
Performance Report

IBM Netfinity 5500 (450MHz)

Version 2.0
August 1998



Executive Overview

The IBM Netfinity 5500 servers provide an affordable, two-way, symmetrical multiprocessing-capable platform designed with the high-availability features required to run business-critical applications. The new Netfinity 5500 models, announced worldwide in August 1998, feature a 450MHz¹ Pentium** II processor that supports 100MHz operations to memory. These new models expand IBM's Netfinity line of midrange servers, providing solid network performance for business-critical applications.*

*The 450MHz system (Model 8650-51U) was evaluated using the following Ziff-Davis** benchmarks:*

- *ServerBench** Version 4.01*
- *WebBench** Version 2.0*
- *NetBench** Version 5.01*

*For comparison, the IBM Netfinity server performance laboratory also conducted measurements with the Compaq** ProLiant** 3000, configured with a 333MHz Pentium II processor. The Compaq ProLiant 3000 was not available with a 450MHz or 400MHz Pentium II processor at the time of testing.*

All results from these benchmarks are presented in this report.

Performance Highlights

Following are highlights of the benchmark results. Please review the more detailed information concerning competitive results later in this report.

For these benchmarks, the IBM Netfinity 5500 was configured with a 450MHz/100MHz Pentium II processor, and the Compaq ProLiant 3000 was configured with a 333MHz/66MHz Pentium II processor. Both systems support symmetrical multiprocessing (SMP) operations.

ServerBench 4.01

ServerBench 4.01 was used to measure the performance of the IBM Netfinity 5500 and the Compaq ProLiant 3000 as dual-processor application servers running Windows** NT Server 4.0 and providing services to Windows NT** Workstation 4.0 clients.

The IBM Netfinity 5500 achieved a peak level of transactions per second that was:

- **35 percent higher** than the Compaq ProLiant 3000 in a RAID-0 configuration
- **39 percent higher** than the Compaq ProLiant 3000 in a RAID-5 configuration

WebBench 2.0

WebBench 2.0 was used to measure the performance of these systems as dual-processor Web servers running Microsoft Internet Information Server 3.0 on Windows NT Server 4.0.

Under a high-end workload of 60 WebBench clients, the IBM Netfinity 5500 system delivered:

- **53 percent more throughput** than the Compaq ProLiant 3000 in a RAID-0 configuration
- **53 percent more throughput** than the Compaq ProLiant 3000 in a RAID-5 configuration

Under the high-end workload of 60 WebBench clients, the IBM Netfinity 5500 system serviced:

- **54 percent more requests per second** than the Compaq ProLiant 3000 in a RAID-0 configuration
- **54 percent more requests per second** than the Compaq ProLiant 3000 in a RAID-5 configuration

NetBench 5.01

Under a high-end workload of 60 NetBench clients, the IBM Netfinity 5500 delivered a level of network throughput that was:

- **60 percent higher** than the Compaq ProLiant 3000 in a RAID-0 configuration
- **22 percent higher** than the Compaq ProLiant 3000 in a RAID-5 configuration

Test Environments and Results

ServerBench 4.01

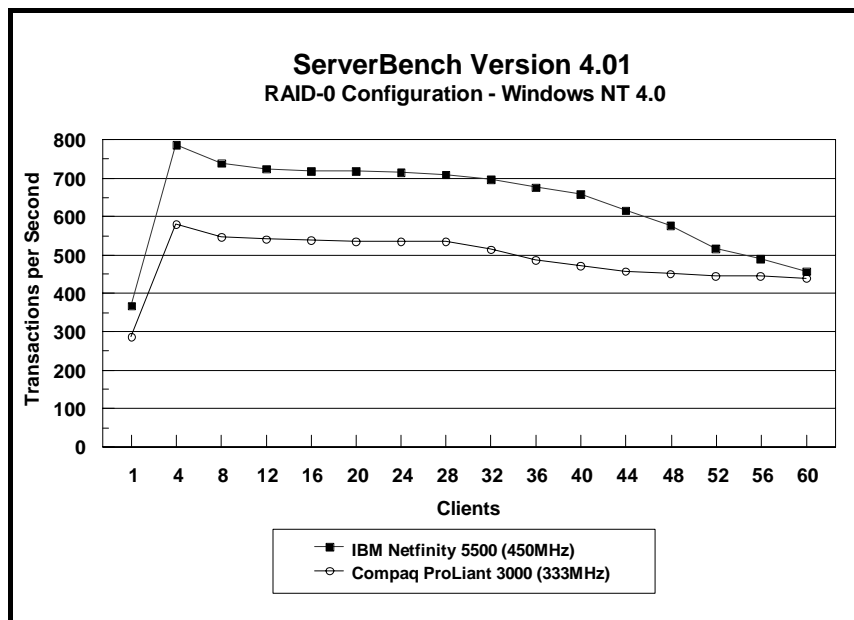
The ServerBench 4.01 system test suite SYS_60.TST was used to measure the performance of the IBM Netfinity 5500 (450MHz) and the Compaq ProLiant 3000 (333MHz) systems, configured as dual-processor, Pentium II-based application servers running Windows NT Server 4.0.

ServerBench 4.01 provides an overall transactions-per-second (TPS) score showing how well the server handles client requests for a variety of operations involving the server's processors, disk and network subsystems.

Results Summary

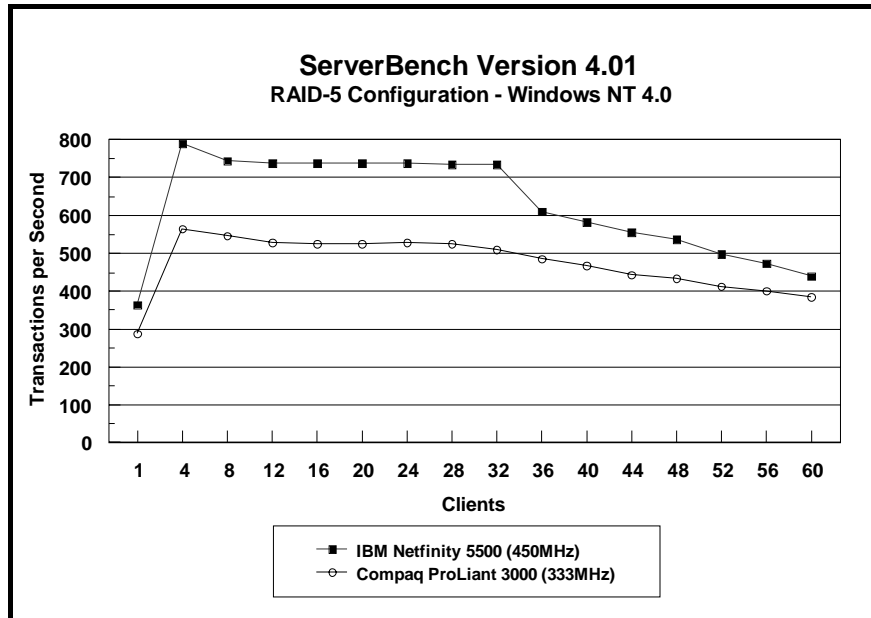
RAID-0 Configuration

The IBM Netfinity 5500 achieved a peak level of transactions per second that was **35 percent higher** than the Compaq ProLiant 3000.



RAID-5 Configuration

The IBM Netfinity 5500 achieved a peak level of transactions per second that was **39 percent higher** than the Compaq ProLiant 3000.



Measurement Methodology

The system test suite was performed using four 100Mbps Ethernet network segments with a total of 60 IBM PC 750 166MHz systems as client workstations attached to the server. Each workstation ran Windows NT 4.0 Workstation and executed the ServerBench 4.01 SYS_60.TST workload, which includes the client/server, processor, server/client, random read, and random write requests typically made in a client/server computing environment. (The default values were used for all NT registry variables. The NT default is 'Max throughput for file sharing'.)

A transaction is a request issued by any one of the 60 clients; the TPS score is the number of transactions per second completed by the server under test. In the ServerBench environment, the server will not service the next request until it has finished the previous one. A higher TPS indicates better performance.

The clients randomly send requests to the server. These requests produce different types of loads on the server. The server performs the work by disk caching if system memory is available, or

swapping mapped memory out to paged files if system memory is full.

The SYS_60.TST test suite contains a total of 16 test mixes. Measurements of transactions per second were recorded as a weighted harmonic mean of the total TPS obtained by all clients in each test mix as clients were added. Clients were added incrementally as follows: 1, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60.

Measurement Analysis

ServerBench's server application on Windows NT provides up to 47 service threads with 60 clients, plus one thread for each server processor. For this test, the servers were configured with two processors; therefore, 49 service threads were used. A client workstation generates a request for the server to begin the next phase of a mix or to ask the server to perform some operation. The server creates a new service thread and passes that connection with the client to an I/O completion port.

As clients are added to the network, the I/O workload increases, requiring more service threads to be allocated to the clients. When all the service threads have been allocated, any new client requests cannot be serviced until an I/O completion port becomes available. Using four 100Mbps network adapters provided sufficient bandwidth to the application server.

ServerBench requires a large amount of system memory to produce a meaningful result. When workload increases gradually, the processor subsystem (processor and system memory) provides adequate service to all requests by caching them in the system memory, which is the primary factor affecting the TPS throughput.

As workload continued to increase (i.e., more clients joined the test mixes), system memory was exhausted, and the server had to rely on the disk subsystem for virtual memory. When this happened, the bottleneck shifted to the disk subsystem, and the application became disk-bound. Running ServerBench with Windows NT may result in a low cache-hit ratio because some NT system threads (e.g., cache manager's lazy writer thread, memory manager's mapped page writer thread) will automatically move some mapped memory into paged files. If a client happens to request that paged-out data again, a cache-hit-miss will result.

The exact number of clients required to move the bottleneck from the processor to the disk subsystem depends on the amount of installed system memory. In these measurements, the application was processor-bound when running from 4 to 8 clients; with more than 40 clients, the application became disk-bound.

WebBench 2.0

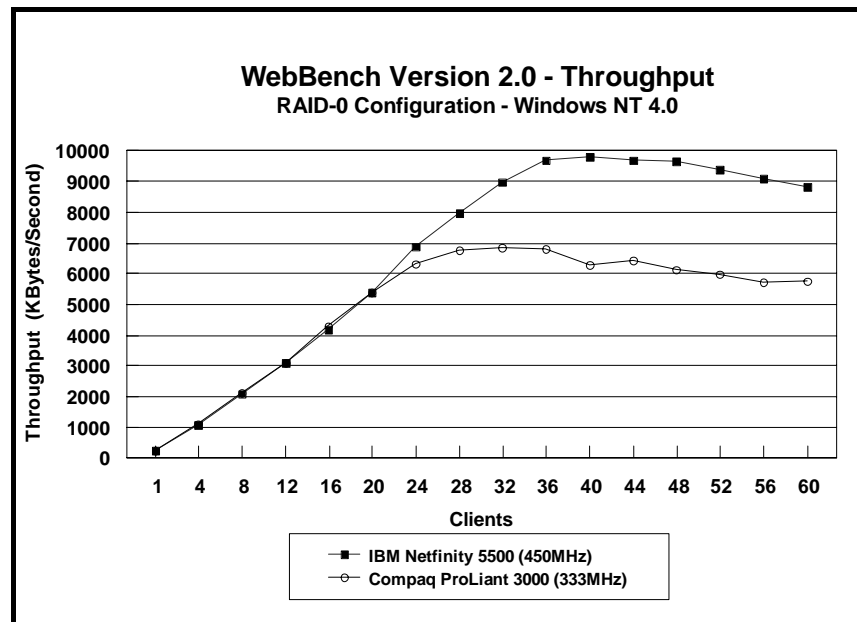
The WebBench 2.0 system test suite NT_SIMPLE_ISAPI20_V20.TST was used to measure the performance of the IBM Netfinity 5500 (450MHz) and the Compaq ProLiant 3000 (333MHz) as dual-processor Pentium II-based Web servers running Microsoft Internet Information Server 3.0 on Microsoft Windows NT Server 4.0 with Service Pack 3.

This system test suite performs both static HTML page requests and dynamic Internet Server API (ISAPI) requests, which are the two primary functions of an enterprise Web server running Microsoft Internet Information Server.

Results Summary

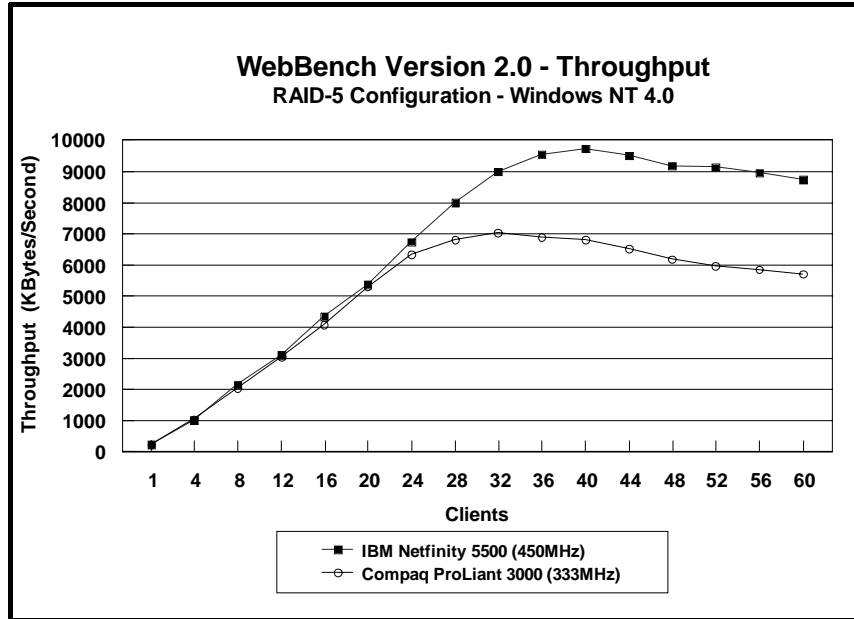
Throughput for RAID-0 Configuration

Under a high-end workload of 60 WebBench clients, the IBM Netfinity 5500 delivered **53 percent more throughput** than the Compaq ProLiant 3000.



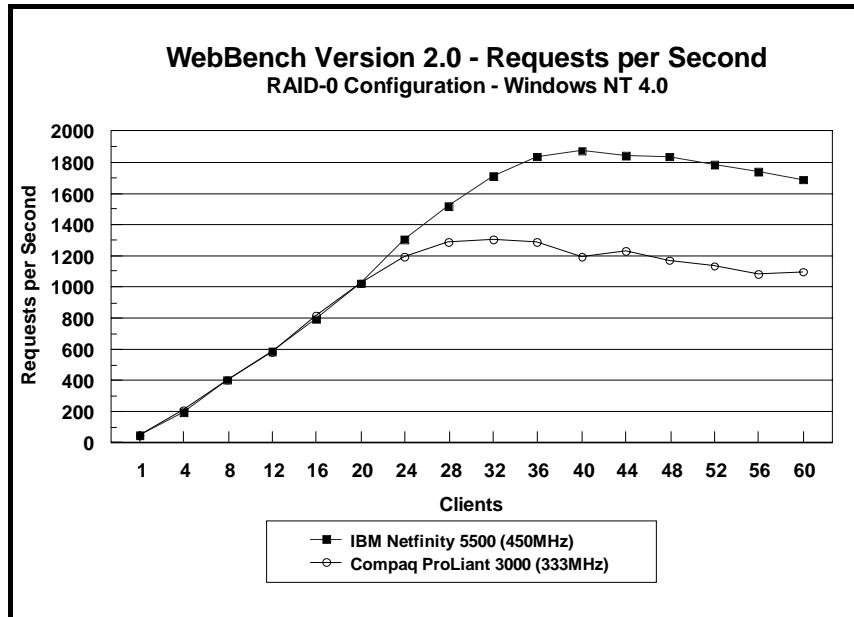
Throughput for RAID-5 Configuration

Under a high-end workload of 60 WebBench clients, the IBM Netfinity 5500 delivered **53 percent more throughput** than the Compaq ProLiant 3000.



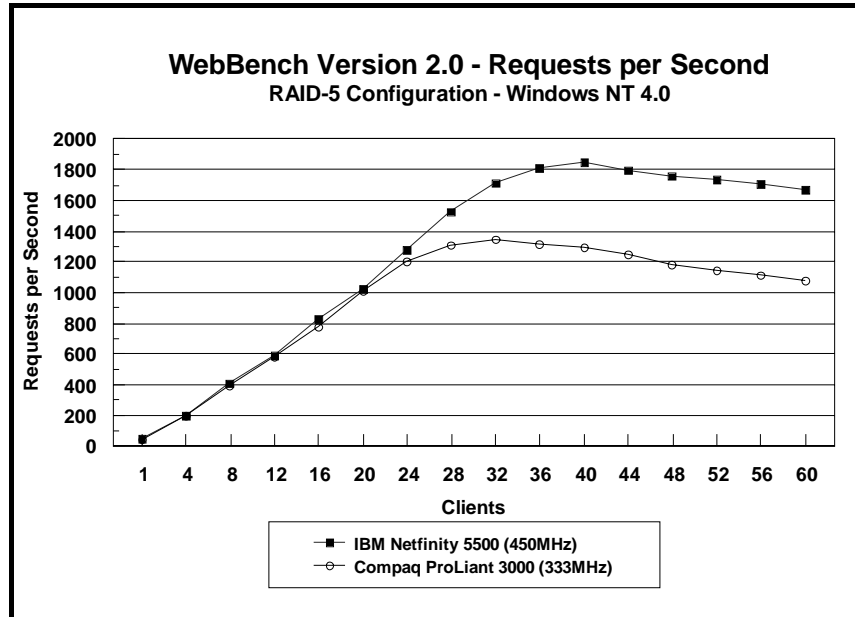
Requests per Second for RAID-0 Configuration

Under the high-end workload of 60 WebBench clients, the IBM Netfinity 5500 serviced **54 percent more requests per second** than the Compaq ProLiant 3000.



Requests per Second for RAID-5 Configuration

Under a high-end workload of 60 clients, the IBM Netfinity 5500 serviced **54 percent more requests per second** than the Compaq ProLiant 3000.



Measurement Methodology

The system test suite was performed using four 100Mbps Ethernet network segments with a total of 60 IBM PC 750 systems as client workstations attached to the server. Two types of transactions are performed:

- Static HTML pages requests, which demonstrates server throughput as each of the 60 clients, simulating an actual Web browser, fetched predesigned HTML pages using the HTTP protocol from the server.
- Dynamic Internet Server API requests, which execute on the server and create the HTML response data, thereby using the server's processing resources.

Each workstation ran Windows NT Workstation 4.0 and executed the WebBench 2.0 NT_SIMPLE_ISAPI20_V20.TST workload, which includes HTML page requests and Internet Server API requests. Each client randomly issued these requests to the Web server according to a workload file that specifies each request a client makes and how frequently the client makes that request. The workload file associates a request percentage with the HTTP and

ISAPI requests. The request percentage tells the client the number of requests it issues during a mix and what the percentage of requests should be for that particular mix. If all clients requested the same file at the same time, the results could be adversely affected; therefore, each client's request access patterns are randomized.

Clients were added incrementally to each mix as follows: 1, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60.

The NT_SIMPLE_ISAPI20_V20.TST test suite contains a total of 16 mixes. Each mix uses 30 seconds as ramp-up time, 30 seconds as ramp-down time, during which periods measurements were not made. Each mix ran for 300 seconds.

After the 16 mixes in the test suite were finished, WebBench created two graphs: one that plots the requests per second against each mix and another that plots the throughput against each mix. Also supplied is the amount of time it took the clients to connect to the server and receive data from the server, and the number of connections per second made by each client.

Measurement Analysis

In a typical two-tier Internet/Intranet environment, the Web browser is usually the user front-end that makes requests to the Web server. The Web server functions either as a large HTML document store directly returning the HTML documents to the browser or as a back-end logic unit building a dynamic HTML document based on calculation of input fields from the Web browser. In a three-tier Internet/Intranet environment, the Web server usually functions as middleware directing Web browser requests to the appropriate business unit (e.g., database) to retrieve information for the user.

WebBench is designed to benchmark a Web server in a two-tier Internet/Intranet environment. In calculating the scores, WebBench counts only completed requests. A completed request consists of four steps:

- The client connects to the server.
- The client issues an HTTP request (either HTML or CGI) to the server.
- The server responds to the request. This response usually results in the server sending to the client an HTML file associated with the URL specified by the client.
- The client disconnects from the server.

In a single mix, the request begins with each client connecting to the server and ends with the client disconnecting from the server,

followed immediately by another repeating the process. The cycle continues until the mix is completed.

To get a valid measure of the server's performance, the requests-per-second and the throughput scores should reach a point where they flatten out. This "flattening out" indicates that the server has been saturated, or fully loaded. In these measurements, adding clients increased the total requests-per-second and throughput scores. The curves increased from 1 to 36 clients, peaked at 40 clients, and then dropped off, indicating that the server had reached its saturation point. Ideally, the curves after the saturation point should remain at the same level where the server's resources (e.g., processor, memory subsystem, disk subsystem) are used optimally. However, due to heavy network traffic and the need to balance each client request load, the curve may dip slightly, reducing the server load.

NetBench 5.01

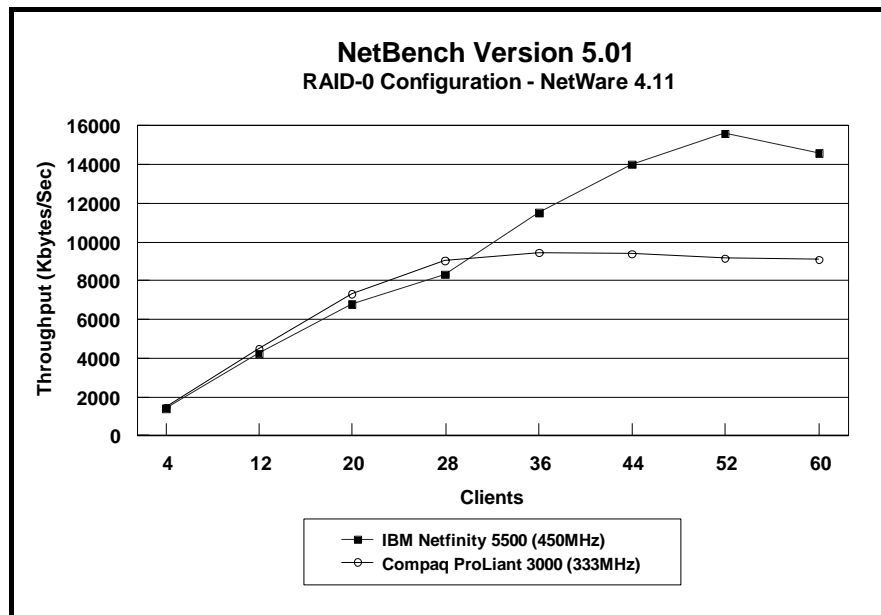
The NetBench 5.01 Disk Mix test suite was used to measure the performance of the IBM Netfinity 5500 (450MHz) and the Compaq ProLiant 3000 (333MHz) systems as single-processor Pentium II-based file servers running Novell NetWare 4.11 with Service Pack IWSP4B. For these measurements, Windows for Workgroups 3.11 clients were used.

The Disk Mix test results are shown as the number of kilobytes (Kbytes) per second obtained by the server under test.

Results Summary

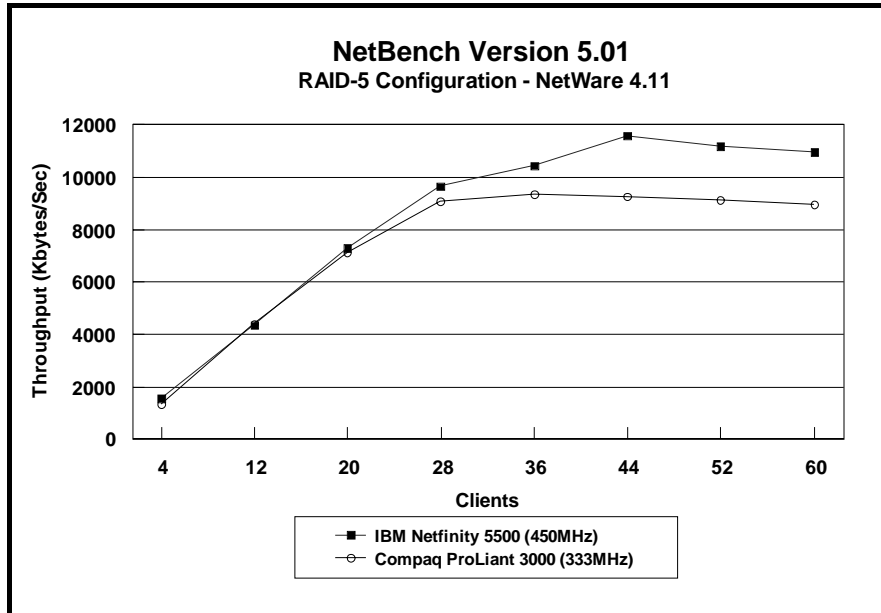
RAID-0 Configuration

Under a high-end workload of 60 NetBench clients, the IBM Netfinity 3000 provided **60 percent more throughput** than the Compaq ProLiant 3000.



RAID-5 Configuration

Under a high-end workload of 60 NetBench clients, the IBM Netfinity 3000 provided **22 percent more throughput** than the Compaq ProLiant 3000.



Measurement Methodology

The Disk Mix test suite was performed using four 100Mbps Ethernet network segments with a total of 60 IBM PC 350 133MHz Pentium-based systems as client workstations attached to the server. Each workstation ran Windows for Workgroups 3.11 and executed the NetBench 5.01 Disk Mix workload, which is based on leading Windows applications.

Each client randomly simulated the Windows for Workgroups application workloads, accessing shared and unshared data files located on the server. Each client used a workspace of 80MB. Clients were added incrementally as follows: 4, 12, 20, 28, 36, 44, 52, 60. Measurements were recorded each time clients were added.

Measurement Analysis

The NetBench 5.01 workload exercises the server in a manner similar to actual Windows applications executing on a networked-attached PC; that is, the NetBench 5.01 Disk Mix emulates the actual I/O operations performed by leading Windows applications, placing a diverse load on the server by using multiple files, different request sizes and different network file operations.

As clients are added to the network, the I/O workload (i.e., the number of I/O requests to the server) increases, requiring more server resources, such as network adapter transfers, processing power, memory and disk operations. Initially, with a small number of clients, server resources are adequate to handle requests. During this time, the server's network adapter becomes the bottleneck.

The Disk Mix test requires each client to have its own directory and also to be able to access the shared directory in the server. As the number of clients increases, any workload involving non-shared data files creates a burden on the disk subsystem. As a result, competition for caching user data in server memory causes the bottleneck to migrate from the network adapter to the disk subsystem.

In addition, when a server's memory buffer space is exhausted, requests are forced to go directly to the disk; therefore, the performance bottleneck quickly migrates from the network adapter to the disk subsystem, resulting in a low, disk cache-hit-ratio. Moreover, if the disk subsystem cannot quickly write "dirty" (updated) data in memory to disk, thereby freeing memory for other I/O requests, memory fills up, creating a disk backlog.

The exact number of clients required to move the bottleneck from the network adapter to the disk subsystem is dependent upon many factors. However, the most significant contributors are the I/O workload, server memory, and server disk subsystem performance. Because the Disk Mix's I/O workload is predefined, server memory and server disk subsystem performance contribute most to the server's disk cache-hit-ratio.

Server hardware can be configured so that the results of the NetBench Disk Mix test highlight the performance of either the server network adapter or the server disk subsystem. For example, if a large amount of memory and a fixed number of 60 simultaneous clients are used, the bottleneck will always be on the server network adapter. If too little memory is used, the bottleneck will most likely occur at the disk subsystem. The ideal measurement configuration should utilize enough memory and simultaneous clients to demonstrate the performance of the server network adapter and the server disk subsystem. This was our goal for the Disk Mix test.

In evaluating the performance results of any measurement, it is important to understand the relationship between the server configuration and the workload generated by the benchmark. We experimented with several configurations. For these servers in this configuration of 60 clients, we found that 128MB of memory optimized the throughput and also stressed the server as the workload increased. The reason is that the 100Mbps network

adapter provided sufficient bandwidth to allow the server's subsystems (i.e., memory, disk and processor complex) to be saturated. This is important because in most production environments, the number of users is dynamic, and the server bottleneck may change several times daily. Showing both the network adapter and disk subsystem bottlenecks provides more useful information about how the server will perform in production environments.

Server Configurations

ServerBench 4.01

RAID Configurations

Features	IBM Netfinity 5500 450MHz/512KB	Compaq ProLiant 3000 333MHz/512KB
Processor	Two 450MHz Pentium II	Two 333MHz Pentium II
Memory	512MB ECC SDRAM	512MB ECC EDO
L2 Cache	512KB (Write-Back)	512KB (Write-Back)
RAID Level	RAID-0 and RAID-5	RAID-0 and RAID-5
Disk Drive	Five IBM 9.1GB ² Wide Ultra SCSI Drives (10K rpm)	Five 4.3GB Wide Ultra SCSI Drives (7200 rpm)
Disk Drive Adapter	ServeRAID II Ultra SCSI PCI Bus on Planar	SMART-2/DH Array Controller
Disk Driver	IPSRAIDN.SYS	CPQARRAY.SYS
Network Adapter	Four IBM EtherJet 100/10 PCI Adapters	Four Netelligent 10/100 TX PCI UTP Controllers
Bus	PCI	PCI
Network Driver	E100BNT.SYS	NETFLX3.SYS
Network Operating System	Windows NT Server 4.0 with Service Pack 3	Windows NT Server 4.0 with Service Pack 3
System Partition Size	1GB	1GB
File System	NTFS	NTFS
Allocation Unit Size	Predefined Default	Predefined Default
ServerBench Version / Test Suite	ServerBench 4.01 / SYS_60.TST	ServerBench 4.01 / SYS_60.TST

WebBench 2.0

RAID Configurations

Features	IBM Netfinity 5500 450MHz/512KB	Compaq ProLiant 3000 333MHz/512KB
Processor	Two 450MHz Pentium II	Two 333MHz Pentium II
Memory	512MB ECC SDRAM	512MB ECC EDO
L2 Cache	512KB (Write-Back)	512KB (Write-Back)
RAID Level	RAID-0 and RAID-5	RAID-0 and RAID-5
Disk Drive	Five IBM 9.1GB Wide Ultra SCSI Drives (10K rpm)	Six 4.3GB Wide Ultra SCSI Drives (7200 rpm)
Disk Drive Adapter	ServeRAID II Ultra SCSI PCI Bus on Planar	SMART-2/DH Array Controller
Disk Driver	IPSRAIDN.SYS	CPQARRAY.SYS
Network Adapter	Four IBM EtherJet 100/10 PCI Adapters	Four Netelligent 10/100 TX PCI UTP Controllers
Bus	PCI	PCI
Network Driver	E100BNT.SYS	NETFLX3.SYS
Network Operating System	Windows NT Server 4.0 with Service Pack 3	Windows NT Server 4.0 with Service Pack 3
System Partition Size	1GB	1GB
File System	NTFS	NTFS
Allocation Unit Size	Predefined Default	Predefined Default
WebBench Version / Test Suite	WebBench 2.0 / NT_SIMPLE_ISAPI20_V20.TST	WebBench 2.0 / NT_SIMPLE_ISAPI20_V20.TST
Web Server	Microsoft Internet Information Server 3.0	Microsoft Internet Information Server 3.0

NetBench 5.01

RAID Configurations

Features	IBM Netfinity 5500 450MHz/512KB	Compaq ProLiant 3000 333MHz/512KB
Processor	One 450MHz Pentium II / Slot 1	One 333MHz Pentium II
Memory	128MB ECC SDRAM	128MB ECC EDO
L2 Cache	512KB (Write-Back)	512KB (Write-Back)
RAID Level	RAID-0 and RAID-5	RAID-0 and RAID-5
Disk Drive	Five IBM 9.1GB Wide Ultra SCSI Drives (10K rpm)	Five 4.3GB Wide Ultra SCSI Drives (7200 rpm)
Disk Drive Adapter	ServeRAID II Ultra SCSI PCI Bus on Planar	SMART-2/DH Array Controller
Disk Driver	IPSRAID.HAM V2.81	CPQDA386.DSK V3.10
Network Adapter	Four IBM EtherJet 100/10 PCI Adapters	Four Netelligent 10/100 TX PCI UTP Controllers
Bus	PCI	PCI
Network Driver	E100B.LAN V3.23	CPQNF3.LAN V2.42
Network Operating System	NetWare 4.11 with IWSP4B Loaded	NetWare 4.11 with IWSP4B Loaded
NetWare Volume Block Size	8KB	16KB
File Compression	Off	Off
Block Allocation	On	On
Data Migration	Off	Off
NetBench Version / Test Suite	NB5.01/Windows for Workgroup Clients/ Disk Mix	NB5.01/Windows for Workgroup Clients/ Disk Mix

Test Disclosure Information

ServerBench 4.01

The ServerBench measurements were conducted using Ziff-Davis' ServerBench 4.01 running the SYS_60.TST test suite with Windows NT Workstation 4.0 as described below:

Version: ServerBench 4.01

Mixes

- System Test Mixes
- Clients: 1, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60
- Data Segment Size: 16MB
- Delay Time: 0
- Think Time: 0
- Ramp up: Default setup
- Ramp down: Default setup

Network Operating System: Windows NT Server 4.0 with Service Pack 3

Testbed Disclosure

The IBM Netfinity 5500 450MHz model is planned to be available September 15, 1998. All other products are shipping versions available to the general public. All measurements were performed without independent verification by Ziff-Davis.

Network	100Mbps Ethernet
Clients	60
Hubs	3COMM 100Mbps Ethernet
Clients per Segment	15
CPU / Memory	166MHz Pentium / 64MB
Network Adapter	IBM 100/10 PCI Ethernet Adapter (Bus 0)
Software	Windows NT 4.0 Workstation
Cache	L2 = 512KB
Controller Software	Microsoft Windows NT Workstation 4.0

WebBench 2.0

The WebBench measurements were conducted using Ziff-Davis' WebBench 2.0 running the NT_SIMPLE_ISAPI20_V20.TST test suite with Windows NT Workstation 4.0 clients as described below:

Version: WebBench 2.0

Mixes

- NT_SIMPLE_ISAPI20_V20.TST
- Clients: 1, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60
- Ramp up: 30 seconds
- Ramp down: 30 seconds
- Length: 300 seconds
- Think: 0 seconds
- Delay: 0 seconds
- Threads per client: 1
- Receive buffer size: 4KB
- Keep-alive: Off
- Web Server: Logon Disabled

Network Operating System: Windows NT Server 4.0 with Service Pack 3

Web Server: Microsoft Internet Information Server 3.0

Testbed Disclosure

The IBM Netfinity 5500 450MHz model is planned to be available September 15, 1998. All other products are shipping versions available to the general public. All measurements were performed without independent verification by Ziff-Davis.

Network	100Mbps Ethernet
Clients	60
Hubs	Asante 100Mbps Ethernet
Clients per Segment	15
CPU / Memory	166MHz Pentium / 32MB
Network Adapter	IBM 100/10 PCI Ethernet Adapter (Bus 0)
Software	Microsoft Windows NT Workstation 4.0
Cache	L2 = 512KB
Controller Software	Windows NT Workstation 4.0

NetBench 5.01

The NetBench measurements were conducted using Ziff-Davis' NetBench 5.01 running the Disk Mix with Windows for Workgroups clients as described below:

Version: NetBench 5.01

Mixes

- Disk Mix
- Clients: 4, 12, 20, 28, 36, 44, 52, 60
- Client workspace: 80MB
- Total runtime: 11 minutes
- Ramp up and down: 30 seconds

Network Operating System: NetWare 4.11 with IWSP4B loaded

NOS Parameters

- Immediate Purge of Deleted Files = ON
- Enable Disk Read after Write Verify = OFF
- Minimum Packet Receive Buffers = 700
- Maximum Packet Receive Buffers = 1400
- Set NCP Packet Signature Option = 0
- Maximum Physical Receive Packet Size = 1514
- Reserved Buffer Below 16MB = 200
- Maximum Service Processes = 70
- Maximum Concurrent Directory Cache Write = 100
- Dirty Directory Cache Delay Time = 10
- Maximum Concurrent Disk Cache Write = 100
- Maximum Directory Cache Buffers = 700
- Minimum Directory Cache Buffers = 150
- Minimum File Cache Buffers = 150
- Maximum Number of Directory Handles = 30
- Dirty Disk Cache Delay Time = 5
- Directory Cache Buffer Non-Referenced Delay = 30
- Directory Cache Allocation Wait Time = 2.2 seconds

If clients drop out, set the following:

- Number of Watchdog Packets = 50
- Delay Between Watchdog Packets = 10 minutes
- Delay Before First Watchdog Packet = 20 minutes

To monitor the dropping out of clients, set:

- Console Display Watchdog Logouts = On

Testbed Disclosure

The IBM Netfinity 5500 450MHz model is planned to be available September 15, 1998. All other products used for these measurements are shipping versions available to the general public. All measurements were performed without independent verification by Ziff-Davis.

Network	100Mbps Ethernet
Clients	60
Hubs	Asante 100Mbps Ethernet
Clients per Segment	15
CPU / Memory	133MHz Pentium / 16MB
Network Adapter	IBM 100/10 PCI Ethernet Adapter (Bus 0)
Software	IBM DOS 6.3/Microsoft Windows for Workgroups 3.11
	NetWare DOS Requester
	LSL.COM (8-3-95)
	E100BODI (5-21-96)
	IPXODI (8-8-95)
	VLM.EXE (11-8-94)
Cache	L2 = 256KB
Controller Software	PC-DOS Version 6.3 Microsoft Windows for Workgroups 3.11

Clients NET.CFG

- Checksum = 0
- Large Internet Packet = On
- PB Buffers = 10
- PBurst Read Windows Size = 64
- PBurst Write Windows Size = 64
- Cache Buffers = 64

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Notes

¹ MHz denotes the internal/external clock speed of the microprocessor only, not application performance. Many factors affect application performance.

² When referring to hard disk capacity, GB, or gigabyte, means one thousand million bytes. Total user-accessible capacity may vary depending on operating environment.