system board	25-pin serial, parallel ports; 8-bit, three 16-bit expansion slots; enhanced keyboard; EMM	Novell NetWare 286, 386; Banyan VINES; IBM PC LAN Program; IBM LAN Server; 3Com 3+Open; Microsoft LAN Manager	One year parts, labor, and return shipment; on-site service by AST, Intelogic Trace; extended warranties; telephone support
AT&T 6286/EL WGS	12.5MHz 80286; socket for 80287	1MB expandable to 16MB using DRAM SIMMs; maximum 4MB on system board	Two 9-pin serial, parallel, mouse ports; VGA adapter; three 16-bit expansion slots; enhanced keyboard; EMM; AT&T diagnostics	Novell NetWare 286, 386; Microsoft LAN Manager; TCP/IP; AT&T Stargroup	One year, parts and labor; service by dealers and AT&T; telephone support
Compaq Deskpro 386N	16MHz 80386SX; socket for 80387SX	1MB expandable to 16MB using DRAM SIMMs; maximum 8MB on system board	9-pin serial, parallel, mouse ports; VGA adapter; two 16-bit expansion slots; high-speed memory slot; enhanced keyboard; video graphics system; CEMM	Novell NetWare 286, 386; Banyan VINES; 3Com 3+Open; Microsoft LAN Manager	One year, parts and labor; on-site service available; telephone support through dealers
NCR PC 286	12.5MHz 80286; socket for 80287	1MB RAM expandable to 16MB using DRAM SIMMs; maximum 5MB on system board	9-pin serial, 25-pin serial, parallel ports; Super VGA adapter; two 16-bit expansion slots; 1.44MB diskette/controller; enhanced keyboard; EMM; utilities	Novell NetWare 286, 386; Banyan VINES; IBM PC LAN Program; IBM LAN Server; 3Com 3+Open; Microsoft LAN Manager	One year, parts and labor; extended warranties available; service through supplier, dealer, and third parties
Unisys PW2 LAN Workstation/286	10MHz 80286; socket for 80287	1MB expandable to 5MB using DRAM SIMMs	Unisys 8-bit Ethernet adapter; remote boot PROM; 9-pin serial, parallel, mouse ports; VGA adapter; enhanced keyboard; DOS 4.01; Windows 3.0; Unisys system diagnostics	Novell NetWare 286, 386	One year, parts and labor; service through supplier; extended warranty available; telephone support

Table 4. 286 Diskless Workstation Features (Continued)

	Weight	Alloy EarthStation IIe	ALR PowerFlex 286	American Mitac MiStation MI212	AST Bravo/286	AT&T 6286/EL WGS	Compaq Deskpro 386N	NCR PC 286	Unisys PW2 LAN Workstation/286
Test Configuration									
Processor Type	0	80286	80286	80286	80286	80286	80386SX	80286	80286
Processor Speed (MHz)	0	12	12.5	12.5	8	12.5	16	12.5	10
Memory Architecture	0	AL2	P	I	P	P,I	P	P,I	P
System RAM Installed (M bytes)	0	2	2	2	2	2	4	3	5
Ethernet Network Adapter	0	PR	W	CNet	CNet	CNet	CNet	CNet	PR
Video Adapter	0	VGA	VGA	VGA	VGA	VGA	VGA	VGA	VGA
Video Adapter Manufacturer	0	CS	INP	PD	PD	PD	CQ	PD	W
Software									
Expanded Memory Emulator	1	—	▲	▲	▲	▲	▲	▲	▲
LIM EMS Version	0	—	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Disk Cache	0	—	▲	—	▲	DOS3	▲	DOS4	—
RAM Disk	1	—	DOS4	—	▲	DOS3	▲	DOS4	DOS4
Keyboard Speed Utility	0	—	—	—	—	—	—	—	—
Low-Level Format Utility	0	—	▲	▲	▲	▲	▲	—	—
ROM-Based System Setup	1	▲	▲	▲	▲	▲	▲	▲	—
ROM-Based User Diagnostics	1	—	—	—	—	—	▲	—	—
Operating Systems									
OS/2	1	AL1	—	—	—	▲	▲	▲	▲
OS/2 1.1	0	—	—	—	▲	▲	▲	▲	▲
OS/2 1.2	0	—	—	—	▲	▲	▲	—	—
DOS 3.3	0	—	▲	—	▲	▲	▲	▲	▲
DOS 4.0	0	—	▲	—	▲	▲	▲	▲	▲
Processor Speed Setting									
Chance Processor Speed	1	—	▲	▲	—	▲	▲	▲	—
Utility Program	0	—	—	▲	—	▲	▲	▲	—
Key Combination	1	—	▲	▲	—	—	—	—	—
Setup Utility	0	—	▲	▲	—	▲	▲	▲	—
DIP Switches	0	—	—	—	—	—	—	—	—
Front Panel	0	—	—	—	—	—	—	—	—
Jumper Setting	0	—	—	—	—	—	—	—	—
Shadow RAM									
System ROM BIOS Shadowing	1	—	▲	▲	—	▲	▲	▲	▲
Selectable ROM BIOS Shadowing	0	—	▲	▲	—	—	—	▲	▲
Amount of RAM Occupied (K bytes)	0	—	AR1	128	—	128	COM1	64	64
System Video ROM Shadowing	1	—	▲	▲	—	▲	▲	▲	▲
Selectable Video ROM Shadowing	0	—	▲	▲	—	▲	—	▲	▲
Amount of RAM Occupied (K bytes)	0	—	AR1	128	—	64	COM1	32	64
Security									
Keyboard Lock (key mechanism)	1	—	—	—	—	—	—	▲	—
Chassis Lock (key mechanism)	1	—	—	—	—	▲	▲	▲	—
Keyboard Password	1	—	—	—	—	—	▲	—	—
Boot Password	1	—	—	—	—	▲	▲	—	—
Power-on Password Disable	0	—	—	—	—	▲	▲	—	—
Parallel/Serial Interface Control	1	—	—	—	—	—	▲	—	—
Diskette Boot Control	0	—	—	—	—	—	▲	—	—
Diskette Write Control	0	—	—	—	—	—	▲	—	—

Table 4. 286 Diskless Workstation Features (Continued)

	Weight	Alloy EarthStation IIe	ALR PowerFlex 286	American Mitac MiStation MI212	AST Bravo/286	AT&T 6286/EL WGS	Compaq Deskpro 386N	NCR PC 286	Unisys PW2 LAN Workstation/286
I/O Ports									
9-Pin Serial	1	▲	—	▲	—	2	▲	▲	▲
25-Pin (RS-232-C) Serial	1	—	▲	—	▲	—	—	▲	—
Parallel	1	▲	▲	▲	▲	▲	▲	▲	▲
Mouse Port	1	—	—	▲	—	▲	▲	—	▲
External Diskette	0	—	—	—	—	—	—	—	—
VGA Port on System Board	1	AL1	—	▲	—	▲	▲	▲	UN1
Video Port/Adapter Standard	0	▲	—	▲	—	▲	▲	▲	▲
System RAM									
Base System RAM (M bytes)	0	1	1	1	640KB	1	1	1	1
Max. RAM (MB) Std. Memory Board	0	4	5	4	4	4	8	5	5
Max. Installable RAM (M bytes)	1	4	16	16	16	16	16	16	5
Memory Type	0	DRAM	DRAM	DRAM	DRAM	DRAM	DRAM	DRAM	DRAM
Memory Package	0	SIMMs	SIMMs	SIMMs	SIMMs	SIMMs	SIMMs	SIMMs	SIMMs
Memory Speed Specification (ns.)	0	80	80	80	100	100	80	100	100
System BIOS									
BIOS Vendor	0	B1	B2	B3	AST	B4	BC	NCR	B3
BIOS Version	0	B1	B2	B3	1.20	B4	BC	3.50	B3
Disk Options									
1.44MB Diskette	0	—	S	▲	▲	▲	▲	▲	—
Hard Disk	0	—	▲	▲	▲	▲	▲	▲	—
Embedded Diskette Controller	1	—	▲	▲	▲	▲	▲	▲	—
Embedded Hard Disk Controller	1	—	▲	▲	▲	▲	▲	▲	—
Maximum Half-Height Devices	0	—	AR2	MT1	AT1	ATT1	COM2	NCR1	—
Maximum Full-Height Devices	0	—	1	—	—	—	—	—	—
Expansion Bus									
Architecture	1	NA	ISA	ISA	ISA	ISA	ISA	ISA	NA
8-bit Short	0	—	—	—	—	—	—	—	—
8-bit Full	0	—	1	—	1	—	—	—	—
16-bit	0	—	—	5	2	3	3	2	2
Slots Remaining*									
8-bit Short	0	—	—	—	—	—	—	—	—
8-bit Full	0	—	1	—	1	—	—	—	—
16-bit	0	—	3	1	1	3	1	1	—
Other	0	—	AR3	—	—	—	COM3	—	—
Power Supply									
Watts	0	40	150	60	100	110	90	75	80
Co-Processor Support									
Intel 80287 Socket	1	▲	▲	▲	▲	▲	—	▲	▲
Intel 80387SX Socket	1	—	—	—	—	—	▲	—	—

Table 4. 286 Diskless Workstation Features (Continued)

	Weight	Alloy EarthStation IIe	ALR PowerFlex 286	American Mitac MiStation MI212	AST Bravo/286	AT&T 6286/EL WGS	Compaq Deskpro 386N	NCR PC 286	Unisys PW2 LAN Workstation/286
Network Configurations									
Ethernet Model	1	▲	—	—	—	—	—	—	▲
Token-Ring Model	1	AL3	—	—	—	—	—	—	—
Arcnet Model	1	AL4	—	—	—	—	—	—	—

**When configured as network workstation with VGA adapter and network interface card.*
▲—Yes, has feature.
AL1—VGA adapter contained in satellite box that attaches to the keyboard.
AL2—Standard memory access.
AL3—EarthStation Model IIIt (not tested).
AL4—EarthStation Model IIa (not tested).
AR1—384KB reserved for shadowing.
AR2—Two 3.5-inch and two 5.25-inch devices.
AR3—One dedicated 386/i486 feature connector.
AT1—Two half-height and one third-height 3.5-inch devices.
ATT1—One half-height and one 3.5-inch storage devices.
B1—Earth 3.09.
B2—Phoenix 3.10 08.
B3—Phoenix 3.10 00.
B4—Phoenix 1.10.
BC—Compaq 080290.
CQ—Compaq.
CS—Cirrus.
COM1—One high-speed memory slot.
COM2—Hard drive and one 3.5-inch diskette.
COM3—128KB reserved for shadowing.
DOS3—DOS 3.30.
DOS4—DOS 4.01.
I—Interleaved memory architecture.
INP—Information not provided.
MT1—One 3.5-inch and one half-height devices.
NA—Not applicable.
NCR1—One 3.5-inch diskette and 3.5-inch hard drive.
P—Paged memory architecture.
PD—Paradise.
PR—Proprietary.
S—Standard.
UNI1—VGA controller provided in Personality module.
W—Western Digital.

Equipment Prices

		Purchase Price ($)
286 Diskless Workstations		
	Alloy EarthStation IIe	
	Base System	1,295
	Test Configuration	1,295
	ALR PowerFlex 286	
	Base System	995
	Test Configuration	1,522
	American Mitac MiStation MI212	
	Base System	1,295
	Test Configuration	1,623
	AST Bravo/286	
	Base System	995
	Test Configuration	1,652
	AT&T 6286/EL WGS	
	Base System	1,499
	Test Configuration	1,827
	Compaq Deskpro 386N	
	Base System	1,999
	Test Configuration	2,327
	NCR PC 286	
	Base System	1,695
	Test Configuration	2,023
	Unisys PW2 LAN Workstation/286	
	Base System	2,090
	Test Configuration	2,090

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