VeriTest®

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1001 Aviation Parkway, Suite 400 • Morrisville, NC 27560 • 919-380-2800 • Fax 919-380-2899
320 B Lakeside Drive • Foster City, CA 94404 • 650-513-8000• Fax 650-513-8099
www.veritest.com • info@veritest.com

Windows Server 2003 File Server, Web Server, and Active Directory Performance Testing

Test report prepared under contract from Microsoft

Executive summary

Microsoft commissioned VeriTest, a division of Lionbridge Technologies, Inc., to conduct a series of tests comparing the Web and File serving performance of the following Microsoft server operating system configurations running on a variety of server hardware and processor configurations:

- Windows Server 2003 Enterprise Edition RC2 (subsequently referred to as Windows Server 2003 in the remainder of this report)
- Windows 2000 Advanced Server/Service Pack 3
- Windows NT 4.0 Server, Enterprise Edition with Service Pack 6a and applicable hot fixes

Key findings

- Windows Server 2003 delivered significantly better File and Web server performance compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition under all test scenarios.
- In our static Web Server performance testing using eight processors, Windows Server 2003 delivered 487 percent better performance compared to Windows NT 4.0 Enterprise Edition and 355 percent better performance compared to Windows 2000 Advanced Server.
- In our File Server performance testing using eight processors, Windows Server 2003 delivered 148 percent better performance compared to Windows NT 4.0 Enterprise Edition and 84 percent better performance compared to Windows 2000 Advanced Server.
- In our Active Directory performance testing using eight processors, Windows Server 2003 delivered 439 percent better performance compared to Windows 2000 Advanced Server using the messaging mix and 1786 percent (18.9x) better performance compared to Windows 2000 Advanced Server using the addressing mix.

Additionally, we conducted a series of Directory server performance tests against Active Directory using the DirectoryMark 1.2 benchmarking software from Mindcraft on the following Microsoft server operating system configurations running on an HP DL760 server utilizing multiple processor configurations:

- Windows Server 2003
- Windows 2000 Advanced Server/Service Pack 3

For these tests, Hewlett Packard supplied three server systems as follows:

- HP ProLiant DL760 server configured with four 900MHz Pentium III Xeon processors, 4GB of RAM and four Intel PRO/1000 MF Server Adapters.

- HP ProLiant DL760 server configured with eight 900MHz Pentium III Xeon processors, 4GB of RAM and eight Intel PRO/1000 MF Server Adapters.
- HP ProLiant DL380 G2 server configured with two 1.4GHz Pentium III processors, 2GB of RAM and two Intel PRO/1000 MF Server Adapters.

Please refer to the Test Methodology section and Appendix A for complete details regarding the server systems used for these tests.

For the Web server performance tests, we used Ziff Davis Media's WebBench 4.1 benchmarking software. WebBench measures Web server performance by using large numbers of physical test clients to generate an HTTP based workload against a Web server under test. These test clients make a series of HTTP 1.0 requests for different combinations of static and dynamic based content. As the Web server under test responds to the client requests, each WebBench client records the number of HTTP requests made and the amount of data moved during the test. Once a test completes, WebBench reports test results in Requests Per Second and throughput in bytes per second.

The Web server performance testing consisted of executing a number of tests using a variety of standard and customized WebBench test suites against each server described above configured with each of the operating systems described above using the following processor combinations:

- DL380 server configured with 2 processors
- DL760 servers configured with 1, 2, 4 and 8 processors.

The following list describes the different types of tests we performed to measure Web server performance. Each item in the list describes a specific combination of content requested from the Web server.

- Static test suite requesting 100 percent static content
- Combination of 80 percent static content and 20 percent CGI-based dynamic content
- Combination of 80 percent static content and 20 percent ISAPI-based dynamic content
- Combination of 76 percent static content, 16 percent CGI-based dynamic content and 8 percent Secure Socket Layer (SSL) 3.0 based static and CGI-based dynamic content
- Combination of 76 percent static content, 16 percent ISAPI-based dynamic content and 8 percent Secure Socket Layer (SSL) 3.0 based static and ISAPI-based dynamic content

Please refer to the Test Methodology section for complete details of the WebBench test suites used during the testing and how we conducted the Web server performance tests.

For the File Server performance tests we used Ziff Davis Media's NetBench 7.02 benchmarking software. Like WebBench, NetBench uses large numbers of physical test clients to generate a file I/O based workload against a file server under test. These test clients make network based file requests to a file server and then record the amount of data moved during the test as a measure of the overall throughput capabilities of the file server. Additionally, the test clients record and generate a measure of overall average response time for the file server as it responded to the various file I/O requests made by the test clients.

The File server performance testing consisted of executing a variety of standard and customized NetBench test suites against each server described above configured with each of the operating systems described above using the following processor combinations.

- DL380 server configured with 2 processors
- DL760 server configured with 1, 2, 4 and 8 processors.

Please refer to the Test Methodology and Test Results sections for complete details of the NetBench test suites used during the testing, how we conducted the File server performance tests and complete NetBench test results.

For the Active Directory Server performance testing, we used DirectoryMark 1.2 from Mindcraft (www.mindcraft.com/directorymark). DirectoryMark is a benchmark that measures the performance of Lightweight Directory Access Protocol (LDAP) server implementations like Active Directory. DirectoryMark simulates a number of clients performing LDAP transactions against the LDAP server under test. DirectoryMark measures latency and throughput for a number of common LDAP operations.

For the Directory Services performance testing, we executed separate DirectoryMark Messaging and Addressing test mixes. The Messaging test mix simulates an e-mail server using a directory server. The Addressing test mix simulates people looking up names in an address book as well as expanding a group for e-mail.

Please refer to the Test Methodology and Test Results sections for complete details of the DirectoryMark test mixes used during the testing, how we conducted the Directory server performance tests and complete DirectoryMark test results.

Web Server Performance Test Results

This section summarizes the Web server performance results. The charts below display the peak requests per second values generated during each type of Web server performance test. Please refer to the Test Methodology section of this report for complete details on the WebBench test suites used to generate these test results.

Static Content Results

We conducted these tests by configuring the WebBench test clients to make 100 percent of their requests for static content. Figure 1 shows the peak static request per second values generated on both the DL380 and DL760 servers using all operating system and processor combinations. We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak Web serving performance using static content compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

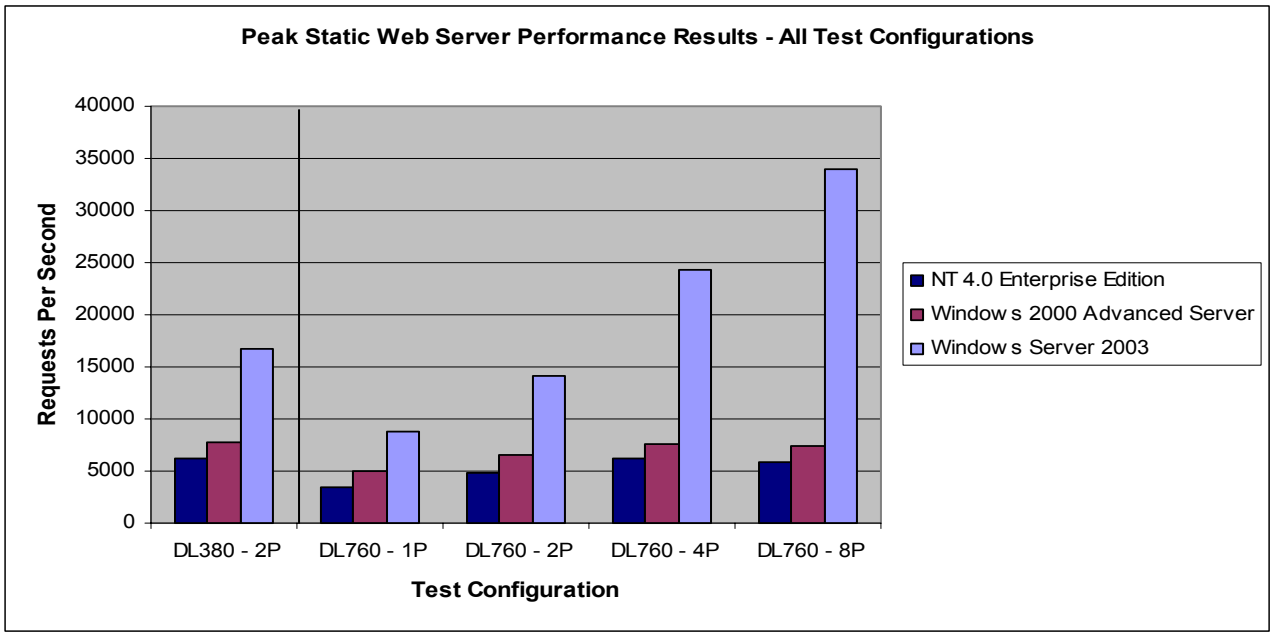

Figure 1. Peak Static Web Server Performance On All Test Configurations

Figure 2 below shows the actual peak WebBench static Web server performance results in requests per second generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 2 shows the percentage improvement in Static Web server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant performance improvements are possible when serving static Web content when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that the performance of Windows Server 2003 scales significantly better than Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition as additional processors are added.

Operating System	DL380 - 2P Req/Sec	DL760 -1P Req/Sec	DL760 - 2P Req/Sec	DL760-4P Req/Sec	DL760-8P Req/Sec
Windows Server 2003	16783	8861	14214	24293	33991
Windows 2000 Advanced Server	7691	4923	6557	7670	7466
NT 4.0 Enterprise Edition	6270	3386	4788	6138	5786
Percent Improvement vs. NT 4.0 Enterprise Edition	168%	162%	197%	296%	487%
Percent Improvement vs. Windows 2000 Advanced Server	118%	80%	117%	217%	355%

Figure 2. Peak Static Web Server Performance and Percentage Improvement of Windows Server 2003 in Static Web Server Performance Data On All Test Configurations

Dynamic Content Performance Test Results

This section describes the test results generated with the WebBench test suites utilizing ISAPI and CGI based dynamic content.

ISAPI-based Content Test Results

We conducted these tests by configuring the WebBench test clients to make 80 percent of their requests for static content and the remaining 20 percent for a simple ISAPI-based module. Figure 3 shows the peak request per second values generated on both the DL380 and DL760 server using all operating system and processor combinations.

We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak Web serving performance using the ISAPI-based content compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

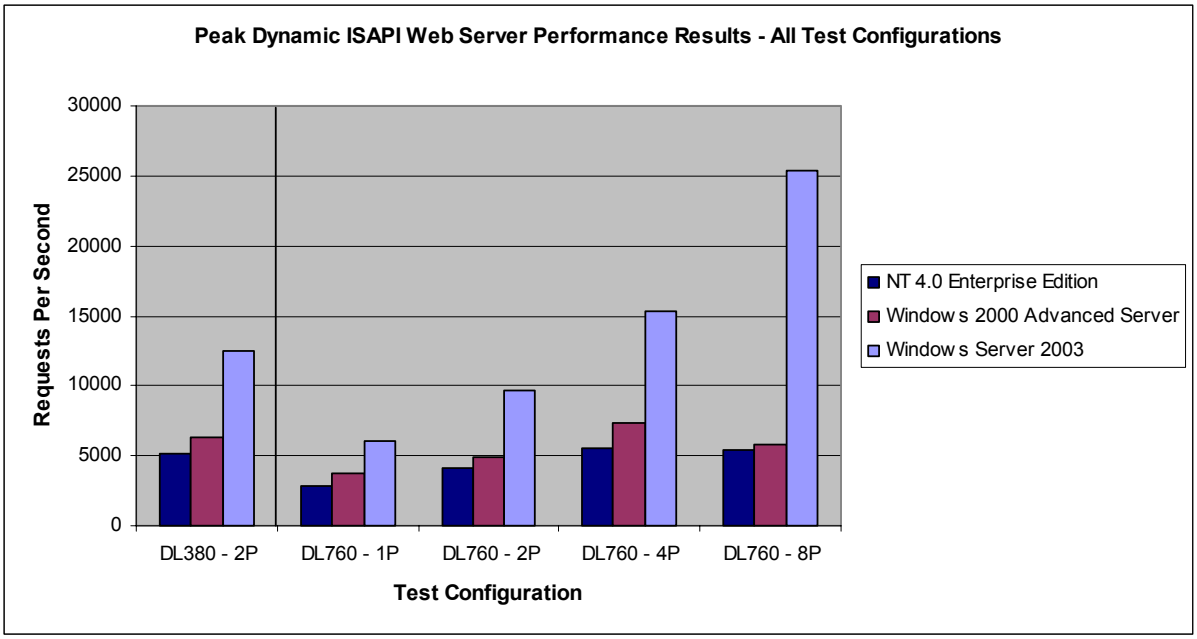

Figure 3. Peak Dynamic ISAPI-based Web Server Performance On All Test Configurations

Figure 4 below shows the actual peak WebBench ISAPI Web server performance results in requests per second generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 4 shows the percentage improvement in ISAPI-based Web server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant performance improvements are possible when serving a combination of static and ISAPI-based Web content when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that significant performance improvements are possible when adding additional processor resources to a Web server running Windows Server 2003 serving a combination of static and ISAPI-based Web content.

Operating System	DL380 - 2P Req/Sec	DL760 -1P Req/Sec	DL760 - 2P Req/Sec	DL760-4P Req/Sec	DL760-8P Req/Sec
Windows Server 2003	12551	6054	9685	15270	25329
Windows 2000 Advanced Server	6296	3701	4901	7285	5855
NT 4.0 Enterprise Edition	5178	2890	4137	5525	5417
Percent Improvement vs. NT 4.0 Enterprise Edition	142%	109%	134%	176%	368%
Percent Improvement vs. Windows 2000 Advanced Server	99%	64%	98%	110%	333%

Figure 4. Peak Dynamic ISAPI Web Server Performance and Percentage Improvement of Windows Server 2003 in ISAPI Web Server Performance Data On All Test Configurations

CGI-based Content Results

We conducted these tests by configuring the WebBench test clients to make 80 percent of their requests for static content and 20 percent for a simple CGI executable. Figure 5 shows the peak request per second values generated on both the DL380 and DL760 server using all operating system and processor combinations we tested.

We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak Web serving performance using the CGI-based content compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

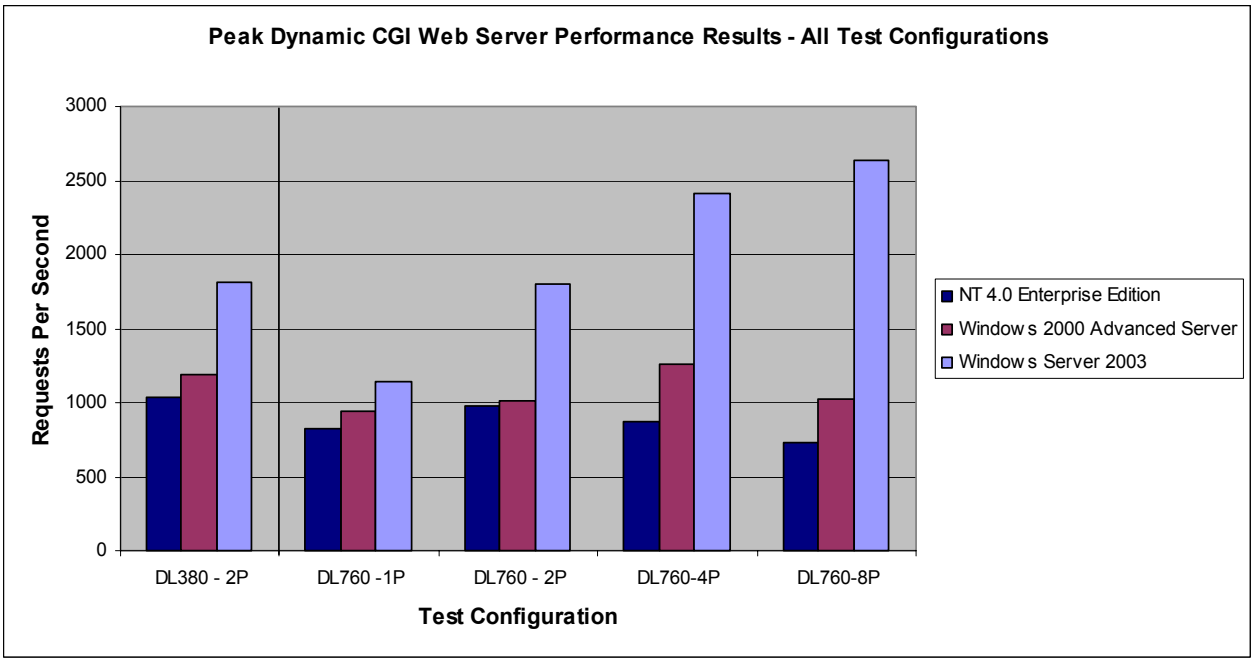

Figure 5. Peak Dynamic CGI-based Web Server Performance On All Test Configurations

Figure 6 below shows the actual peak WebBench CGI Web server performance results in requests per second generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 6 shows the percentage improvement in CGI-based Web server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant performance improvements are possible when serving a combination of static and CGI-based Web content when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that significant performance improvements are possible when adding additional processor resources to a Web server running Windows Server 2003 serving a combination of static and CGI-based Web content.

Operating System	DL380 - 2P Req/Sec	DL760 -1P Req/Sec	DL760 - 2P Req/Sec	DL760-4P Req/Sec	DL760-8P Req/Sec
Windows Server 2003	1814	1140	1805	2413	2639
Windows 2000 Advanced Server	1187	942	1013	1262	1018
NT 4.0 Enterprise Edition	1033	819	980	876	727
Percent Improvement vs. NT 4.0 Enterprise Edition	76%	39%	84%	175%	263%
Percent Improvement vs. Windows 2000 Advanced Server	53%	21%	78%	91%	159%

Figure 6. Peak Dynamic CGI Web Server Performance and Percentage Improvement of Windows Server 2003 in CGI Web Server Performance Data On All Test Configurations

E-Commerce Performance Test Results

This section describes the test results generated with the WebBench test suites utilizing ISAPI and CGI based dynamic content and the Secure Socket Layer (SSL) 3.0 protocol.

SSL/ISAPI-based Content Results

We conducted these tests by configuring the WebBench test clients to make 76 percent of their requests for static content, 16 percent for a simple ISAPI module and the remaining 8 percent for static and ISAPI content using SSL3.0 for secure Web server communications. Figure 7 shows the peak request per second values generated on both the DL380 and DL760 server using all operating system and processor combinations we tested. There are no test results for the SSL/ISAPI content for NT 4.0 Server Enterprise Edition on the DL760 running eight processors. Each time we attempted this test, IIS 4.0 generated an exception and the test halted.

We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak Web serving performance using the SSL/ISAPI-based content compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

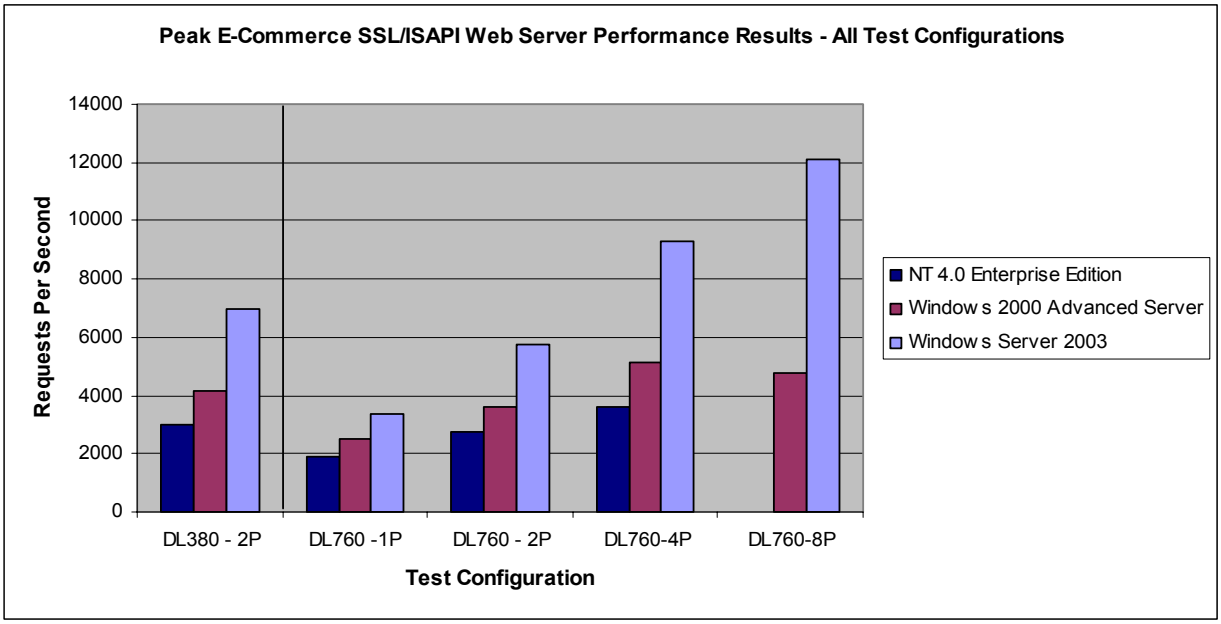

Figure 7. Peak E-commerce SSL/ISAPI-based Web Server Performance On All Test Configurations

Figure 8 below shows the actual peak WebBench SSL/ISAPI Web server performance results in requests per second generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 8 shows the percentage improvement in SSL/ISAPI-based Web server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant performance improvements are possible when serving a combination of static and SSL/ISAPI-based Web content when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that significant performance improvements are possible when adding additional processor resources to a Web server running Windows Server 2003 serving a combination of static and SSL/ISAPI-based Web content.

Operating System	DL380 - 2P Req/Sec	DL760 -1P Req/Sec	DL760 - 2P Req/Sec	DL760-4P Req/Sec	DL760-8P Req/Sec
Windows Server 2003	6999	3338	5768	9285	12079
Windows 2000 Advanced Server	4152	2482	3593	5127	4795
NT 4.0 Enterprise Edition	2997	1915	2747	3596	N/A
Percent Improvement vs. NT 4.0 Enterprise Edition	134%	74%	110%	158%	N/A
Percent Improvement vs. Windows 2000 Advanced Server	69%	34%	61%	81%	152%

Figure 8. Peak E-Commerce SSL/ISAPI Web Server Performance and Percentage Improvement of Windows Server 2003 in SSL/ISAPI Web Server Performance Data On All Test Configurations

SSL/CGI-based Content Results

We conducted these tests by configuring the WebBench test clients to make 76 percent of their requests for static content, 16 percent for a simple CGI executable and the remaining 8 percent for static and CGI-based content using SSL 3.0 for secure Web server communications. Figure 9 shows the peak request per second values generated on both the DL380 and DL760 server using all operating system and processor combinations we tested.

We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak Web serving performance using the SSL/CGI-based content compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

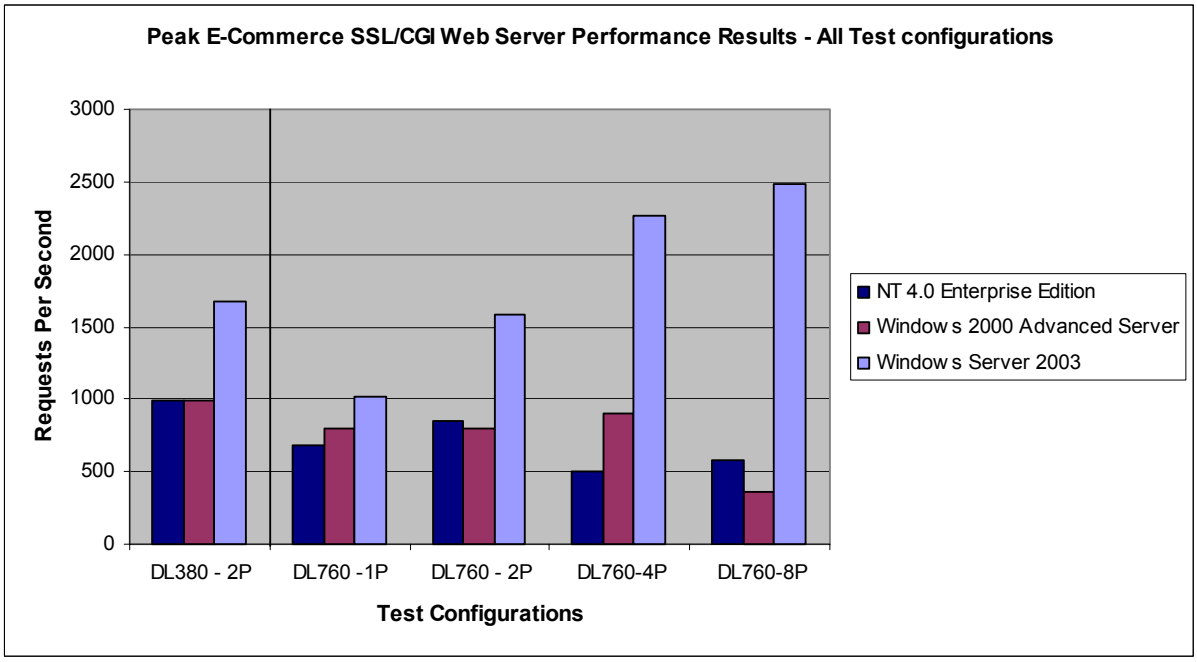

Figure 9. Peak E-Commerce SSL/CGI-based Web Server Performance On All Test Configurations

Figure 10 below shows the actual peak WebBench CGI Web server performance results in requests per second generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 10 shows the percentage improvement in CGI-based Web server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant performance improvements are possible when serving a combination of static and SSL/CGI-based Web content when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that significant performance improvements are possible when adding additional processor resources to a Web server running Windows Server 2003 serving a combination of static and SSL/CGI-based Web content.

Operating System	DL380 - 2P Req/Sec	DL760 -1P Req/Sec	DL760 - 2P Req/Sec	DL760-4P Req/Sec	DL760-8P Req/Sec
Windows Server 2003	1668	1020	1580	2268	2480
Windows 2000 Advanced Server	988	796	804	906	361
NT 4.0 Enterprise Edition	989	682	852	505	577
Percent Improvement vs. NT 4.0 Enterprise Edition	69%	50%	85%	349%	330%
Percent Improvement vs. Windows 2000 Advanced Server	69%	28%	97%	150%	587%

Figure 10. Peak E-Commerce SSL/CGI Web Server Performance and Percentage Improvement of Windows Server 2003 in SSL/CGI Web Server Performance Data On All Test Configurations

File Server Performance Test Results

This section summarizes the File server performance results. The charts below display the peak throughput values generated during each type of File server performance testing in megabits per second (Mbps). Please refer to the Test Methodology section of this report for complete details on the NetBench test suites used to generate these test results. Refer to Test Results section for complete test results.

Figure 11 shows the peak throughput values generated on both the DL380 and DL760 server using all operating system and processor combinations we tested. In addition to the tests we conducted using Intel PRO/1000 MF Server Adapters, we also conducted a set of file server performance tests using Windows Server 2003 after configuring the DL760 server containing eight processors with a set of eight Alacritech gigabit network adapters that provided TCP Offload Engine (TOE) technology. This technology allows the normal TCP related activity normally processed by software to be off-loaded to the network adapter where it is processed by specialized hardware. This allows improved overall performance.

We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak File serving performance compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition. Additionally, we found that using the Alacritech network adapters resulted in a performance improvement of approximately 26 percent compared to using the Intel PRO/1000 MF Server Adapters.

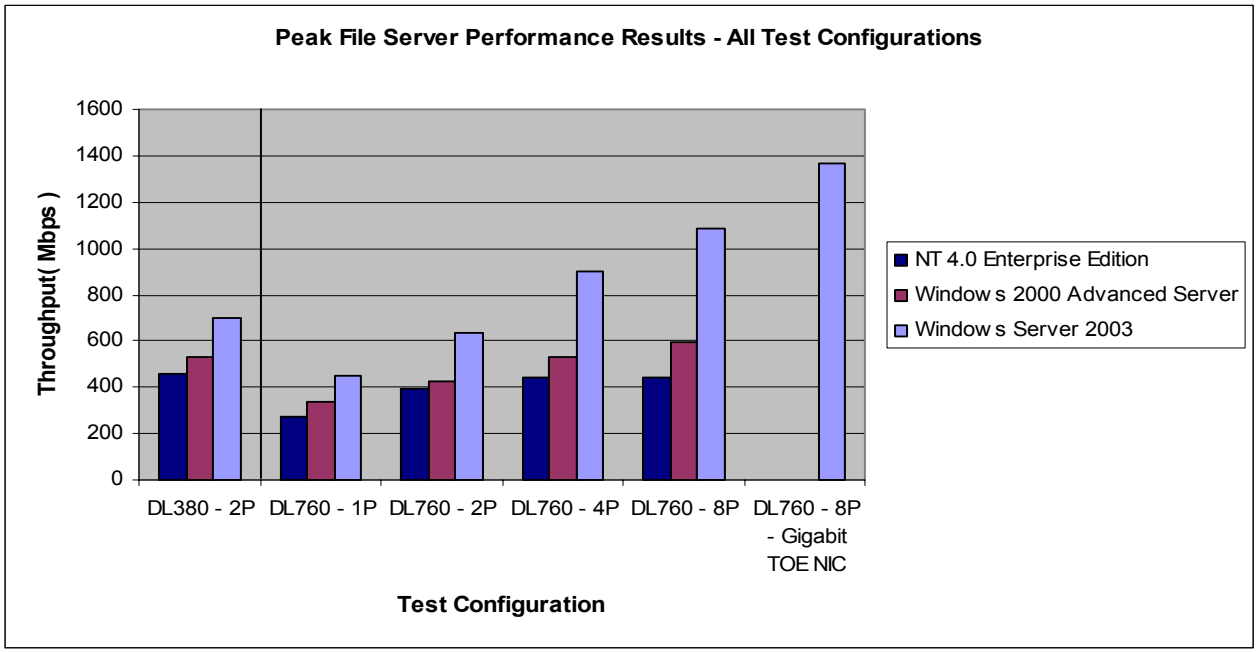

Figure 11. Peak File Server Performance On All Test Configurations

Figure 12 below shows the actual peak File server performance throughput results in megabits per second (Mbps) generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 12 shows the percentage improvement in File server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant file serving performance improvements are possible when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that significant file serving performance improvements are possible when adding additional processor resources to a server running Windows Server 2003.
We did not conduct tests using the Alacritech network adapters on Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition.

Operating System	DL380 - 2P (Mbps)	DL760 - 1P (Mbps)	DL760 – 2P (Mbps)	DL760- 4P (Mbps)	DL760- 8P (Mbps)	DL760 - 8P GB TOE NIC (Mbps)
Windows Server 2003	700	453	632	901	1088	1370
Windows 2000 Advanced Server	532	336	427	533	591	N/A
NT 4.0 Enterprise Edition	457	277	397	446	439	N/A
Percent Improvement vs. NT 4.0 Enterprise Edition	53%	64%	59%	102%	148%	N/A
Percent Improvement vs. Windows 2000 Advanced Server	32%	35%	48%	69%	84%	N/A

Figure 12. Peak File Server Performance and Percentage Improvement of Windows Server 2003 in File Server Performance On All Test Configurations

Directory Server Performance Testing Results

This section summarizes the Directory server performance results generated using DirectoryMark 1.2. Please refer to the Test Methodology section of this report for complete details on the DirectoryMark test mixes used to generate these test results. Refer to Test Results section for complete test results.

Figure 13 below shows the results of the DirectoryMark Messaging test mix for both Windows Server 2003 and Windows 2000 Advanced Server using all tested processor combinations. We found that Windows Server 2003 generated significantly better performance compared to Windows 2000 Advanced Server when testing with the Messaging Mix.

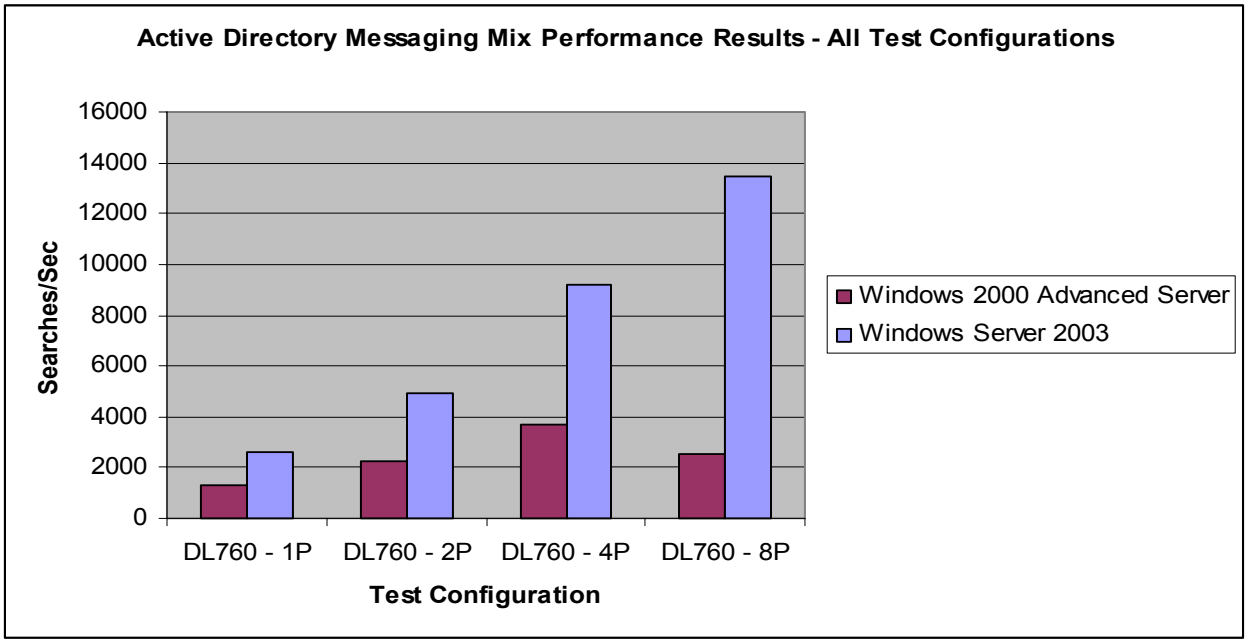

Figure 13. Active Directory Messaging Mix Performance Results – All Test Configurations

Figure 14 below shows the actual results of the DirectoryMark Messaging test mix for both Windows Server 2003 and Windows 2000 Advanced Server using all tested processor combinations. Additionally, figure 14 shows the percentage increase in searches/sec using Windows Server 2003 compared to Windows 2000 Advanced Server. In all test configurations Windows Server 2003 generated a minimum of 100 percent better performance compared to Windows 2000 Advanced Server and, when using eight processors, generated 439 percent better performance using the Messaging Mix compared to Windows 2000 Advanced Server.

Operating System	DL760 - 1P	DL760 - 2P	DL760 - 4P	DL760 - 8P
Windows Server 2003 (searches/sec)	2637	4889	9159	13482
Windows 2000 Advanced Server (searches/sec)	1307	2268	3677	2501
Percent Increase in Searches/Sec using Windows Server 2003	102%	116%	149%	439%

Figure 14. Directory Server Performance Test Results – Messaging Test

Figure 15 below shows the results of the DirectoryMark Addressing test mix for both Windows Server 2003 and Windows 2000 Advanced Server using all tested processor combinations. We found that Windows Server 2003 generated significantly better performance compared to Windows 2000 Advanced Server when testing with the Addressing Mix.

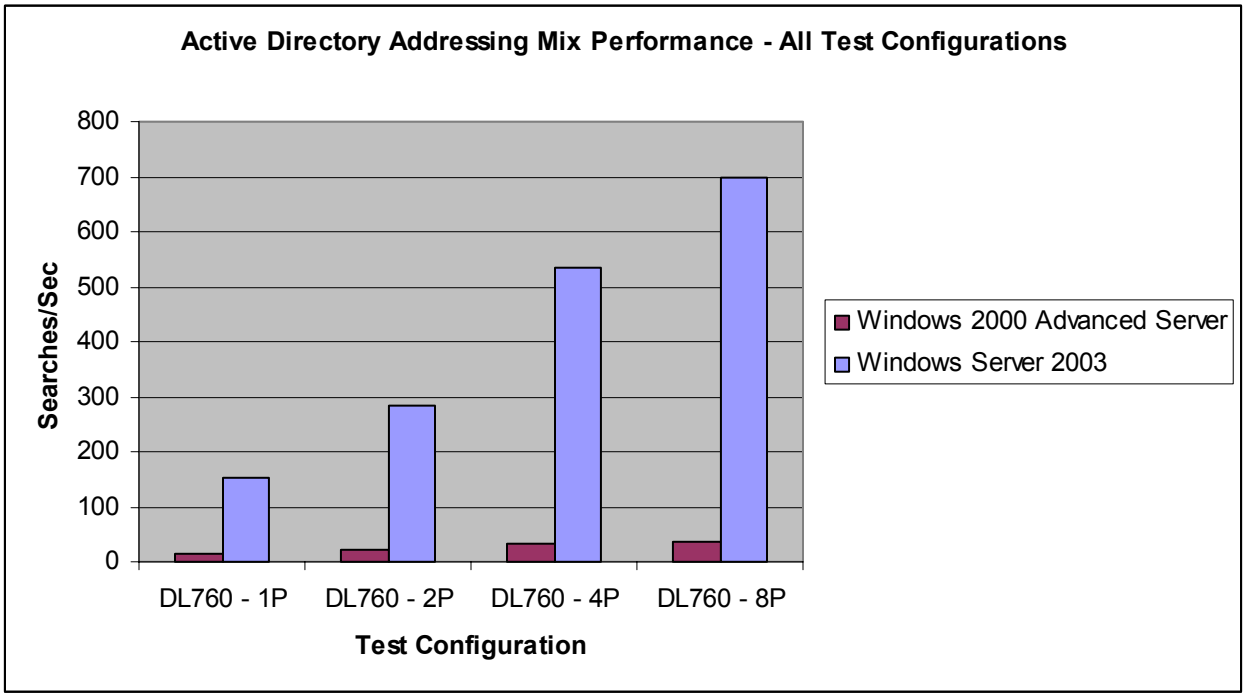

Figure 15. Active Directory Addressing Mix Performance – All Test Configurations

Figure 16 below shows the actual results of the DirectoryMark Addressing test mix for both Windows Server 2003 and Windows 2000 Advanced Server using all tested processor combinations. In all test configurations Windows Server 2003 generated a minimum of 926 percent (10.3x) better performance compared to Windows 2000 Advanced Server and, when using eight processors, generated 1786 percent (18.9x) better performance using the Addressing Mix compared to Windows 2000 Advanced Server SP3.

Operating System	DL760 - 1P	DL760 - 2P	DL760 - 4P	DL760 - 8P
Windows Server 2003 (searches/sec)	154	284	534	698
Windows 2000 Advanced Server (searches/sec)	15	22	32	37
Percent Increase in Searches/Sec using Windows Server 2003	926% (10.3x)	1190% (12.9x)	1569% (16.7x)	1786% (18.9x)

Figure 16. Directory Server Performance Test Results – Addressing Test

Testing methodology

Microsoft commissioned VeriTest, a division of Lionbridge Technologies, Inc., to conduct a series of tests comparing the Web and File serving performance of the following server operating system configurations running on a variety of server hardware and processor configurations:

- Windows Server 2003 Enterprise Edition Release Candidate 2(RC2)
- Windows 2000 Advanced Server and Service Pack 3
- Windows NT 4.0 Server, Enterprise Edition with Service Pack 6a and applicable hot fixes

Hewlett-Packard supplied the server hardware for these tests. Specifically, we used the following systems:

- HP ProLiant DL760 G2 server configured with four 900MHz Pentium III Xeon processors, 4GB of RAM and four Intel PRO/1000 MF Server Adapters. This system contained an embedded SmartArray 5i RAID controller connected to four 36.4GB 15,000RPM Ultra3 SCSI disk drives. Additionally, we installed a second RAID subsystem consisting of a total of 28 18.2GB 15,000 RPM Ultra3 SCSI disk drives connected to a SmartArray 5300 RAID controller.

- HP ProLiant DL760 G2 server configured with eight 900MHz Pentium III Xeon processors, 4GB of RAM and eight Intel PRO/1000 MF Server Adapters. This system contained an embedded SmartArray 5i RAID controller connected to four 36.4GB 15,000RPM Ultra3 SCSI disk drives. Additionally, we installed a second RAID subsystem consisting of a total of 28 18.2GB 15,000 RPM Ultra3 SCSI disk drives connected to a SmartArray 5300 RAID controller.

- HP ProLiant DL380 G2 server configured with two 1.4GHz Pentium III processors, 2GB of RAM and two Intel PRO/1000 MF Server Adapters. This system contained an embedded SmartArray 5i RAID controller connected to six 36.4GB 15,000RPM Ultra3 SCSI disk drives.

VeriTest provided the network test client hardware for these tests. Specifically, we used the following systems:

- 240 client systems configured with a single 850Mhz Pentium III processor, 256MB of RAM, 10GB IDE hard drive and single 100 Mbps Ethernet adapter.

Test Network Configuration

For both the File and Web server performance tests, we created two distinct test networks each using 120 physical clients. We connected the first 120-node network to the DL760 server containing four processors and four network adapters. We connected all 120 clients through four Extreme Summit48 switches (30 clients per switch) using 100 Mbps, full duplex connections. We configured the 120 clients into four distinct subnets each containing 30 clients. We used the Gigabit connections on the Summit48 switch to connect each subnet of 30 clients to one of the four Intel PRO/1000 MF Gigabit Server Adapters installed in the DL760 server.

We connected the second 120-node network to the DL760 server containing eight processors and eight network adapters. We connected all 120 clients through four Extreme Summit48 switches (30 clients per switch) using 100 Mbps, full duplex connections. We configured the 120 clients into eight distinct subnets each containing 15 clients. We used the Gigabit connections on the Summit48 switch to connect each subnet of 15 clients to one of the eight Intel PRO/1000 MF Gigabit Server Adapters installed in the DL760 server.

Because the DL380 server contained only two network adapters, we used two of the 30-client network segments configured in the first 120-client network described above for all tests involving the DL380 server. We connected each 30-client network segment through a separate Extreme Summit48 switch using 100 Mbps, full duplex connections. We used the Gigabit connections on each Summit48 switch to connect each

subnet of 30 clients to one of the two Intel PRO/1000 MF Gigabit Server Adapters installed in the DL380 server.

For the Directory server performance testing, we disabled all but one of the Intel PRO/1000 MF Gigabit Server Adapters in both the HP DL760 servers. We then connected both of the HP DL760 servers used for this testing through an Extreme Summit48 switch using 1GBps, full duplex connections.

Please refer to Appendix D of this report for visual representations of the network configurations used for these tests.

Web Server Performance Testing

For the Web server performance tests, we used Ziff Davis Media's WebBench 4.1 benchmarking software. WebBench measures Web server performance by using large numbers of physical test clients to generate an HTTP based workload against a Web server under test. These test clients make a series of HTTP 1.0 requests for different combinations of static and dynamic based content. As the Web server under test responds to the client requests, each client records the number of HTTP requests made and the amount of data moved during the test. Once a test completes, WebBench reports test results in requests per second and throughput in bytes per second.

Web servers are generally capable of handling HTTP requests for both static and dynamically generated content using both secure and unsecure connections. The Web server performance testing consisted of executing a total of six distinct test suites against each server described above specifically requesting the following combinations of static and dynamic content:

- Static test suite requesting 100 percent static content
- Combination of 80 percent static content and 20 percent CGI-based dynamic content
- Combination of 80 percent static content and 20 percent ISAPI-based dynamic content
- Combination of 76 percent static content, 16 percent CGI-based dynamic content and 8 percent Secure Socket Layer (SSL) based static and CGI-based dynamic content
- Combination of 76 percent static content, 16 percent ISAPI-based dynamic content and 8 percent Secure Socket Layer (SSL) based static and ISAPI-based dynamic content

To test the DL380 system, we used the standard WebBench 4.1 static and dynamic test suites to generate the loads described above. The standard WebBench test suites use a total of 60 physical clients. Each test suite starts using a single load generating client and slowly increases the load on the Web server by adding test clients in increments of four until a total of 60 clients have participated in the test. Each of the standard test suites described above started one WebBench engine running one thread to generate the load during the test.

Because the DL760 systems contained more memory and processing power compared to the DL380 system, we created a new set of test suites using the workloads from the standard test suites to test the DL760 systems. Like the standard test suites, these new test suites started with a single test client but increased the load on the Web server by adding test clients in groups of eight until a total of 120 clients had participated in the test. These new test suites used identical workloads compared to standard test suites, but were designed to put roughly twice the load on the server compared to the standard test suites. Like the standard WebBench test suites, each of the new test suites created to test the DL760 systems starts one WebBench engine running one thread on each physical test client to generate the load during the test.

The Web server performance testing consisted of running the test suites described above against the DL760 servers using 1, 2, 4 and 8 processor configurations running each of the operating systems described. Additionally, we ran each of the six standard test suites described above against the DL380 server using a two-processor configuration. When testing the DL760 servers, we modified the boot.ini file on the DL760 server containing four processors and four network segments to allow us to start the server using 1, 2, or 4 processors. For the one processor testing on the DL760 server, we loaded the appropriate uni-processor kernel and hardware abstraction library (HAL) for each operating system tested. We used the uni-processor

kernel and HAL for NT 4.0 Server Enterprise Edition found on the Service Pack 6a CD. We used the uni-processor kernel and HAL for Windows 2000 Advanced Server found on the Service Pack 3 CD. We used the uni-processor kernel and HAL for Windows Server 2003 found on the Windows Server 2003 media sent by Microsoft for these tests.

During the Web server performance testing, it became apparent that while the test suites described above were more than sufficient to determine the peak Web serving performance of all tested server configurations running Windows 2000 Advanced Server and NT 4.0 Server, they were not capable of saturating either the DL380 or the DL760 systems under certain combinations of processors and content type when running Windows Server 2003 RC2. Specifically, these scenarios are as follows:

- DL760 server configured with four or eight processors serving 100 percent static content
- DL760 server configured with eight processors serving a combination of 80 percent static content and 20 percent ISAPI-based content.
- DL380 server configured with two processors serving 100 percent static content.

To determine the peak Web serving performance under the above scenarios, we created an additional set of five test suites that placed substantially more load on the Web server at all client load points. These test suites ran a single WebBench engine on each physical test client, but had each WebBench engine run different numbers of threads when requesting specific types of content from the Web server under test. These test suites are described in figure 17 below.

Server	# of Processors	Content Type	Client Thread Configuration
DL380	2	Static	4 threads per engine at all client load points
DL760	4	Static	4 threads per engine at all client load points
DL760	8	Static	10 threads per engine at client loads of 1 – 88, 15 threads per engine at client loads of 96 - 120
DL760	8	ISAPI	10 threads per engine at all client load points

Figure 17. Custom multi-threaded WebBench Test Suites

To allow a direct comparison of test results across platforms, we ran the single threaded test suites described above on all configurations tested. We then used the multi-threaded test suites described in figure 17 to find the peak Web serving performance only for those scenarios where the single threaded test suites were not sufficient to determine the peak Web serving performance.

For all testing, each of the test suites were executed twice for each specific configuration to ensure the accuracy and repeatability of the test results. We then computed the average of these two test runs at each client load point to determine the results presented in this report.

For all Web server performance testing, the 240 network test clients ran Windows XP and Service Pack 1.

File Server Performance Testing

For the File Server performance tests we used Ziff Davis Media's NetBench 7.02 benchmarking software. Like WebBench, NetBench uses large numbers of physical test clients to generate a file I/O based workload against a file server under test. These test clients make network based file requests to a file server and then record the amount of data moved during the test as a measure of the overall throughput capabilities of the file server. Additionally, the test clients record and generate a measure of overall average response time for the file server as it responded to the various file I/O requests made by the test clients.

To test the DL380 system, we used the standard NetBench 7.02 Enterprise Disk Mix test suite to conduct all testing. The standard NetBench Enterprise Disk Mix test suite use a total of 60 physical clients. Each test

suite starts using a single load generating client and slowly increases the load on the file server by adding test clients in increments of four until a total of 60 clients have participated in the test.

Because the DL760 systems contained more memory and processing power compared to the DL380 system, we created a new set of test suites using the workloads from the standard NetBench Enterprise Disk Mix test suites to test the DL760 systems. Like the standard Enterprise Disk Mix test suite, this new test suite started with a single test client but increased the load on the File server by adding test clients in groups of eight until a total of 120 clients had participated in the test. These new test suites used identical workloads compared to the standard Enterprise Disk Mix test suite, but were designed to put roughly twice the load on the server compared to the standard Enterprise Disk Mix test suite.

The file server performance testing consisted of running the modified Enterprise Disk Mix test suite against the DL760 servers using 1, 2, 4 and 8 processor configurations running each of the tested operating systems. Additionally, we ran the standard Enterprise Disk Mix test suite against the DL380 server using a two-processor configuration. When testing the DL760 servers, we modified the boot.ini file on the DL760 server containing four processors and four network segments to allow us to start the server using 1, 2, or 4 processors. For the one processor testing on the DL760 server, we loaded the appropriate uni-processor kernel for each operating system tested. We used the uni-processor kernel and HAL for Windows 2000 Advanced Server found on the Service Pack 3 CD. We used the uni-processor kernel and HAL for Windows Server 2003 found on the Windows Server 2003 media sent by Microsoft for these tests.

In addition to the file server performance tests we conducted using Intel PRO/1000 MF Server Adapters, we also conducted a set of file server performance tests using Windows Server 2003 after configuring the DL760 server containing eight processors with a set of eight Alacritech gigabit network adapters that provided TCP Offload Engine (TOE) technology. This technology allows the normal TCP related activity normally processed by software to be off-loaded to the network adapter where it is processed by specialized hardware. This allows improved overall performance.

For the File server performance testing, we used the server and network test client operating system combinations described in figure 18 below for all configurations tested. For the file server performance testing using Windows Server 2003, Microsoft provided a set of post Windows XP SP1 redirector hot fixes that we installed on the network test clients prior to conducting the testing using Windows Server 2003.

Server Operating System	Network Test Client Operating System
Windows NT 4.0 Enterprise Edition and SP 6a	Windows NT 4.0 Workstation and SP 6a
Windows 2000 Advanced Server and SP 3	Windows 2000 Professional and SP3
Windows Server 2003	Windows XP Professional and SP1

Figure 18. File Server Performance Testing: Server and Testbed Client Operating Systems

For all testing, each of the test suites described above were executed twice for each specific configuration to ensure the accuracy and repeatability of the test results. We then computed the average of these two test runs at each client load point to determine the results presented in this report.

When conducting file server performance testing using NT 4.0 Enterprise Edition, we simply deleted the remaining NetBench data files from the data partitions on the RAID drives between tests. When testing using either Windows 2000 Advanced Server or Windows Server 2003, we reformatted the NetBench data volumes on the RAID and reset the NTFS Log Volume size to 64K between each test as specified in the Microsoft tuning guidelines.

Directory Server Performance Testing

For the Directory Server performance testing, we used DirectoryMark 1.2 from Mindcraft to conduct testing. DirectoryMark is a benchmark that measures the performance of Lightweight Directory Access Protocol (LDAP) server implementations like Active Directory. DirectoryMark uses one or more physical clients to simulate a number of actual clients performing transactions against the LDAP server under test. DirectoryMark measures latency and throughput for a number of common LDAP operations like searches and deletions.

Microsoft provided a copy of DirectoryMark 1.2 for this testing which included the standard Messaging and Addressing test mixes for this testing. The Messaging test mix simulates an e-mail server using a directory server. The Addressing test mix simulates people looking up names in an address book as well as expanding a group for e-mail.

The DirectoryMark 1.2 test suites consist of running a number of logical clients on the load generating systems. Each of the logical clients is capable of running one or more threads when making requests of the LDAP server under test. Each test suite consists of one or more warmup runs followed by a run of the desired test suite, either the messaging or addressing test mix. The scripts provided by Microsoft for these tests ran using different numbers of clients and threads in an attempt to determine the maximum performance under a specific test configuration.

Figure 19 shows the combinations of DirectoryMark clients and threads used during the Directory server performance testing for all tested processor configurations. Additionally, figure 19 shows the different client and thread combinations that generated the peak DirectoryMark test results displayed in this report.

# of Processors	# of Test Clients	# of Test Threads	Peak Clients	Peak Threads
1	2,3,4,5	5	5	5
2	5,8	5	5	5
4	3,4	4	4	4
8	5	5	5	5

Figure 19. DirectoryMark Test Suite and Peak Performance Parameters

For these tests, we used the HP DL760 server configured with eight processors as the LDAP server running Active directory. After installing either Windows Server 2003 or Windows 2000 Advanced Server SP3 on the HP DL760 server configured with eight processors, we promoted the server to a Primary Domain Controller (PDC) and installed Active Directory. We then created a new domain on the HP DL760 server running Active Directory. Finally, used a series of test scripts to create 1,000,000 users in the Active Directory database. During testing, DirectoryMark test scripts request information related to these users. Please refer to Appendix C for specifics of how we installed Windows Server 2003 Server and Windows 2000 Advanced Server.

Before testing, we modified the boot.ini file on the HP DL760 server containing eight processors to allow us to start the server using 1, 2, 4 and 8 processors. For the one processor testing on the HP DL760 server, we loaded the appropriate uni-processor kernel for each operating system tested. We used the uni-processor kernel and HAL for Windows 2000 Advanced Server found on the Service Pack 3 CD. We used the uni-processor kernel and HAL for Windows Server 2003 found on the Windows Server 2003 media sent by Microsoft for these tests. Additionally, we added the /3GB option to the modified boot.ini file for all processor configurations.

When conducting tests using four processors, we physically removed four of the eight processors in the HP DL760 system located on the left side of the server. For testing both Windows Server 2003 and Windows 2000 Advanced Server SP3, we placed the Active Directory database and log volumes on separate 121GB RAID 0 volumes created on the HP DL760 server.

We used the HP DL760 server configured with four processors as our DirectoryMark client system to generate the load against the LDAP server under test. We installed Windows Server 2003 on this system. During testing, this client system makes LDAP search requests to the LDAP server under test. For the testing, we added the HP DL760 client system to the domain we created on the LDAP server system.

Microsoft provided a set of tuning parameters for both the LDAP server system under test and the DirectoryMark client system to maximize the performance when conducting Directory Server performance testing using Active Directory. Please refer to Appendix F for the specific tuning options used in these tests.

Test results

This section shows the results of the Web and File serving performance we conducted. Please refer to the Testing Methodology section for complete information on the tests we performed.

Web Server Performance Test Results

This section contains the detailed results of the Web server performance testing we conducted using Windows Server 2003, Windows 2000 Advanced Server with SP3 and Windows NT Server 4.0 Enterprise Edition with SP 6a and applicable hot fixes on both the DL380 and DL760 servers.

In general, we found that Windows Server 2003 provided significantly better overall Web serving performance compared to both Windows 2000 Advanced Server and NT Server 4.0 Enterprise Edition. This was true regardless of the specific content type used during the test. Additionally, we found that Windows Server 2003 provided significantly better overall Web server performance scaling when testing with additional processors in the DL760 server configurations compared to both Windows 2000 Advanced Server and NT Server 4.0 Enterprise Edition.

Again, when testing on the DL380 server, we used only the dual processor configuration. When testing on the DL760 server, we conducted tests using configurations of one, two, four and eight processors.

Static Test Results

We conducted these tests by configuring the WebBench test clients to make 100 percent of their requests for static content. Figure 20 shows the peak static request per second values generated on both the DL380 and DL760 servers using all operating system and processor combinations. We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak Web serving performance using static content compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

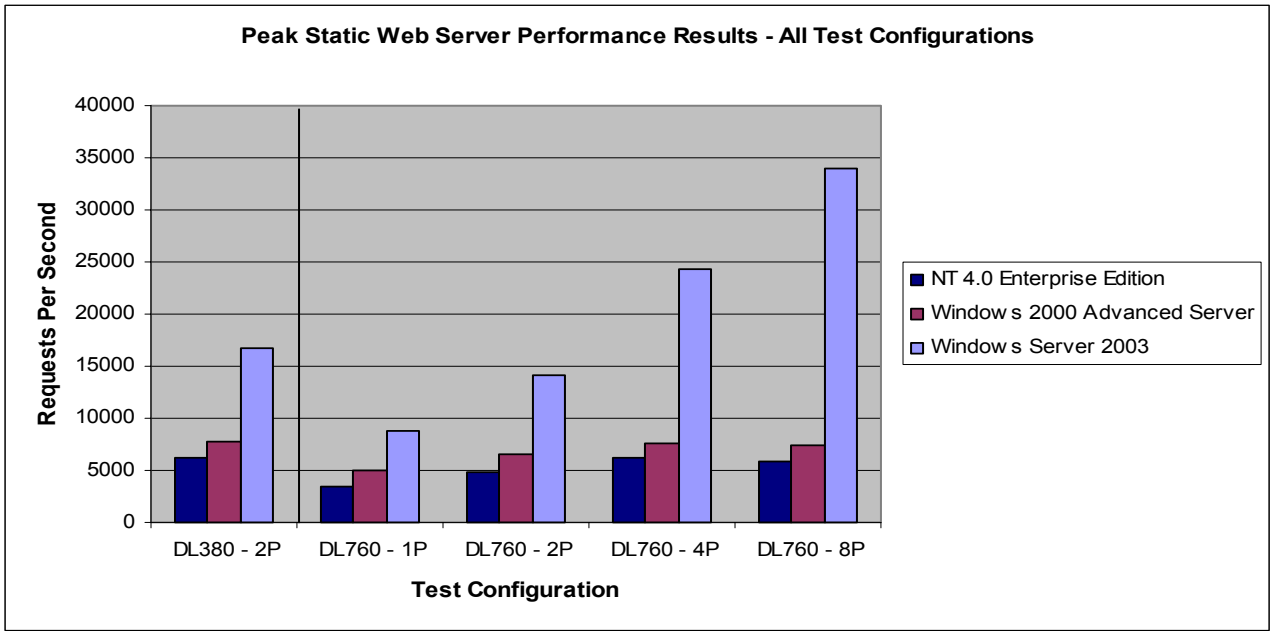

Figure 20. Peak Static Web Server Performance On All Test Configurations

Figure 21 below shows the actual peak WebBench static Web server performance results in requests per second generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 2 shows the percentage improvement in Static Web server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant performance improvements are possible when serving static Web content when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that the performance of Windows Server 2003 scales significantly better than Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition as additional processors are added.

Operating System	DL380 - 2P Req/Sec	DL760 -1P Req/Sec	DL760 - 2P Req/Sec	DL760-4P Req/Sec	DL760-8P Req/Sec
Windows Server 2003	16783	8861	14214	24293	33991
Windows 2000 Advanced Server	7691	4923	6557	7670	7466
NT 4.0 Enterprise Edition	6270	3386	4788	6138	5786
Percent Improvement vs. NT 4.0 Enterprise Edition	168%	162%	197%	296%	487%
Percent Improvement vs. Windows 2000 Advanced Server	118%	80%	117%	217%	355%

Figure 21. Peak Static Web Server Performance and Percentage Improvement of Windows Server 2003 in Static Web Server Performance Data On All Test Configurations

When conducting testing using static content on the DL380 server platform, we used the standard, single threaded WebBench static test suite as well as custom multi-threaded test suites to determine the peak Web serving performance when requesting 100 percent static content. Please refer to the Test Methodology section of this report for complete details of the test suites used.

Figure 22 below shows the results of the static content testing on the DL380 server platform for all operating systems tested using both the standard, single threaded static test suite and the multi-threaded static test suite using four threads on each physical test client. Analyzing the results, it is clear that the increasing trend of the result curve using the single-threaded static test suite with Windows Server 2003 shows that we had not encountered the true peak capabilities of the Web server. Using the multi-threaded static test suite allows us to completely saturate the Web server and find this peak. When using the multi-threaded static test suite, Windows Server 2003 generated a peak of 16,783 requests per second. This is an increase of approximately 22 percent compared to the peak results generated using the single threaded static test suite.

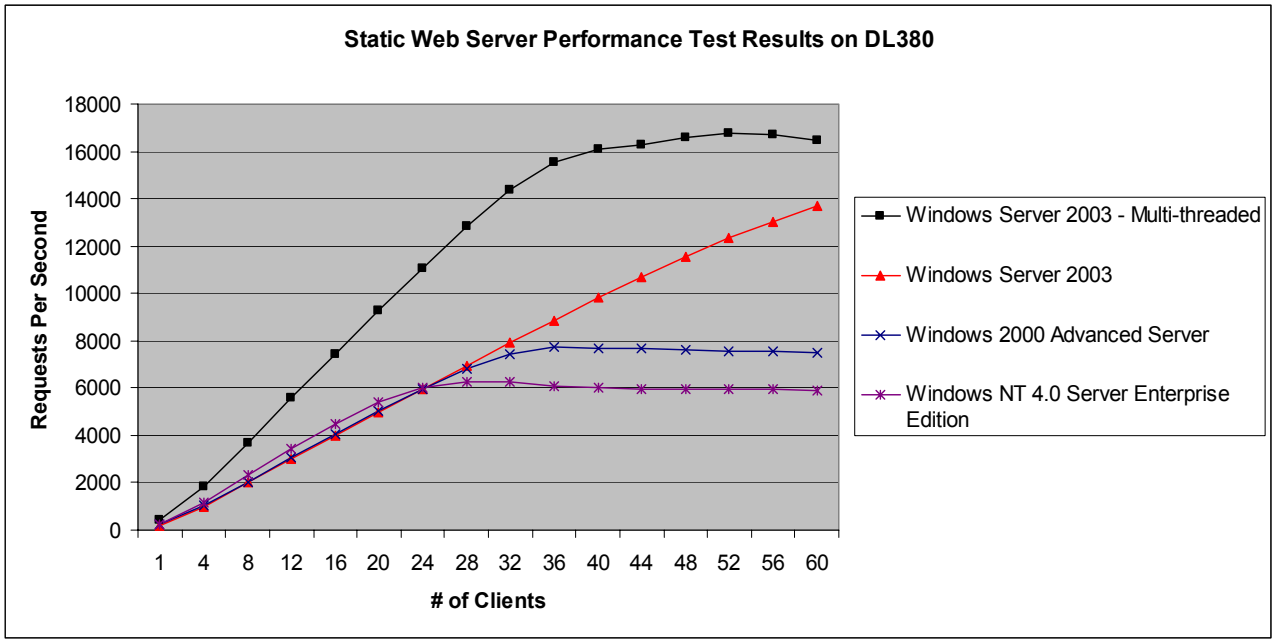

Figure 22. Static Web Server Performance Results on DL380 server configuration

Figures 23 - 26 below display the full set of WebBench data for the static Web server performance results on the DL760 server platform for all Operating Systems and processor configurations using 1, 2, 4 and 8 processors. These results show that, in addition to providing superior peak static Web server performance, Windows Server 2003 provides significantly better static Web serving performance at lower, medium and high client loads compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

Figure 25 and 26 below shows the results of the static content testing on the DL760 server platform using four and eight processors respectively for all operating systems tested using both the single threaded static test suite and the multi-threaded static test suites. Analyzing the results, it is clear that the increasing trend of the result curve using the single-threaded static test suite with both four and eight processors with Windows Server 2003 shows that we had not encountered the true peak capabilities of the Web server. Using the multi-threaded static test suite allows us to completely saturate the Web server and find this peak with both four and eight processors.

When using the multi-threaded static test suite on the DL760 configured with four processors, Windows Server 2003 generated a peak of 24,293 requests per second compared to a peak of 20,886 requests per second using the single-threaded static test suite. This is an increase of approximately 16 percent compared to the peak results generated using the single threaded static test suite.

When using the multi-threaded static test suite on the DL760 configured with eight processors, Windows Server 2003 generated a peak of 33,991 requests per second compared to a peak of 23,387 requests per second using the single-threaded static test suite. This is an increase of approximately 45 percent compared to the peak results generated using the single threaded static test suite.

The test result curve in figure 26 showing the full WebBench multi-threaded static test results for the HP DL760 server using eight processors looks considerably different compared to the results generated by the single threaded version of the test suite. This is because the multi-threaded test suite used for this test utilized a total of 10 threads per each WebBench client through loads of up to 88 clients and then uses 15 threads per WebBench client at loads after 88 clients. This has the effect of suddenly increasing the level of the overall load placed on IIS 6.0 by the WebBench clients and results in a dramatic improvement in the number of requests sent by the WebBench clients and processed by IIS 6.0 during the test mixes.

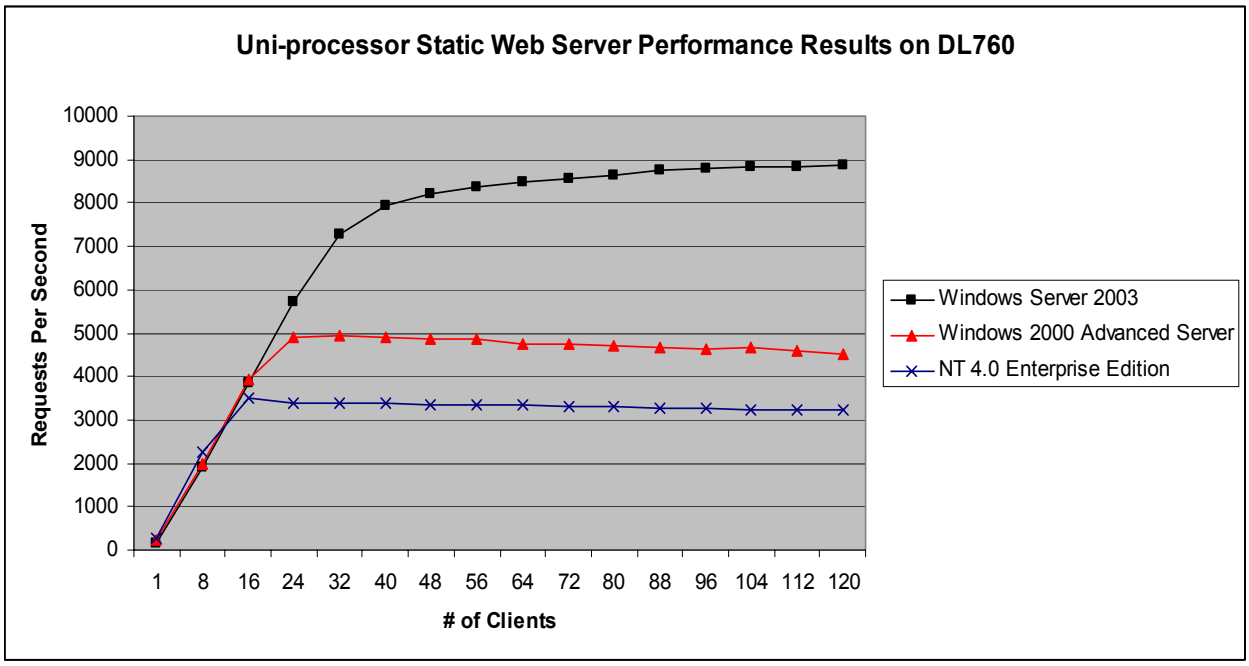

Figure 23. Uni-processor Static Web Server Performance Results on DL760

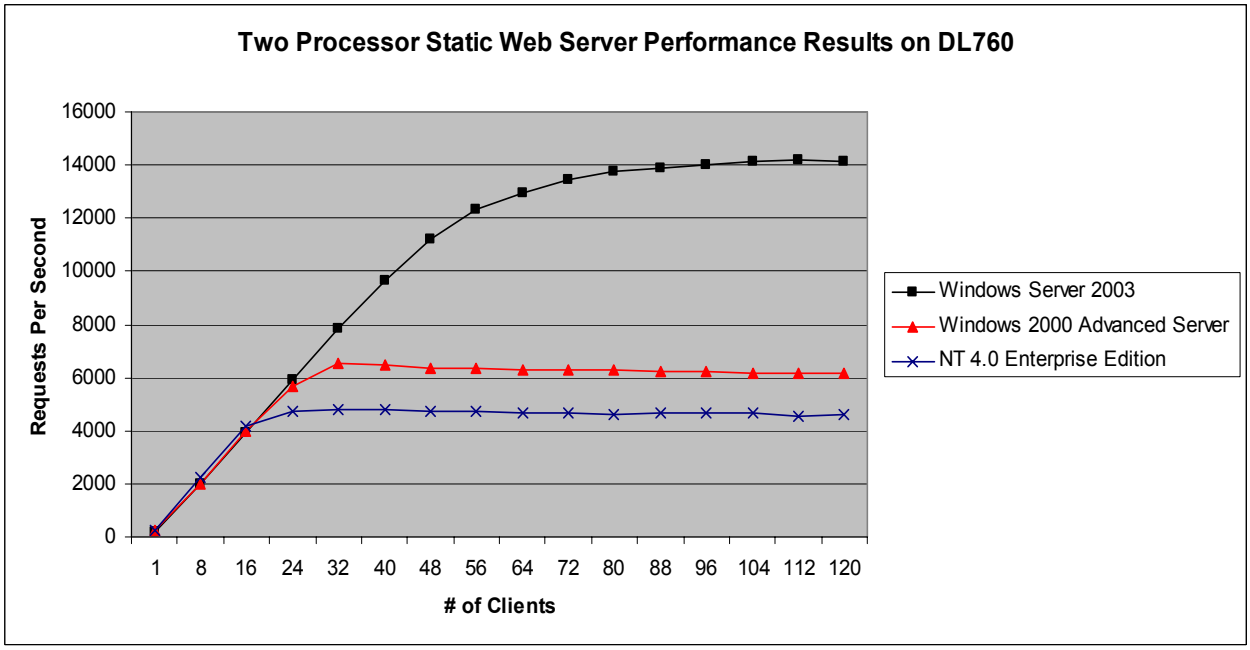

Figure 24. Two Processor Static Web Server Performance Results on DL760

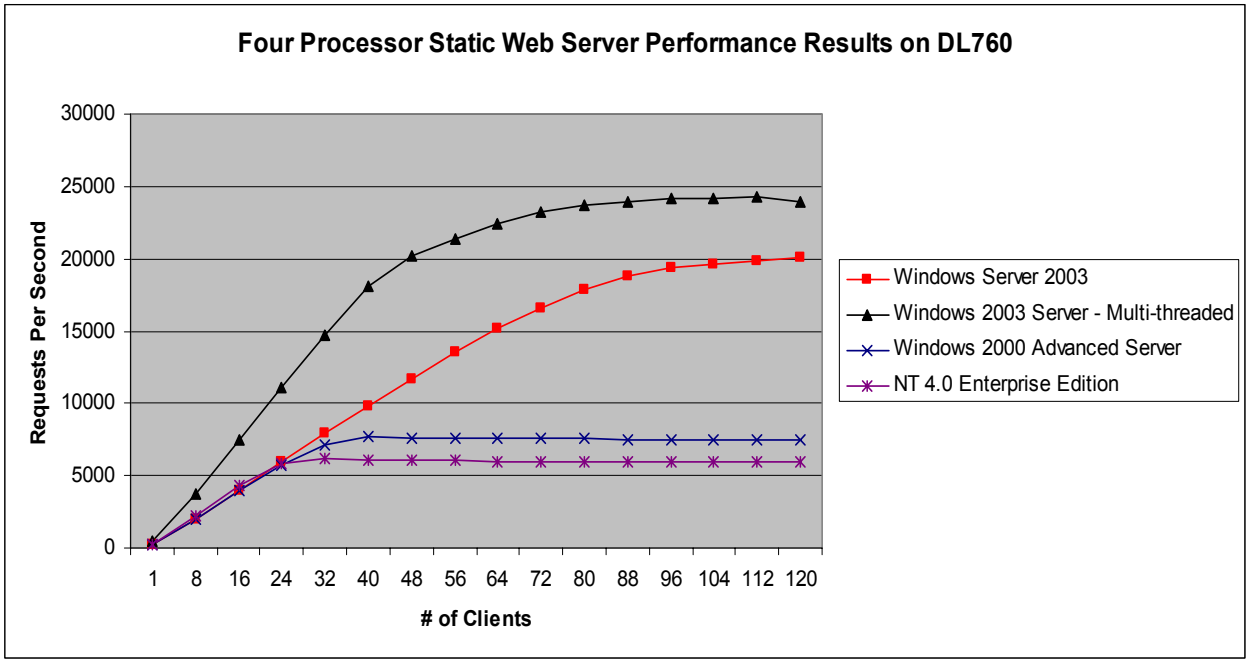

Figure 25. Four Processor Static Web Server Performance Results on DL760

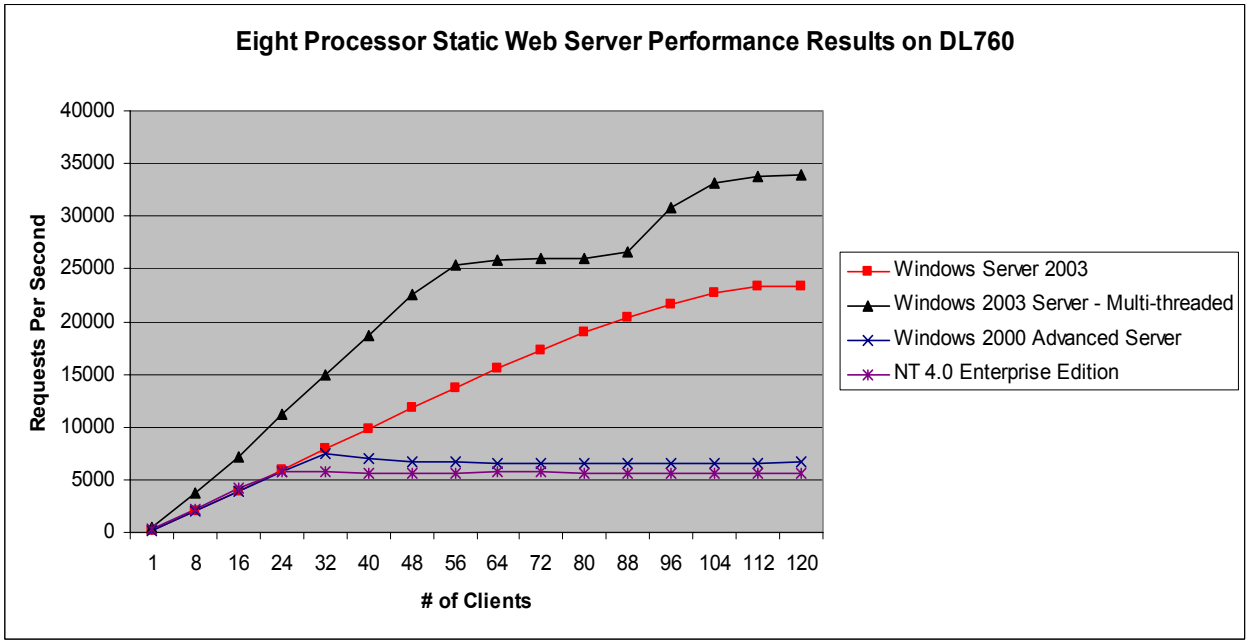

Figure 26. Eight Processor Static Web Server Performance Results on DL760

Dynamic Content Performance Test Results

This section describes the test results generated with the WebBench test suites utilizing ISAPI and CGI based dynamic content.

ISAPI-based Content Test Results

We conducted these tests by configuring the WebBench test clients to make 80 percent of their requests for static content and the remaining 20 percent for a simple ISAPI-based module. Figure 27 shows the peak request per second values generated on both the DL380 and DL760 server using all operating system and processor combinations.

We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak Web serving performance using the ISAPI-based content compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

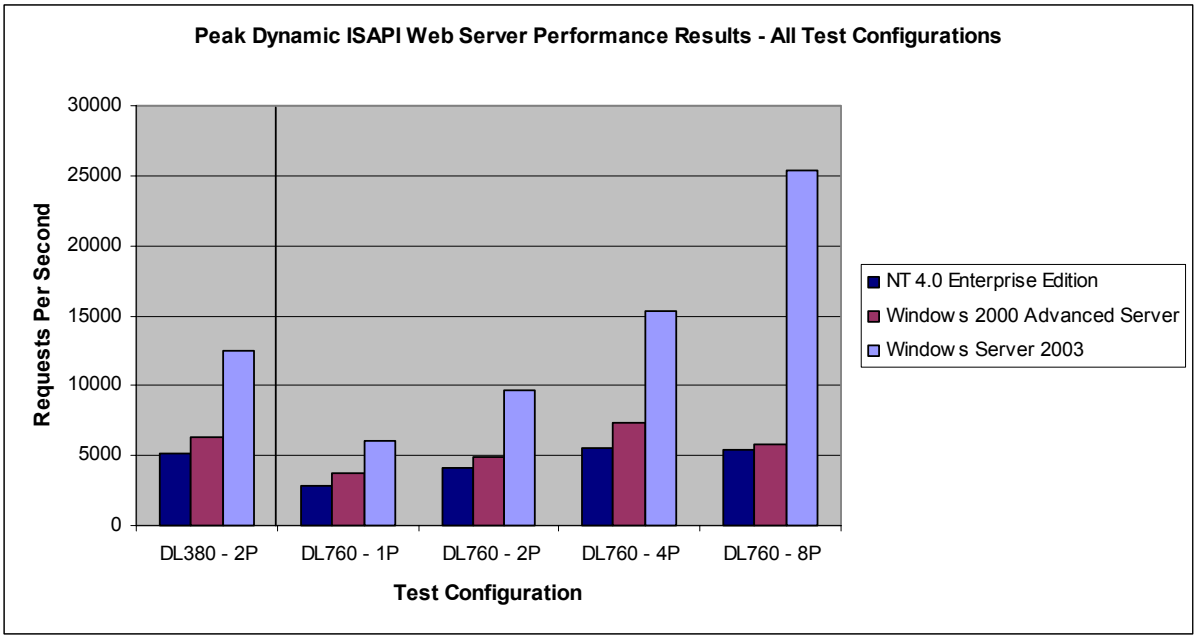

Figure 27. Peak Dynamic ISAPI-based Web Server Performance On All Test Configurations

Figure 28 below shows the actual peak WebBench ISAPI Web server performance results in requests per second generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 5 shows the percentage improvement in ISAPI-based Web server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant performance improvements are possible when serving a combination of static and ISAPI-based Web content when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that significant performance improvements are possible when adding additional processor resources to a Web server running Windows Server 2003 serving static content.

Operating System	DL380 - 2P Req/Sec	DL760 -1P Req/Sec	DL760 - 2P Req/Sec	DL760-4P Req/Sec	DL760-8P Req/Sec
Windows Server 2003	12551	6054	9685	15270	25329
Windows 2000 Advanced Server	6296	3701	4901	7285	5855
NT 4.0 Enterprise Edition	5178	2890	4137	5525	5417
Percent Improvement vs. NT 4.0 Enterprise Edition	142%	109%	134%	176%	368%
Percent Improvement vs. Windows 2000 Advanced Server	99%	64%	98%	110%	333%

Figure 28. Peak Dynamic ISAPI Web Server Performance and Percentage Improvement of Windows Server 2003 in ISAPI Web Server Performance Data On All Test Configurations

When conducting testing using ISAPI-based content on the DL380 server platform, we used the standard, single threaded WebBench ISAPI test suite as well as custom multi-threaded test suites to determine the peak Web serving performance when requesting the ISAPI-based content. Please refer to the Test Methodology section of this report for complete details of the test suites used.

Figure 29 below shows the results of the ISAPI-based content testing on the DL380 server platform for all operating systems tested using both the standard, single threaded ISAPI-based test suite and the multi-threaded ISAPI-based test suite using four threads on each physical test client. Analyzing the results, it is clear that the increasing trend of the result curve using the single-threaded ISAPI-based test suite with Windows Server 2003 shows that we had not encountered the true peak capabilities of the Web server. Using the multi-threaded ISAPI-based test suite allows us to completely saturate the Web server and find this peak. When using the multi-threaded ISAPI-based test suite, Windows Server 2003 generated a peak of 12,551 requests per second. This is an increase of approximately 7 percent compared to the peak results generated using the single threaded ISAPI-based test suite.

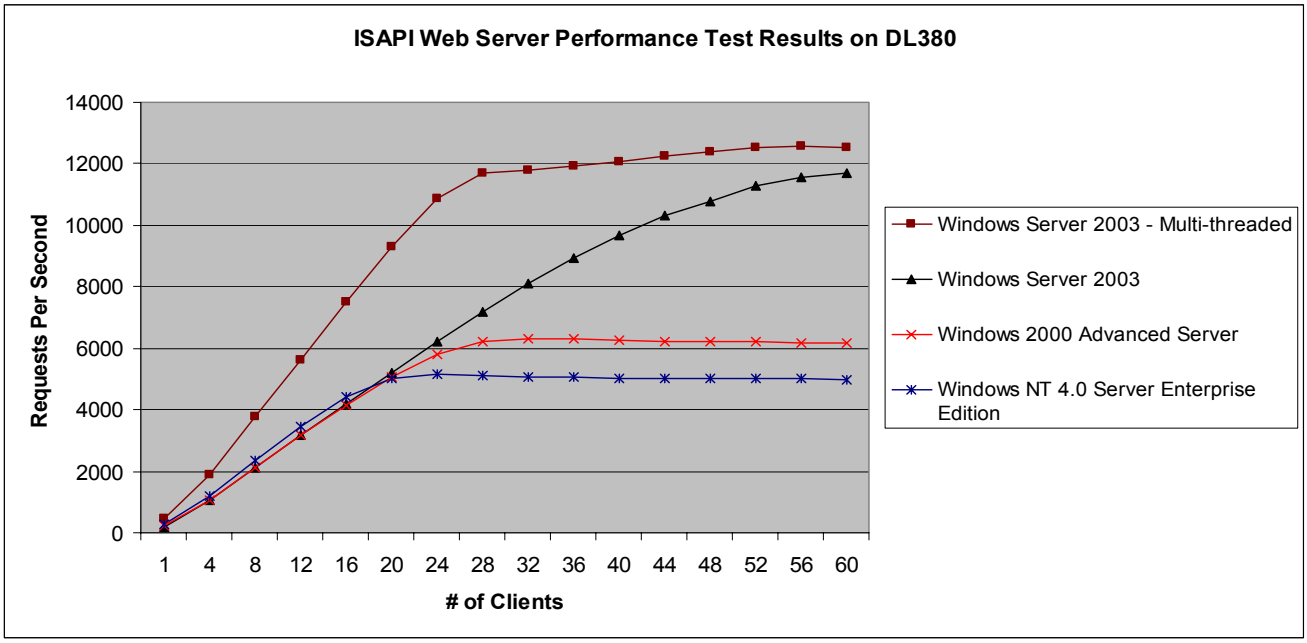

Figure 29. ISAPI-based Web Server Performance Results on DL380

Figures 30 - 33 below display the full set of WebBench data for the ISAPI-based Web server performance results on the DL760 server platform for all operating systems and processor configurations we tested. These results show that, in addition to providing superior peak ISAPI-based Web server performance, Windows

Server 2003 provides significantly better ISAPI-based Web serving performance at lower, medium and high client loads compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

Figure 33 below shows the results of the ISAPI-based content testing on the DL760 server platform using eight processors respectively for all operating systems tested using both the single threaded ISAPI-based test suite and the multi-threaded ISAPI-based test suites. Analyzing the results, it is clear that the increasing trend of the result curve using the single-threaded ISAPI-based test suite with eight processors with Windows Server 2003 shows that we had not encountered the true peak capabilities of the Web server. Using the multi-threaded ISAPI-based test suite allows us to completely saturate the Web server and find this peak with eight processors.

When using the multi-threaded static test suite on the DL760 configured with eight processors, Windows Server 2003 generated a peak of 25,378 requests per second compared to a peak of 18,304 requests per second using the single-threaded static test suite. This is an increase of approximately 39 percent compared to the peak results generated using the single threaded static test suite.

The test result curve in figure 33 showing the full WebBench multi-threaded ISAPI test results for the HP DL760 server using eight processors looks considerably different compared to the results generated by the single threaded version of the test suite. This is because the multi-threaded test suite used for this test utilized a total of 10 threads per each WebBench client through loads of up to 88 clients and then uses 15 threads per WebBench client at loads after 88 clients. This has the effect of suddenly increasing the level of the overall load placed on IIS 6.0 by the WebBench clients and results in a dramatic improvement in the number of requests sent by the WebBench clients and processed by IIS 6.0 during the test mixes.

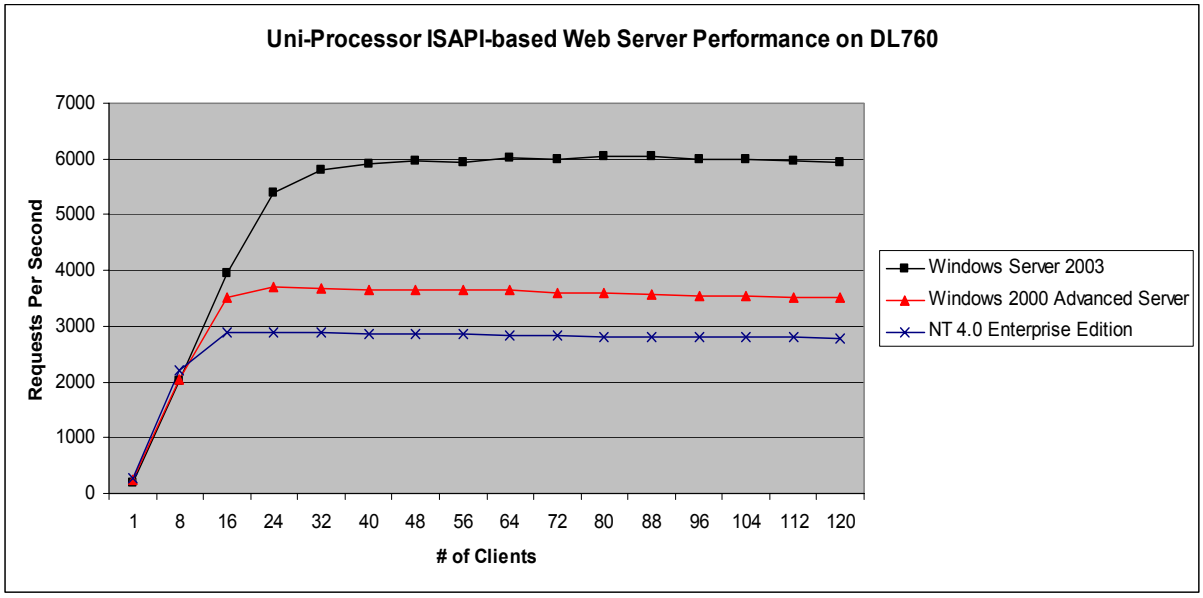

Figure 30. Uni-processor ISAPI-based Web Server Performance On DL760

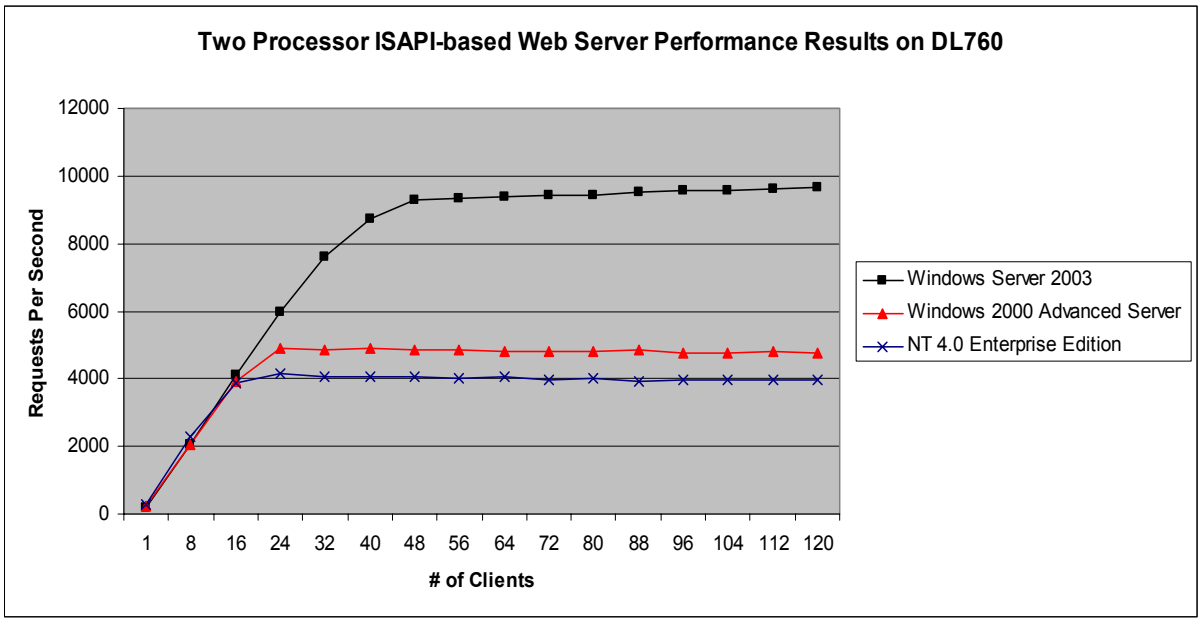

Figure 31. Two processor ISAPI-based Web Server Performance On DL760

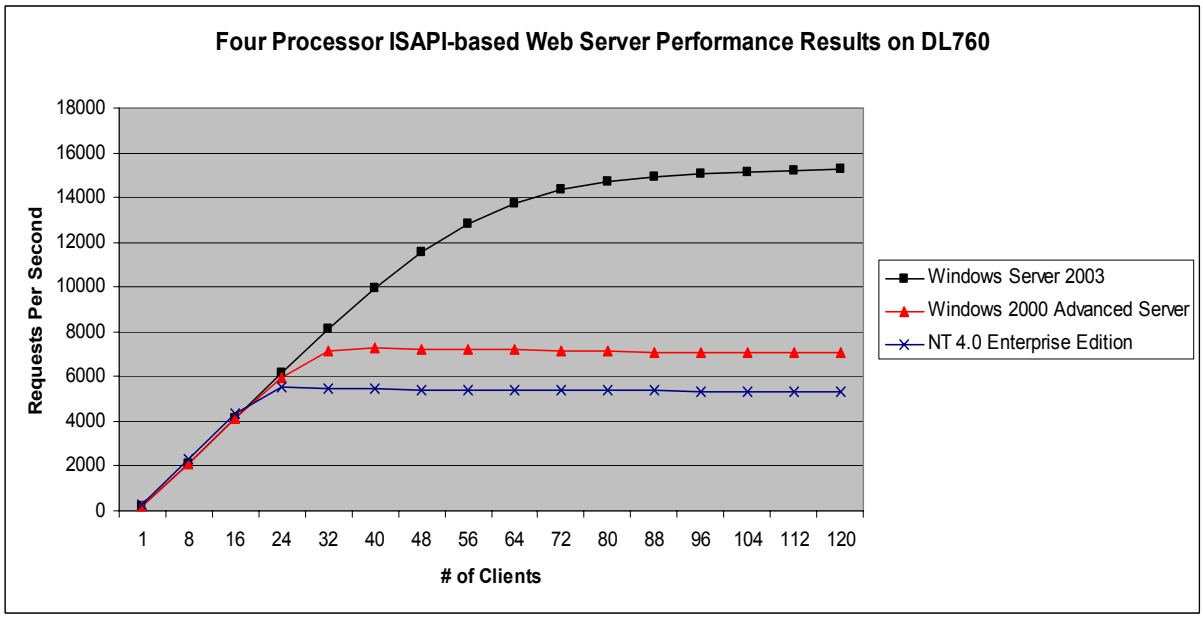

Figure 32. Four processor ISAPI-based Web Server Performance On DL760

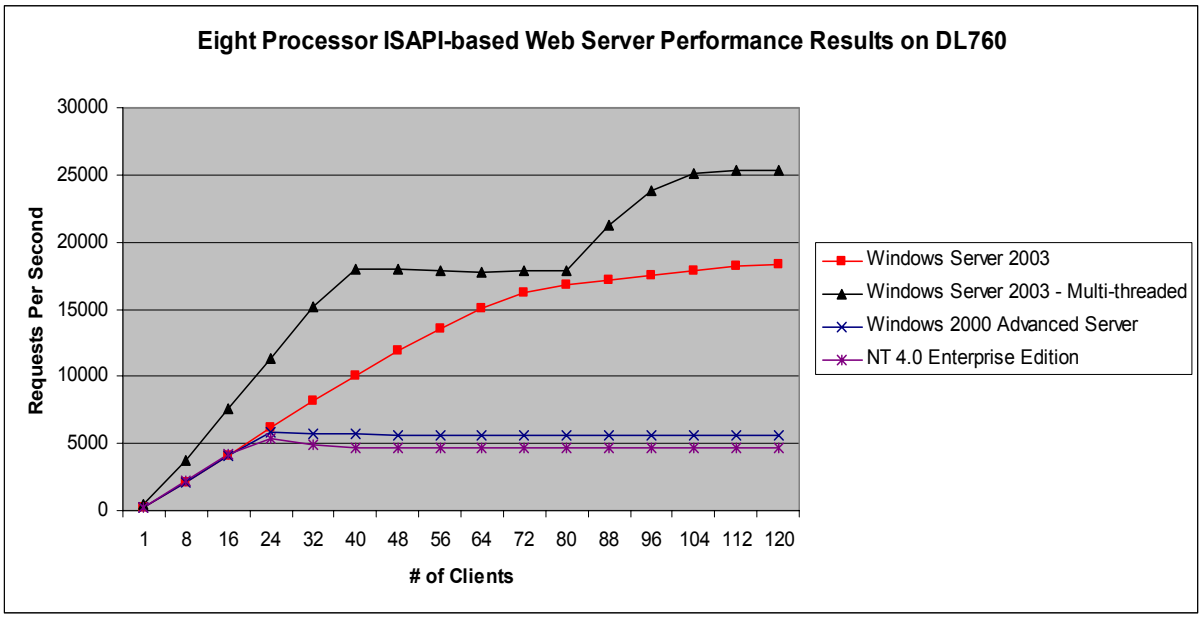

Figure 33. Eight processor ISAPI-based Web Server Performance On DL760

CGI-based Content Results

We conducted these tests by configuring the WebBench test clients to make 80 percent of their requests for static content and 20 percent for a simple CGI executable. Figure 34 shows the peak request per second values generated on both the DL380 and DL760 server using all operating system and processor combinations we tested.

We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak Web serving performance using the CGI-based content compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

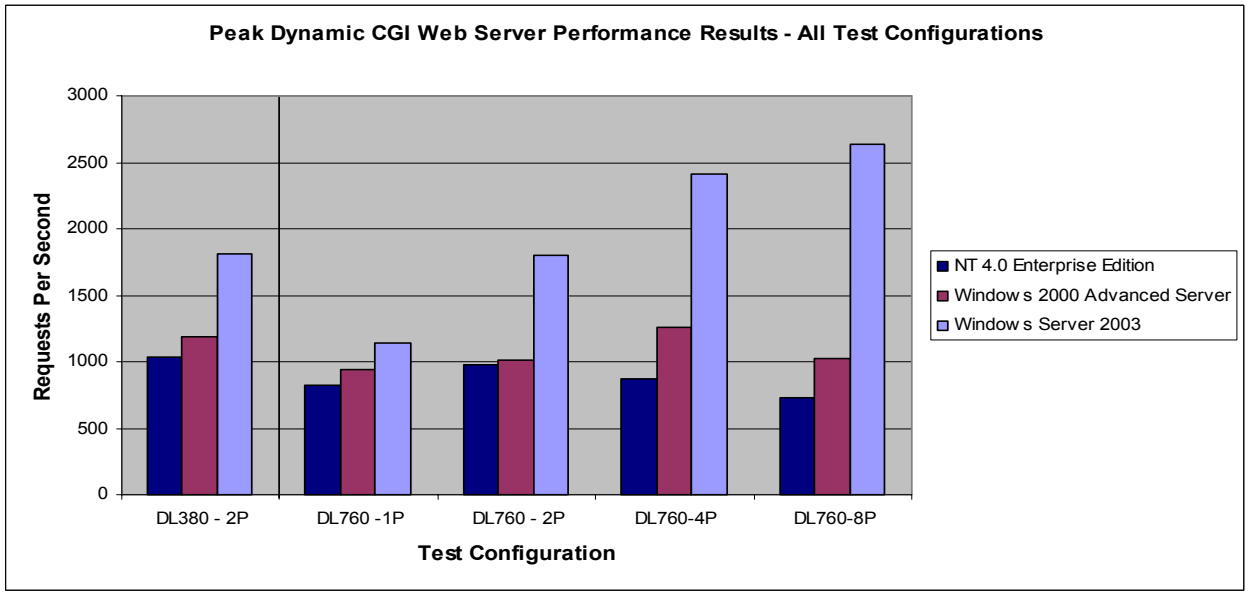

Figure 34. Peak Dynamic CGI-based Web Server Performance On All Test Configurations

Figure 35 below shows the actual peak WebBench CGI Web server performance results in requests per second generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 35 shows the percentage improvement in CGI-based Web server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant performance improvements are possible when serving a combination of static and CGI-based Web content when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that significant performance improvements are possible when adding additional processor resources to a Web server running Windows Server 2003 serving a combination of static and CGI-based Web content.

Operating System	DL380 - 2P Req/Sec	DL760 -1P Req/Sec	DL760 - 2P Req/Sec	DL760-4P Req/Sec	DL760-8P Req/Sec
Windows Server 2003	1814	1140	1805	2413	2639
Windows 2000 Advanced Server	1187	942	1013	1262	1018
NT 4.0 Enterprise Edition	1033	819	980	876	727
Percent Improvement vs. NT 4.0 Enterprise Edition	76%	39%	84%	175%	263%
Percent Improvement vs. Windows 2000 Advanced Server	53%	21%	78%	91%	159%

Figure 35. Peak Dynamic CGI Web Server Performance and Percentage Improvement of Windows Server 2003 in CGI Web Server Performance Data On All Test Configurations

Figure 36 below shows the results of the CGI content testing on the DL380 server platform for all operating systems tested using the standard, single threaded CGI test suite. These results show that using the single-threaded CGI test suite, Windows Server 2003 delivered the best overall Web serving performance of all platforms tested.

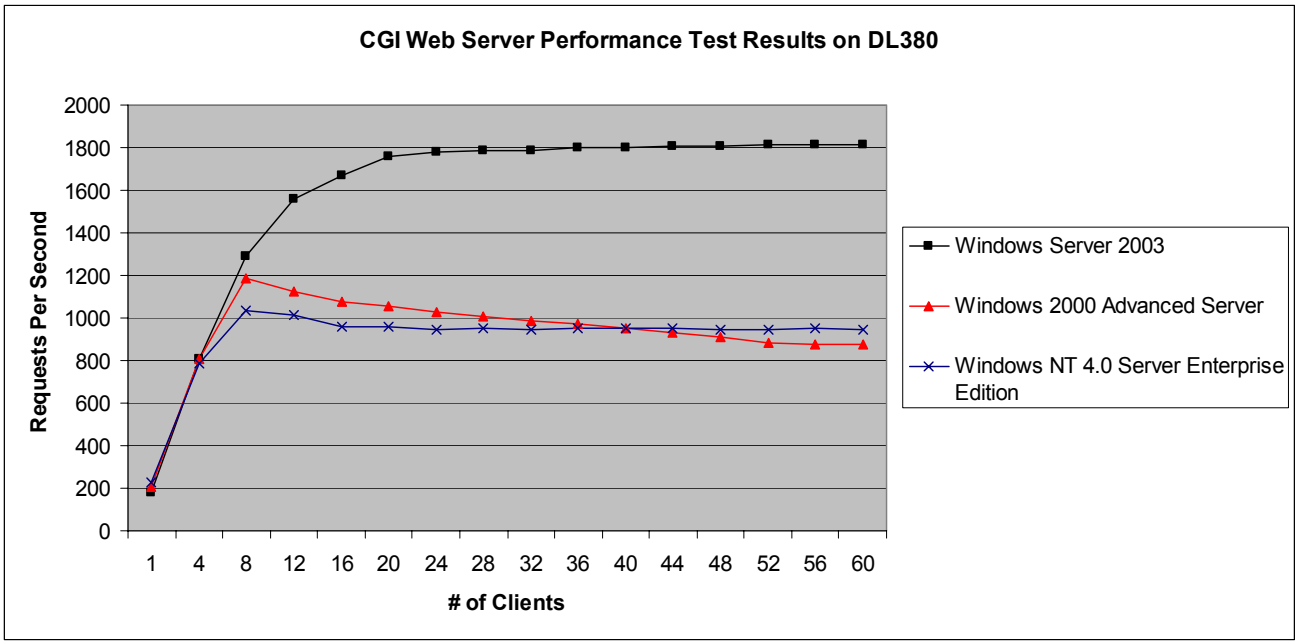

Figure 36. CGI-based Web Server Performance Results on DL380

Figures36 - 39 below display the full set of WebBench data for the CGI Web server performance results on the DL760 server platform for all operating systems and processor configurations using 1, 2, 4 and 8

processors. These results show that, in addition to providing superior peak CGI Web server performance, Windows Server 2003 provides significantly better CGI Web serving performance at lower, medium and high client loads compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

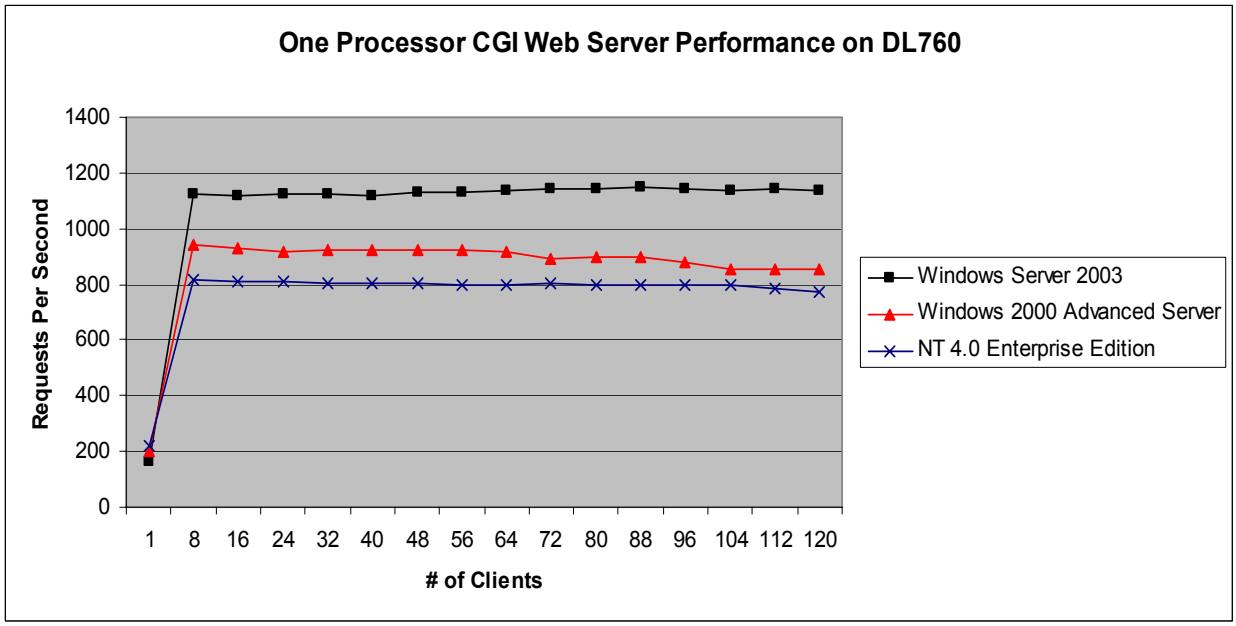

Figure 36. Uni-Processor CGI-based Web Server Performance Results on DL760

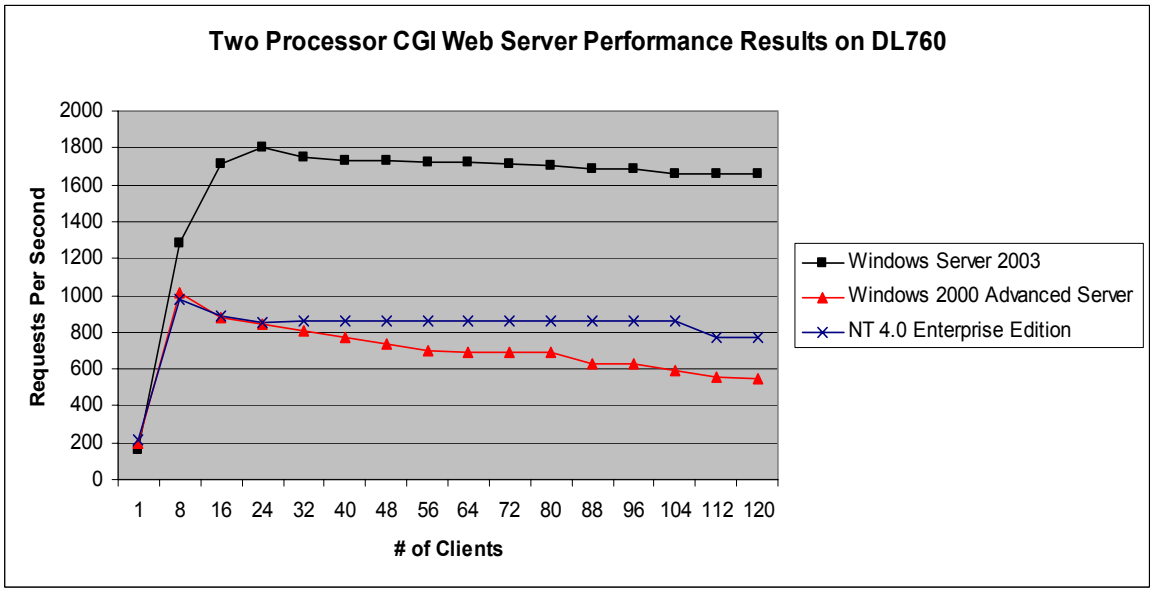

Figure 37. Two Processor CGI-based Web Server Performance Results on DL760

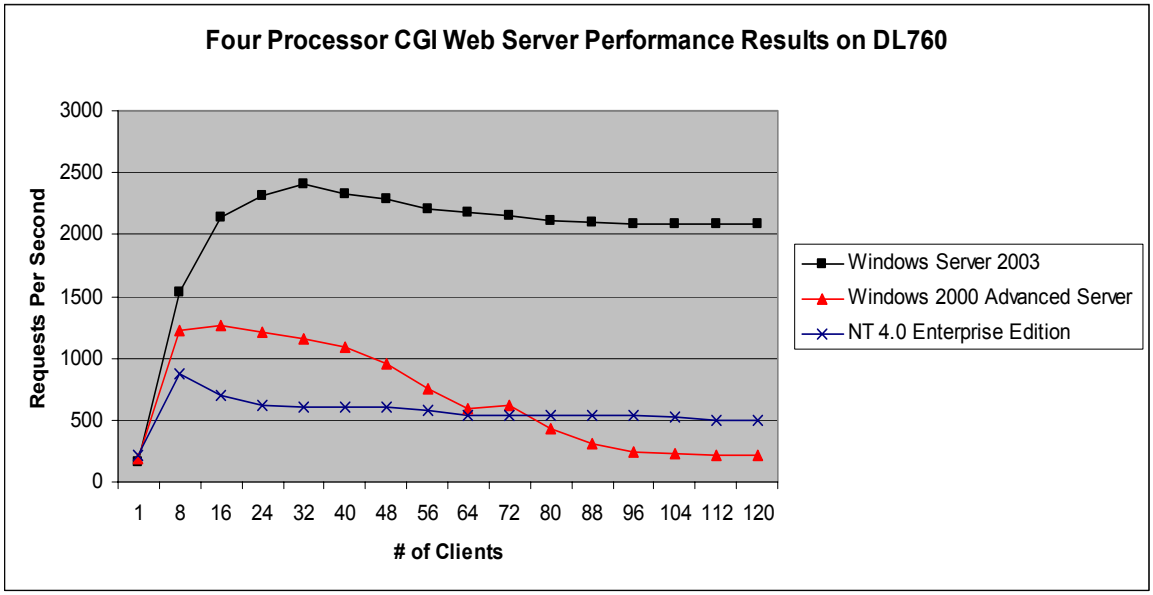

Figure 38. Four Processor CGI-based Web Server Performance Results on DL760

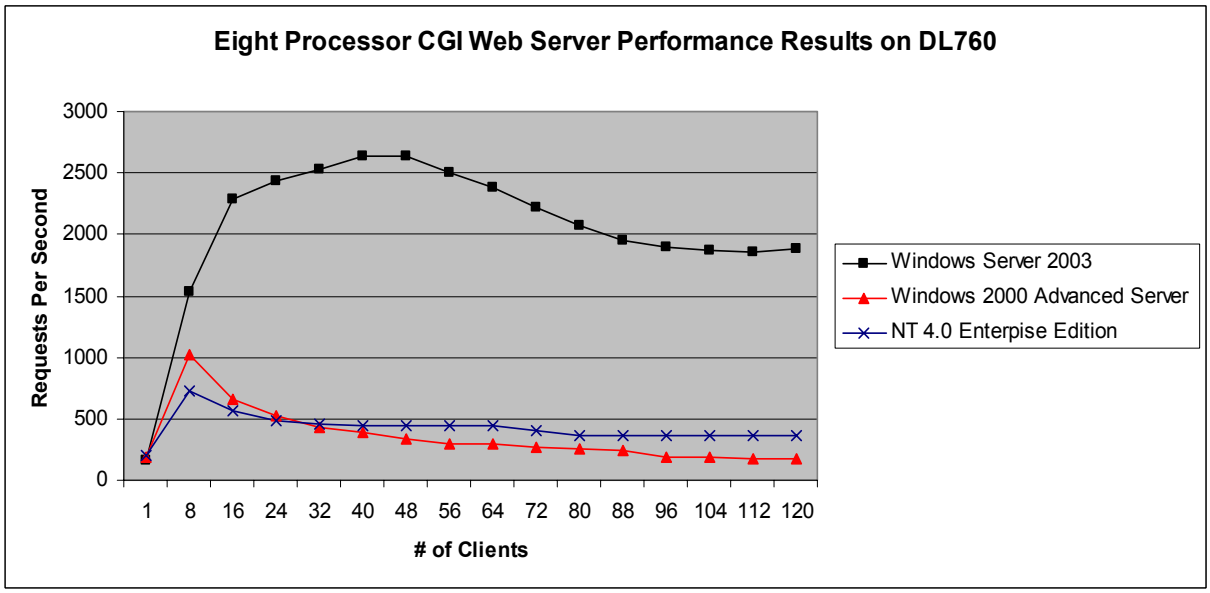

Figure 39. Eight Processor CGI-based Web Server Performance Results on DL760

HTTP API based Test Results

In addition to the ISAPI and CGI based methods for generating dynamic content with Internet Information Server (IIS) 6.0, Windows Server 2003 provides a new interface to generate dynamic content, called HTTP API. This is a Web development interface that allows users to create dynamic Web content that takes advantage of the new kernel mode web support available in Windows Server 2003.

While testing the performance of this new interface was not part of the main testing conducted for this report, we did perform a series of WebBench tests using dynamic content generated using this new interface. For these tests, we used the HTTP API interface to develop a module based on the standard WebBench ISAPI module code. Like the standard WebBench ISAPI module, the HTTP API module we created for this test

issued queries for a number of Web server environment variables, put the results together into an HTML string of 1024 bytes and sent the resulting HTML data back to the requesting client.

We conducted these tests by configuring the WebBench test clients to make 80 percent of their requests for static content and the remaining 20 percent for a simple HTTP API module.

Figure 40 shows the peak HTTP API and standard ISAPI request per second values generated on both the HP DL380 and HP DL760 servers using Windows Server 2003 with all processor combinations tested. Because the HTTP API is not available on either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition, there are no comparisons to these platforms. We found that regardless of the server employed or the number of processors, using the HTTP API module under Windows Server 2003 generated better peak Web serving performance compared to the ISAPI-based content running under Windows Server 2003 Enterprise Edition RC2.

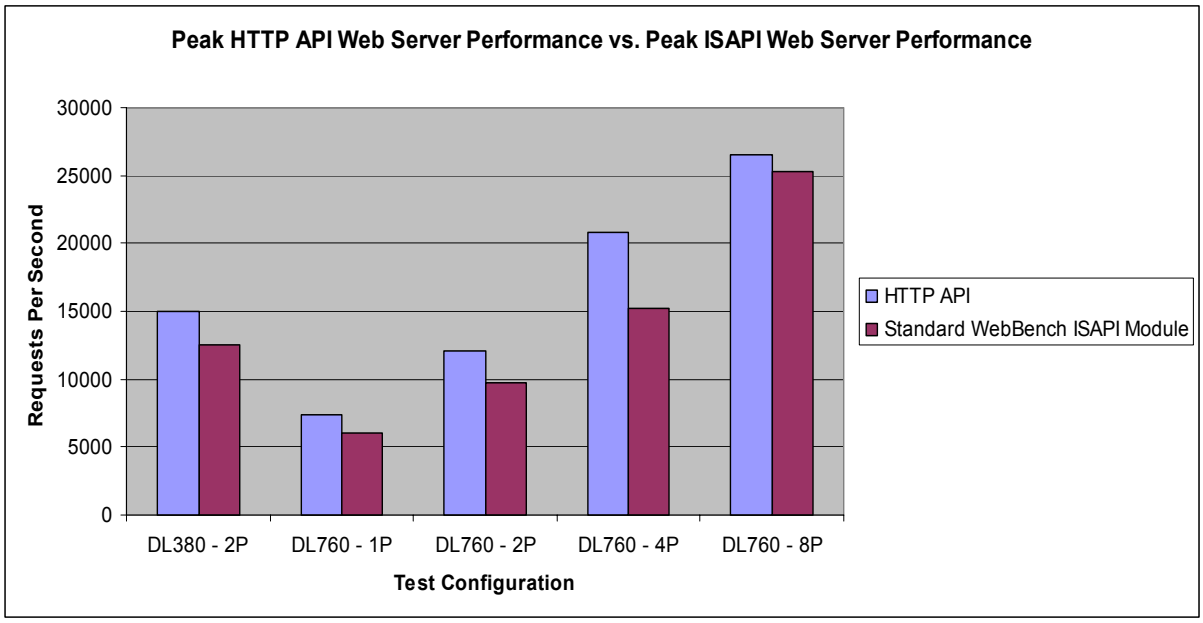

Figure 40. Peak Performance Comparison of HTTP API module vs. Standard ISAPI

Figure 41 below compares the actual peak WebBench test results using the HTTP API based content and the standard ISAPI-based content testing on both the DL380 and DL760 server platforms for Windows Server 2003 Enterprise Edition RC2.

Test Configuration	HTTP API	Standard WebBench ISAPI Module
DL380 - 2P	15046	12551
DL760 - 1P	7371	6054
DL760 - 2P	12064	9685
DL760 - 4P	20817	15270
DL760 - 8P	26583	25329

Figure 41. Peak HTTP API Test Results vs. Peak Standard ISAPI Test Results

Figure 42 below shows the percentage increase in overall performance when using the HTTP API module compared to the standard WebBench ISAPI module under Windows Server 2003 Enterprise Edition RC2.

Test Configuration	Percentage Increase
DL380 - 2P	20%
DL760 - 1P	22%
DL760 - 2P	25%
DL760 - 4P	36%
DL760 - 8P	5%

Figure 42. Percentage Increase In Performance Using HTTP API module vs. Standard ISAPI

E-Commerce Performance Test Results

This section describes the test results generated with the WebBench test suites utilizing ISAPI and CGI based dynamic content and the Secure Socket Layer (SSL) 3.0 protocol.

SSL/ISAPI-based Content Results

We conducted these tests by configuring the WebBench test clients to make 76 percent of their requests for static content, 16 percent for a simple ISAPI module and the remaining 8 percent for static and ISAPI content using SSL3.0 for secure Web server communications. Figure 43 shows the peak request per second values generated on both the DL380 and DL760 server using all operating system and processor combinations we tested. There are no test results for the SSL/ISAPI content for NT 4.0 Server Enterprise Edition on the DL760 running eight processors. Each time we attempted this test, IIS 4.0 generated an exception and the test halted.

We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak Web serving performance using the SSL/ISAPI-based content compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

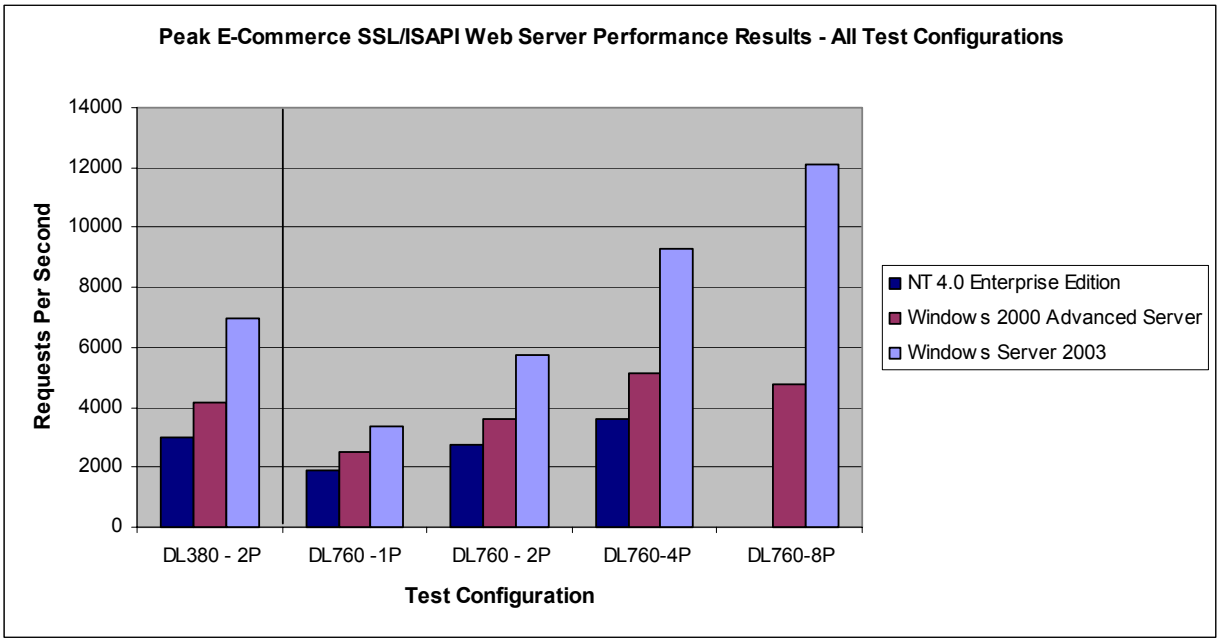

Figure 43. Peak E-commerce SSL/ISAPI-based Web Server Performance On All Test Configurations

Figure 44 below shows the actual peak WebBench SSL/ISAPI Web server performance results in requests per second generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 44 shows the percentage improvement in SSL/ISAPI-based Web server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant performance improvements are possible when serving a combination of static and SSL/ISAPI-based Web content when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that significant performance improvements are possible when adding additional processor resources to a Web server running Windows Server 2003 serving a combination of static and SSL/ISAPI-based Web content.

Operating System	DL380 - 2P Req/Sec	DL760 -1P Req/Sec	DL760 - 2P Req/Sec	DL760-4P Req/Sec	DL760-8P Req/Sec
Windows Server 2003	6999	3338	5768	9285	12079
Windows 2000 Advanced Server	4152	2482	3593	5127	4795
NT 4.0 Enterprise Edition	2997	1915	2747	3596	N/A
Percent Improvement vs. NT 4.0 Enterprise Edition	134%	74%	110%	158%	N/A
Percent Improvement vs. Windows 2000 Advanced Server	69%	34%	61%	81%	152%

Figure 44. Peak E-Commerce SSL/ISAPI Web Server Performance and Percentage Improvement of Windows Server 2003 in SSL/ISAPI Web Server Performance Data On All Test Configurations

When conducting testing using a combination of 80 percent static and 12 percent ISAPI and 8 percent SSL based content on the DL380 server platform, we used the standard, single threaded WebBench e-commerce ISAPI test suite. Please refer to the Test Methodology section of this report for complete details of the test suites used.

Figure 45 below shows the results of the SSL/ISAPI based content testing on the DL380 server platform for all operating systems tested using the standard, single threaded e-commerce ISAPI WebBench test suite. These results show that using the single-threaded e-commerce ISAPI test suite, Windows Server 2003 delivered the best overall Web serving performance of all platforms tested.

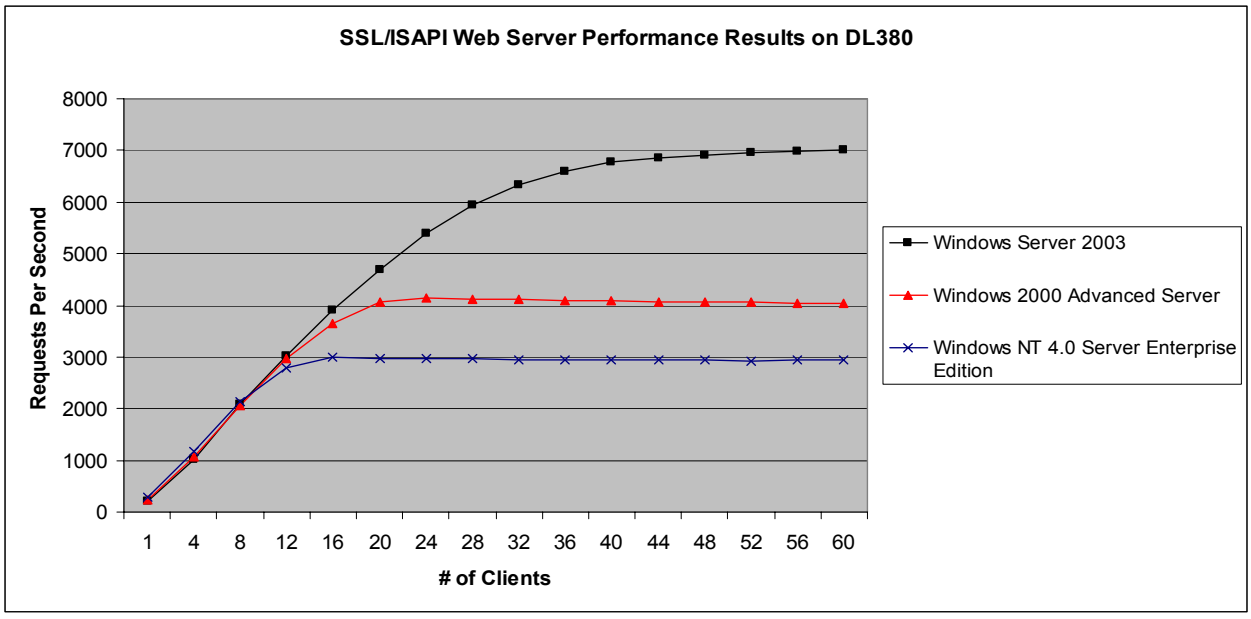

Figure 45. SSL/ISAPI-based Web Server Performance Results on DL380

Figures 46 - 49 below display the full set of WebBench data for the SSL/ISAPI Web server performance results on the DL760 server platform for all operating systems and processor configurations using 1, 2, 4 and 8 processors. These results show that, in addition to providing superior peak SSL/ISAPI Web server performance, Windows Server 2003 provides significantly better SSL/ISAPI Web serving performance at lower, medium and high client loads compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

There are no test results for the SSL/ISAPI content for NT 4.0 Server Enterprise Edition on the DL760 running eight processors. Each time we attempted this test, IIS 4.0 generated an exception and the test halted.

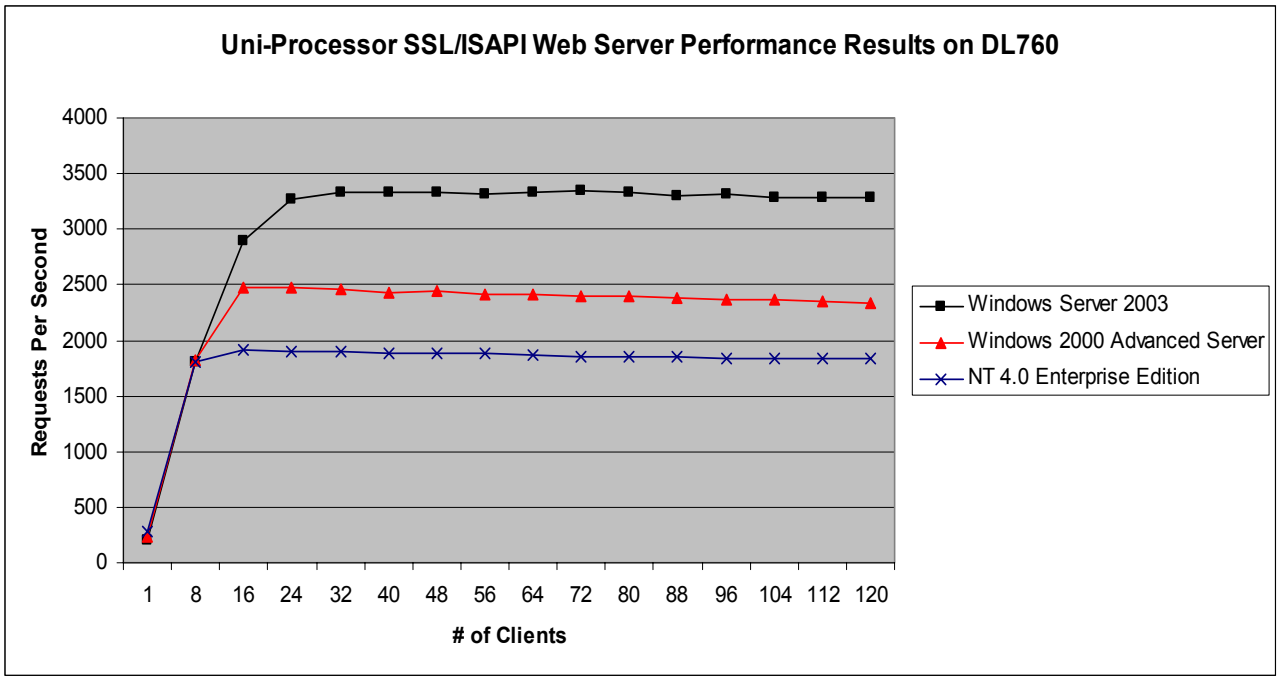

Figure 46. Uni-Processor SSL/ISAPI-based Web Server Performance Results on DL760

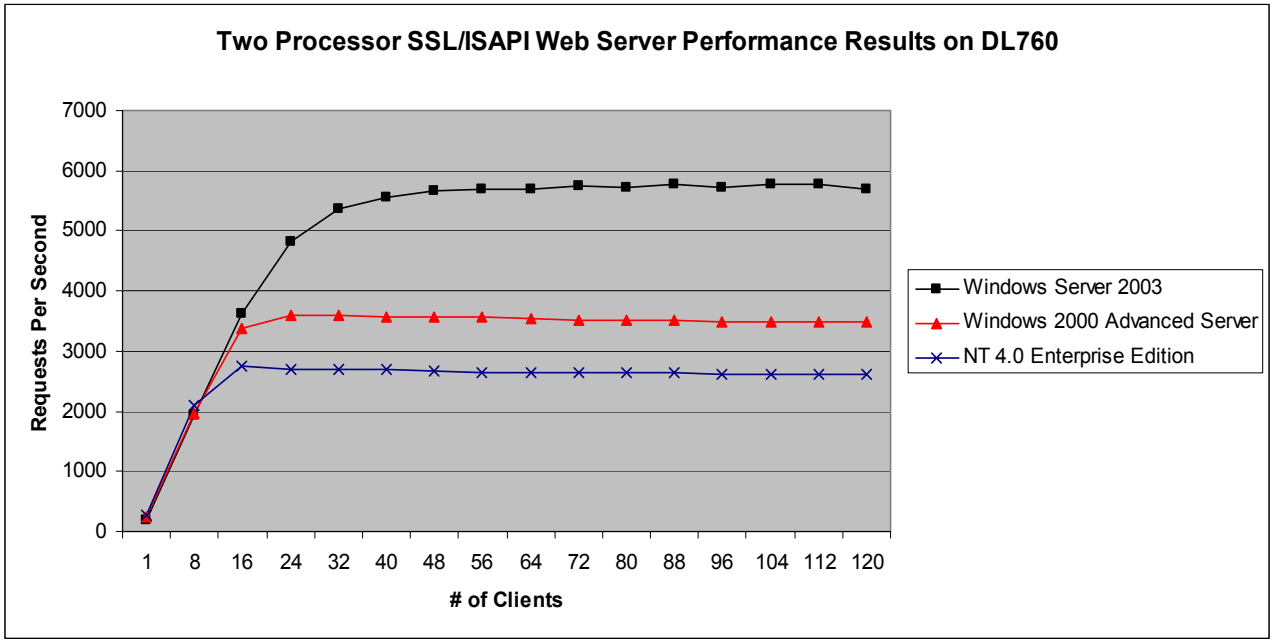

Figure 47. Two-Processor SSL/ISAPI-based Web Server Performance Results on DL760

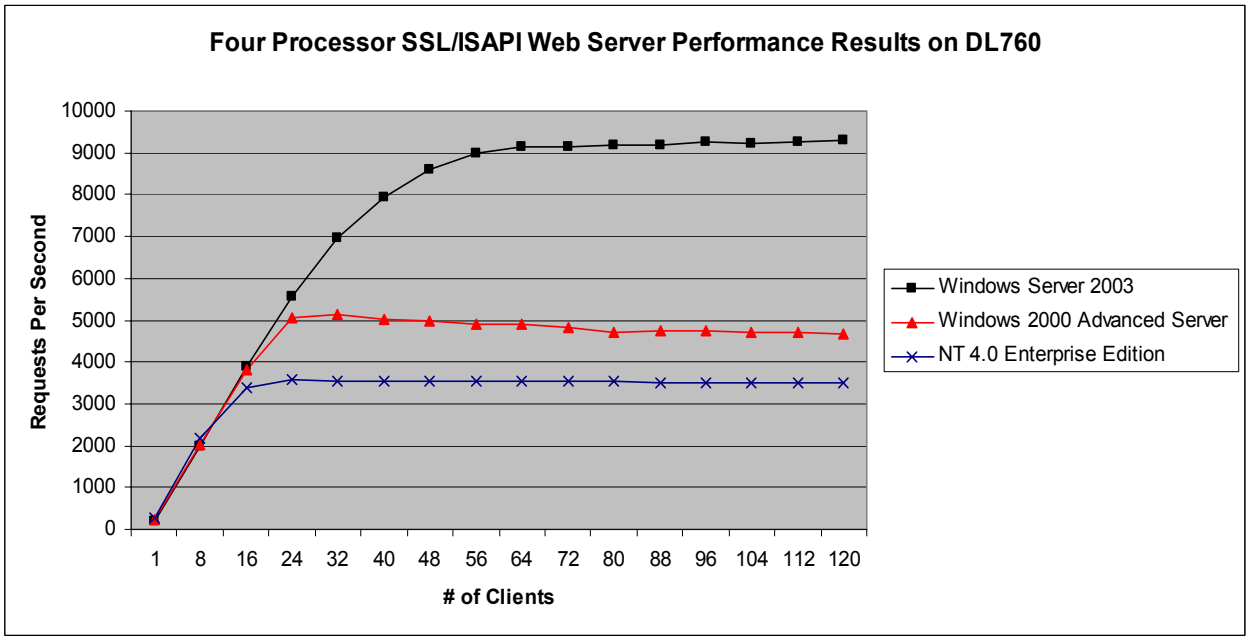

Figure 48. Four Processor SSL/ISAPI-based Web Server Performance Results on DL760

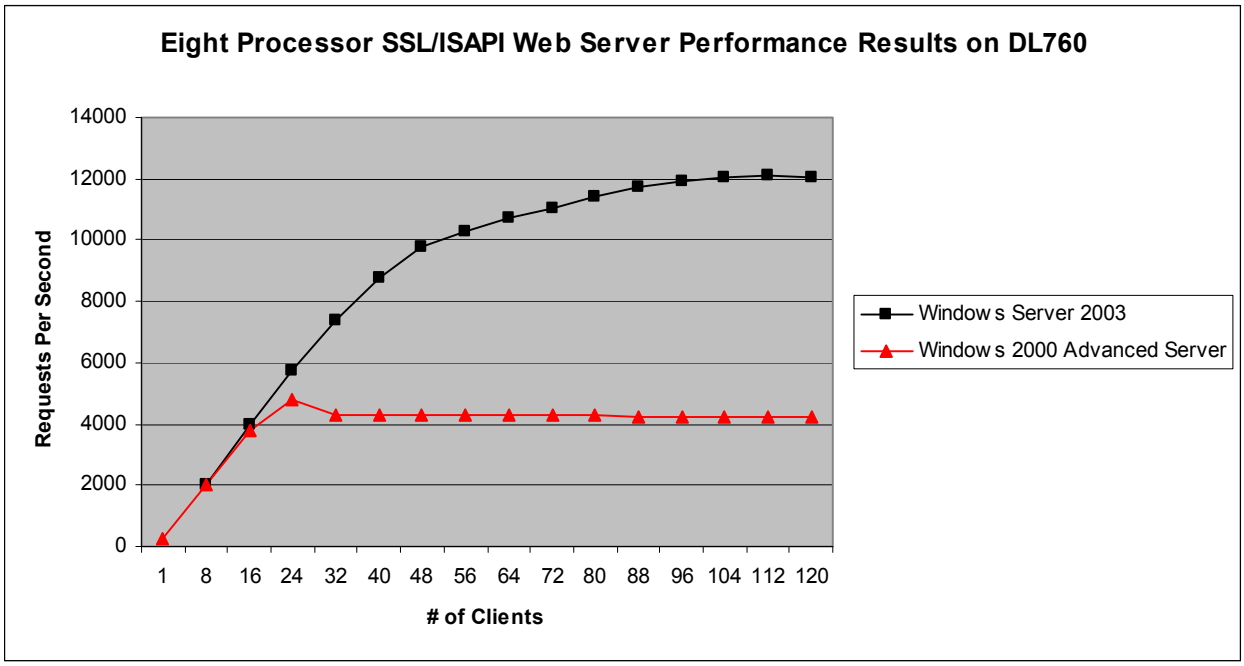

Figure 49. Eight Processor SSL/ISAPI-based Web Server Performance Results on DL760

SSL/CGI-based Content Results

We conducted these tests by configuring the WebBench test clients to make 76 percent of their requests for static content, 16 percent for a simple CGI executable and the remaining 8 percent for static and CGI-based content using SSL 3.0 for secure Web server communications. Figure 50 shows the peak request per second values generated on both the DL380 and DL760 server using all operating system and processor combinations we tested.

We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak Web serving performance using the SSL/CGI-based content compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

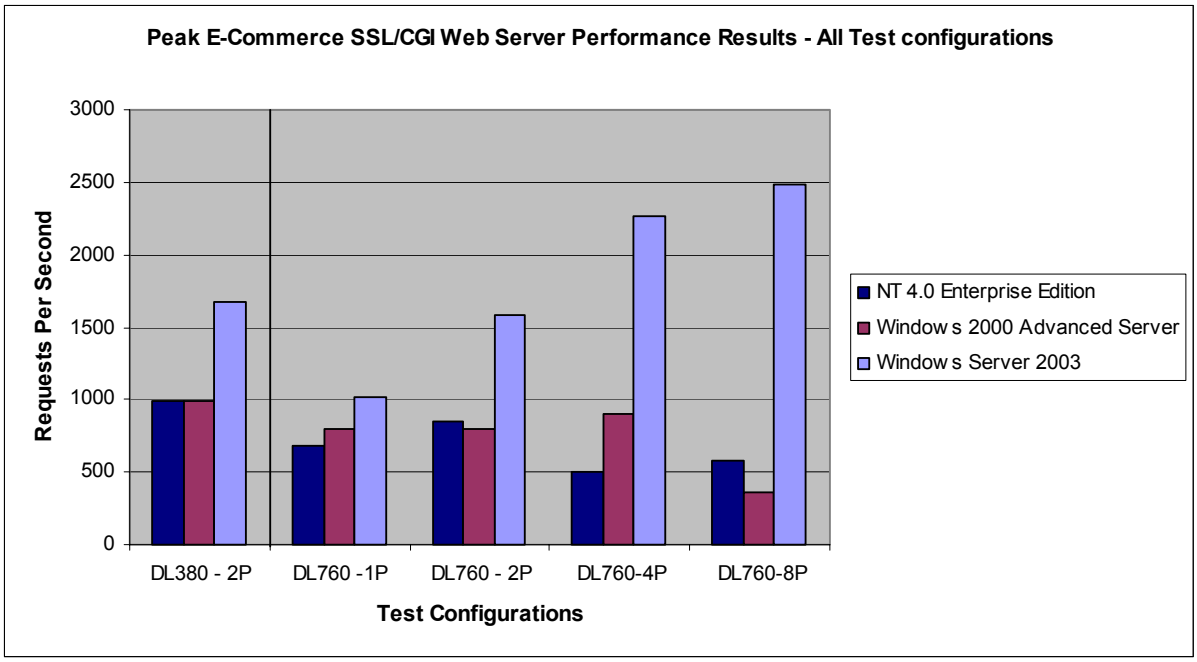

Figure 50. Peak SSL/CGI-based Web Server Performance On All Test Configurations

Figure 51 below shows the actual peak WebBench CGI Web server performance results in requests per second generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 51 shows the percentage improvement in CGI-based Web server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant performance improvements are possible when serving a combination of static and SSL/CGI-based Web content when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that significant performance improvements are possible when adding additional processor resources to a Web server running Windows Server 2003 serving a combination of static and SSL/CGI-based Web content.

Operating System	DL380 - 2P Req/Sec	DL760 -1P Req/Sec	DL760 - 2P Req/Sec	DL760-4P Req/Sec	DL760-8P Req/Sec
Windows Server 2003	1668	1020	1580	2268	2480
Windows 2000 Advanced Server	988	796	804	906	361
NT 4.0 Enterprise Edition	989	682	852	505	577
Percent Improvement vs. NT 4.0 Enterprise Edition	69%	50%	85%	349%	330%
Percent Improvement vs. Windows 2000 Advanced Server	69%	28%	97%	150%	587%

Figure 51. Peak E-Commerce SSL/CGI Web Server Performance and Percentage Improvement of Windows Server 2003 in SSL/CGI Web Server Performance Data On All Test Configurations

Figure 52 below shows the results of the SSL/CGI content testing on the DL380 server platform for all operating systems tested using the standard, single threaded CGI test suite. These results show that using the single-threaded SSL/CGI test suite, Windows Server 2003 delivered the best overall Web serving performance of all platforms tested.

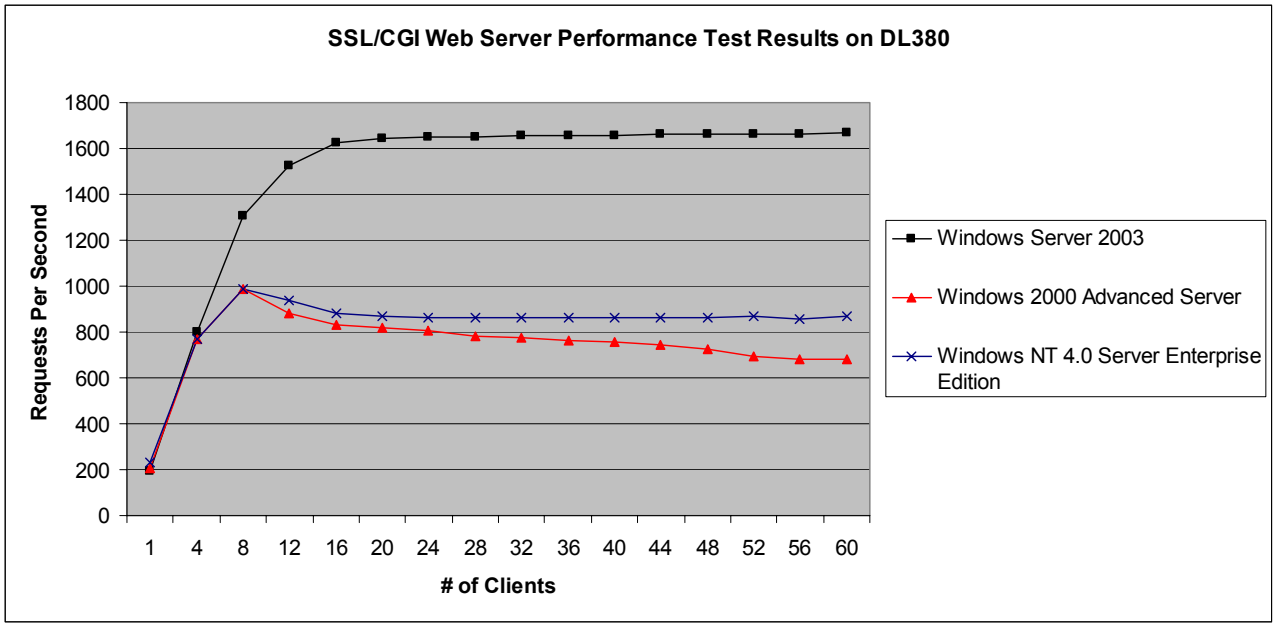

Figure 52. SSL/CGI-based Web Server Performance Results on DL380

Figures 53 - 56 below display the full set of WebBench data for the SSL/CGI Web server performance results on the DL760 server platform for all operating systems and processor configurations using 1, 2, 4 and 8 processors. These results show that, in addition to providing superior peak SSL/CGI Web server performance, Windows Server 2003 provides significantly better SSL/CGI Web serving performance at lower, medium and high client loads compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

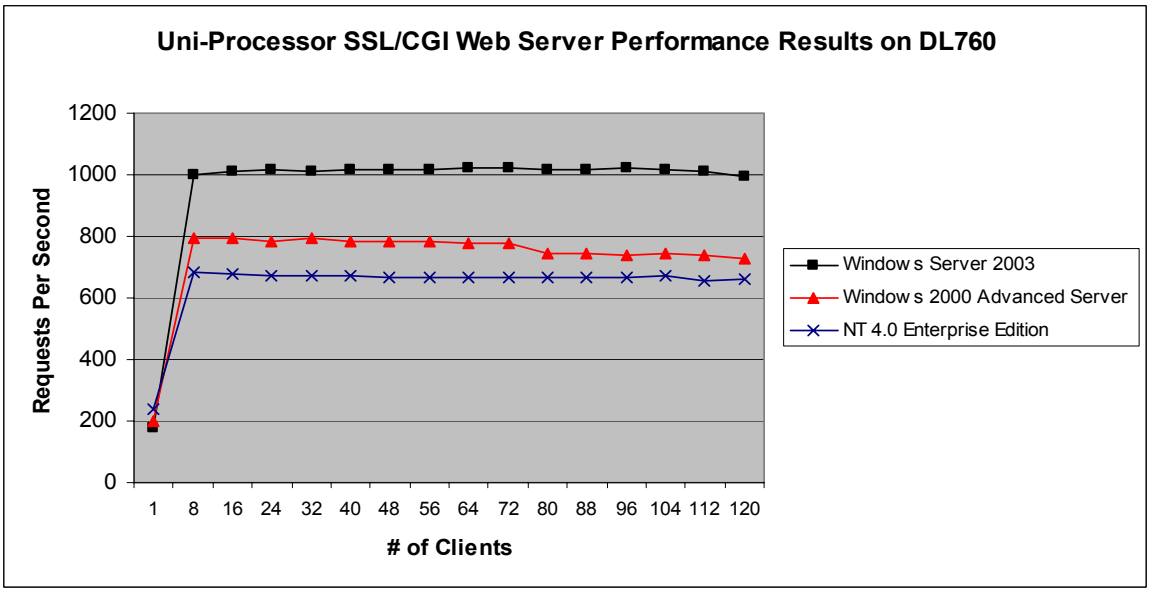

Figure 53. Uni-Processor SSL/CGI-based Web Server Performance Results on DL760

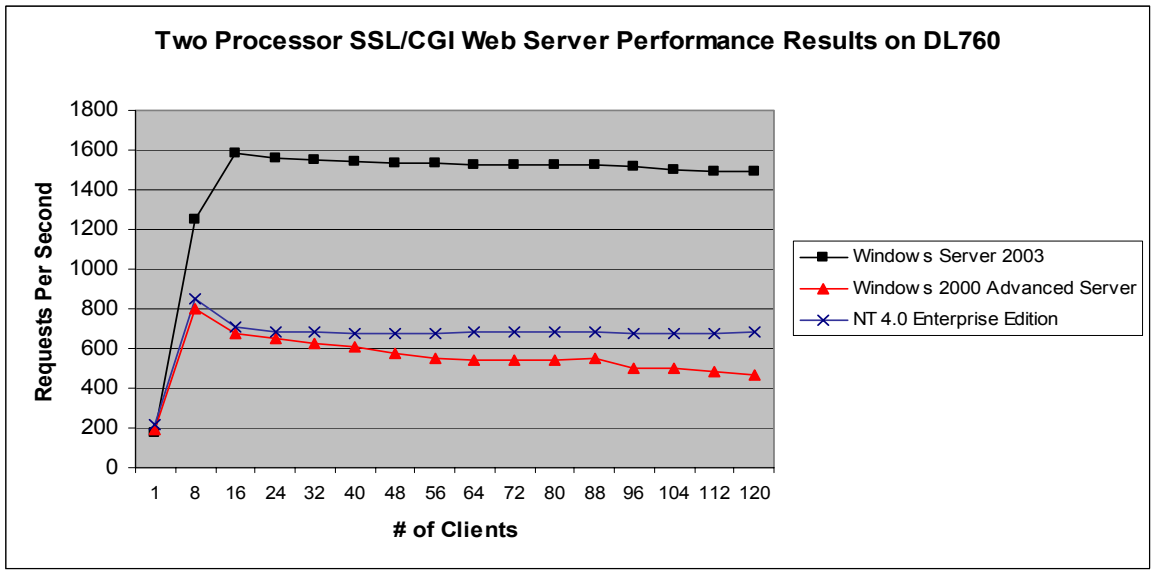

Figure 54. Two Processor SSL/CGI-based Web Server Performance Results on DL760

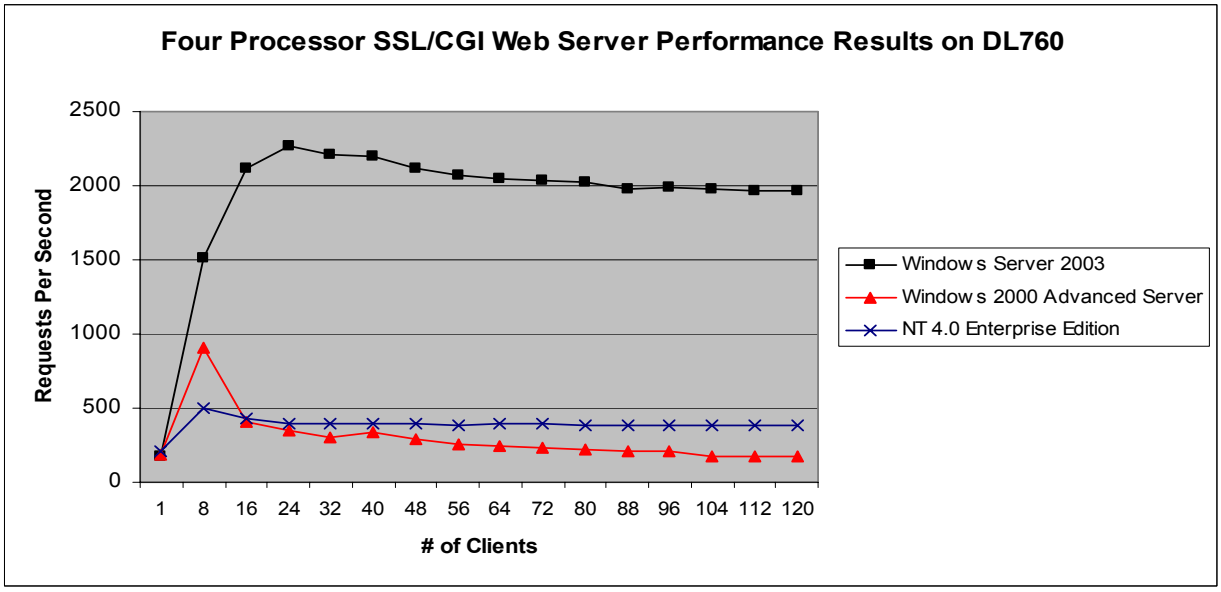

Figure 55. Four Processor SSL/CGI-based Web Server Performance Results on DL760

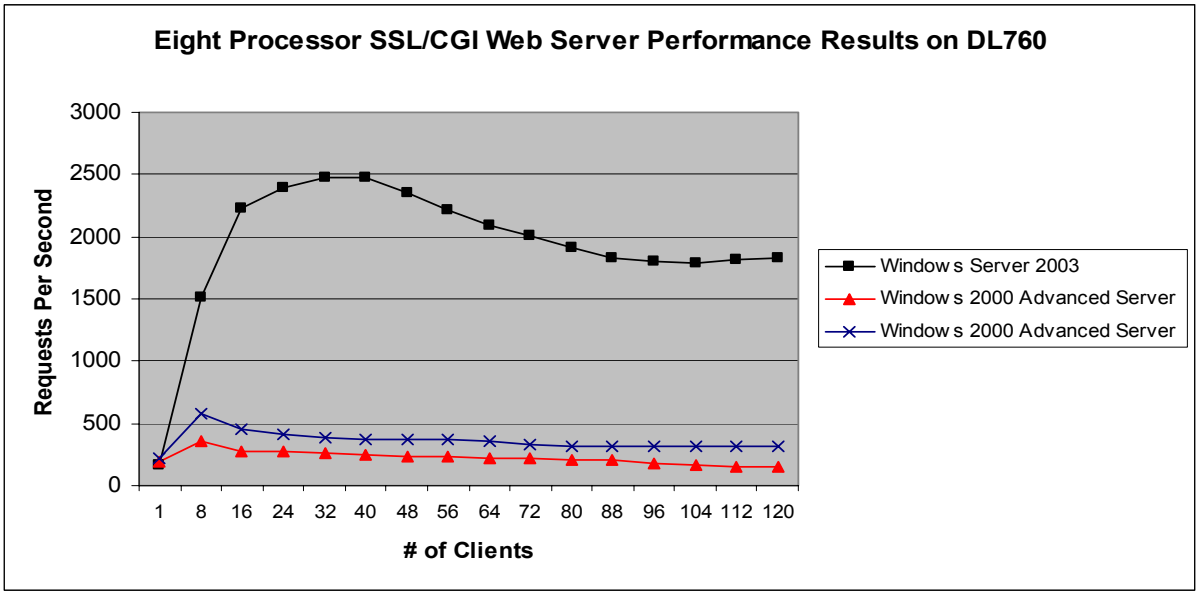

Figure 56. Eight Processor SSL/CGI-based Web Server Performance Results on DL760

File Server Performance Test Results

This section summarizes the File server performance results. The charts below display the peak throughput values generated during each type of File server performance testing in megabits per second (Mbps). Please refer to the Test Methodology section of this report for complete details on the NetBench test suites used to generate these test results. Refer to Test Results section for complete test results.

Figure 57 shows the peak throughput values generated on both the DL380 and DL760 server using all operating system and processor combinations we tested. In addition to the tests we conducted using Intel PRO/1000 MF Server Adapters, we also conducted a set of file server performance tests using Windows Server 2003 after configuring the DL760 server containing eight processors with a set of eight Alacritech gigabit network adapters that provided TCP Offload Engine (TOE) technology. This technology allows the normal TCP related activity normally processed by software to be off-loaded to the network adapter where it is processed by specialized hardware. This allows improved overall performance.

We found that regardless of the server employed or the number of processors, Windows Server 2003 generated significantly better peak File serving performance compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition. Additionally, we found that using the Alacritech network adapters resulted in a performance improvement of approximately 26 percent compared to using the Intel PRO/1000 MF Server Adapters.

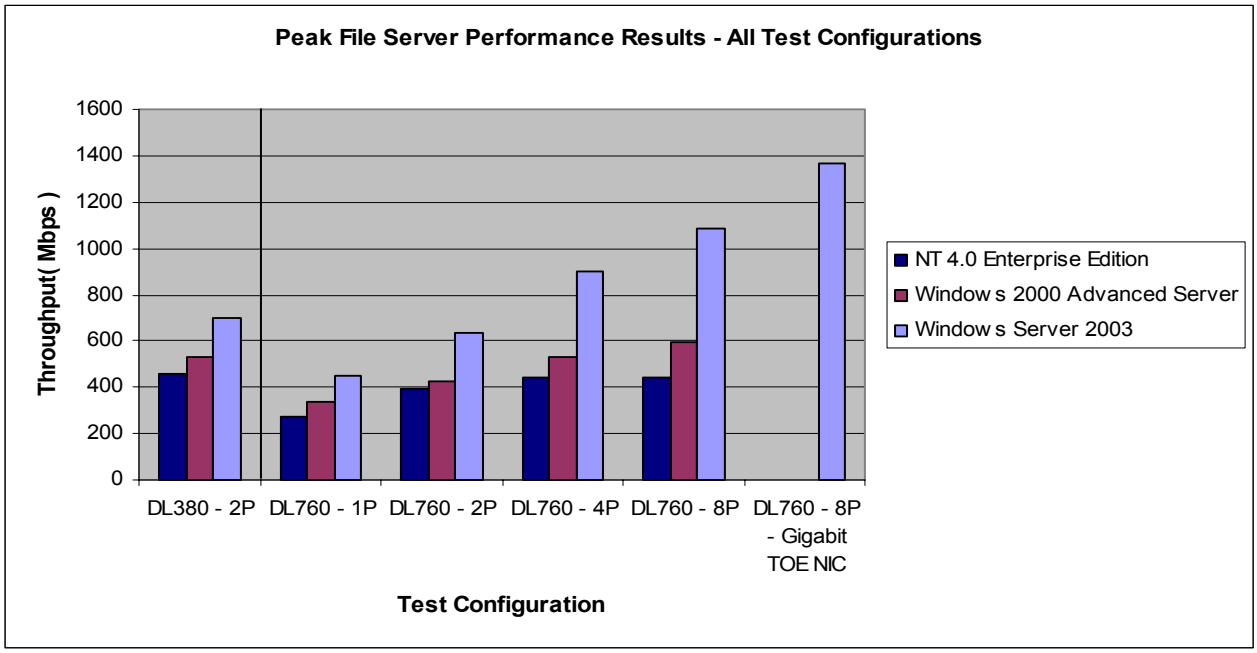

Figure 57. Peak File Server Performance On All Test Configurations

Figure 58 below shows the actual peak File server performance throughput results in megabits per second (Mbps) generated on both the DL380 and DL760 server using all operating system and processor combinations. Additionally, figure 58 shows the percentage improvement in File server performance when testing with Windows Server 2003 compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

These results clearly show that significant file serving performance improvements are possible when moving from either Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition to Windows Server 2003. Additionally, these results show that significant file serving performance improvements are possible when adding additional processor resources to a server running Windows Server 2003.

We did not conduct tests using the Alacritech network adapters on Windows 2000 Advanced Server or NT 4.0 Server Enterprise Edition.

Operating System	DL380 - 2P (Mbps)	DL760 - 1P (Mbps)	DL760 - 2P (Mbps)	DL760- 4P (Mbps)	DL760- 8P (Mbps)	DL760 - 8P GB TOE NIC (Mbps)
Windows Server 2003	700	453	632	901	1088	1370
Windows 2000 Advanced Server	532	336	427	533	591	N/A
NT 4.0 Enterprise Edition	457	277	397	446	439	N/A
Percent Improvement vs. NT 4.0 Enterprise Edition	53%	64%	59%	102%	148%	N/A
Percent Improvement vs. Windows 2000 Advanced Server	32%	35%	48%	69%	84%	N/A

Figure 58. Peak File Server Performance and Percentage Improvement of Windows Server 2003 in File Server Performance On All Test Configurations

Figure 59 below shows the results of the File server performance testing on the DL380 server platform for all operating systems tested using the standard NetBench Enterprise Disk Mix Test suite. These results show that Windows Server 2003 delivered the best overall File serving performance of all platforms tested.

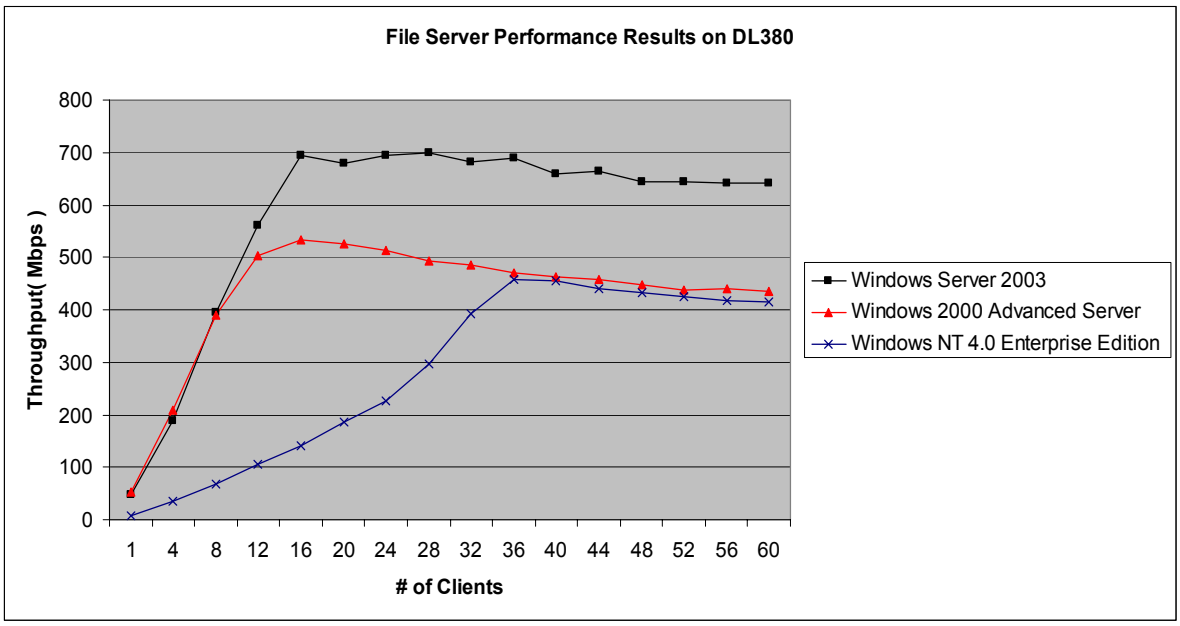

Figure 59. File Server Performance Results on DL380

Figures 60 - 63 below display the full set of NetBench data for the File server performance results on the DL760 server platform for all operating systems and processor configurations using 1, 2, 4 and 8 processors. These results show that, in addition to providing superior peak File server performance, Windows Server 2003 provides significantly better File server performance at lower, medium and high client loads compared to Windows 2000 Advanced Server and NT 4.0 Server Enterprise Edition.

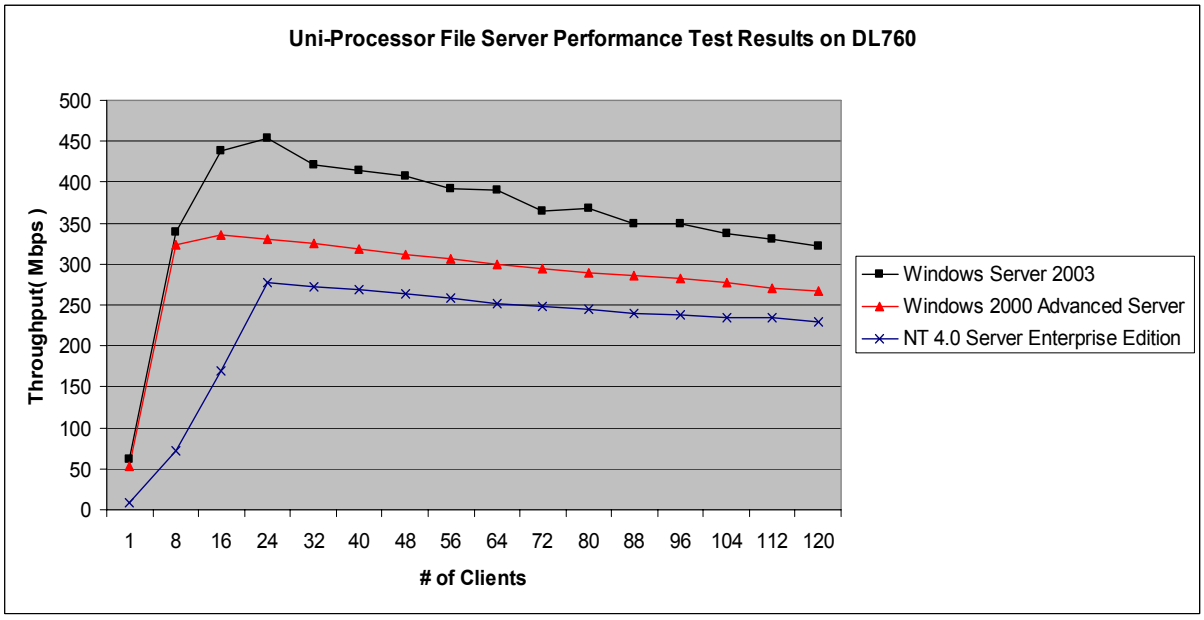

Figure 60. Uni-Processor File Server Performance Test Results on DL760

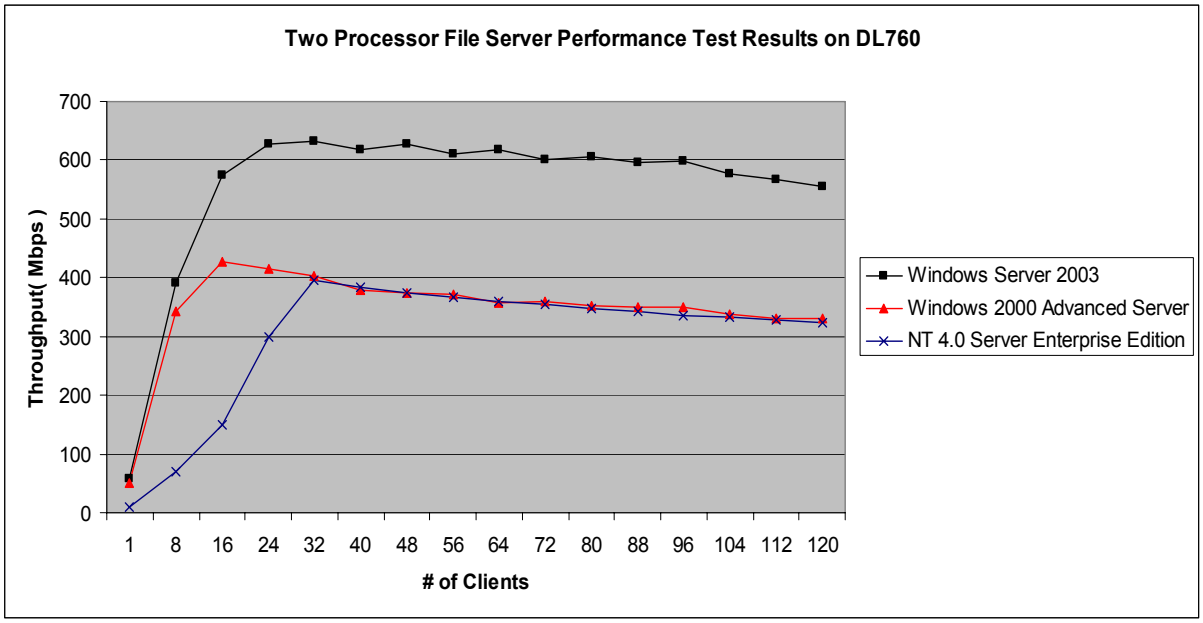

Figure 61. Two Processor File Server Performance Test Results on DL760

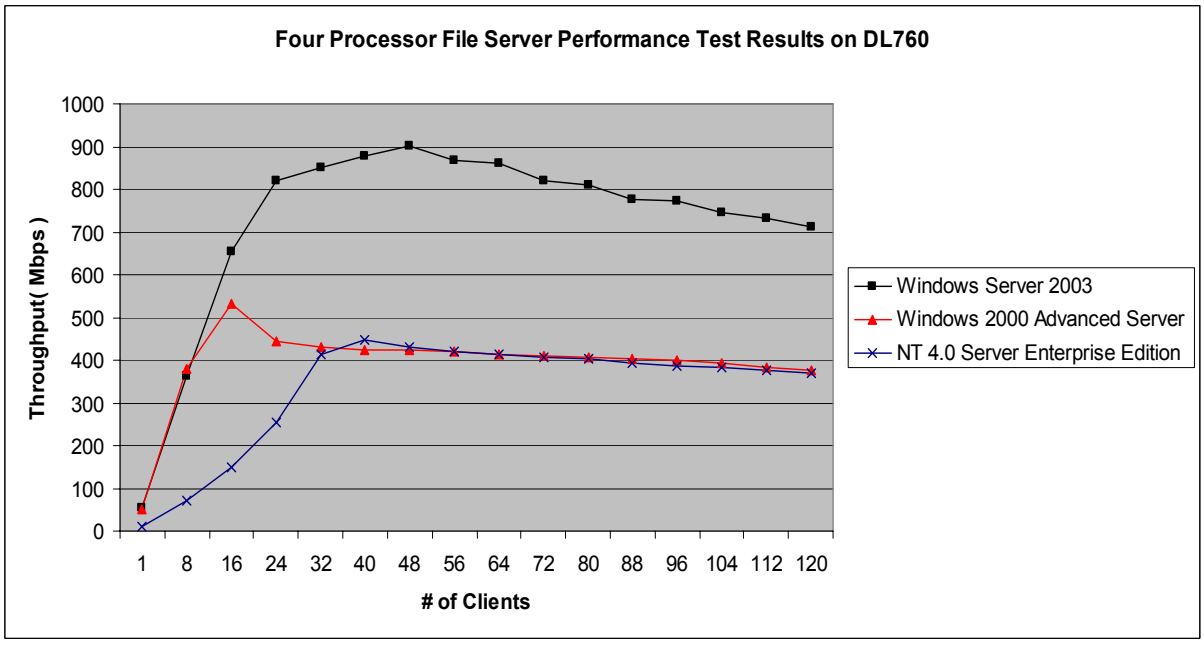

Figure 62. Four Processor File Server Performance Test Results on DL760

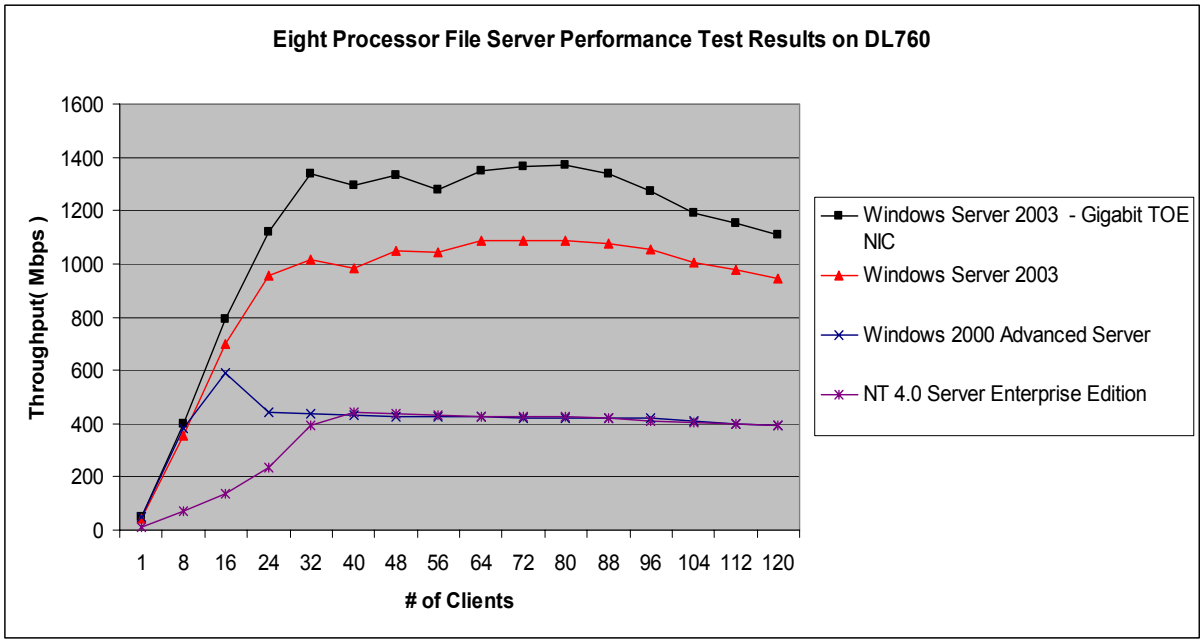

Figure 63. Eight Processor File Server Performance Test Results on DL760

Directory Server Performance Testing Results

This section summarizes the Directory server performance results generated using DirectoryMark 1.2. Please refer to the Test Methodology section of this report for complete details on the DirectoryMark test mixes used to generate these test results.

Figure 64 below shows the results of the DirectoryMark Messaging test mix for both Windows Server 2003 and Windows 2000 Advanced Server using all tested processor combinations. We found that Windows Server 2003 generated significantly better performance compared to Windows 2000 Advanced Server when testing with the Messaging Mix.

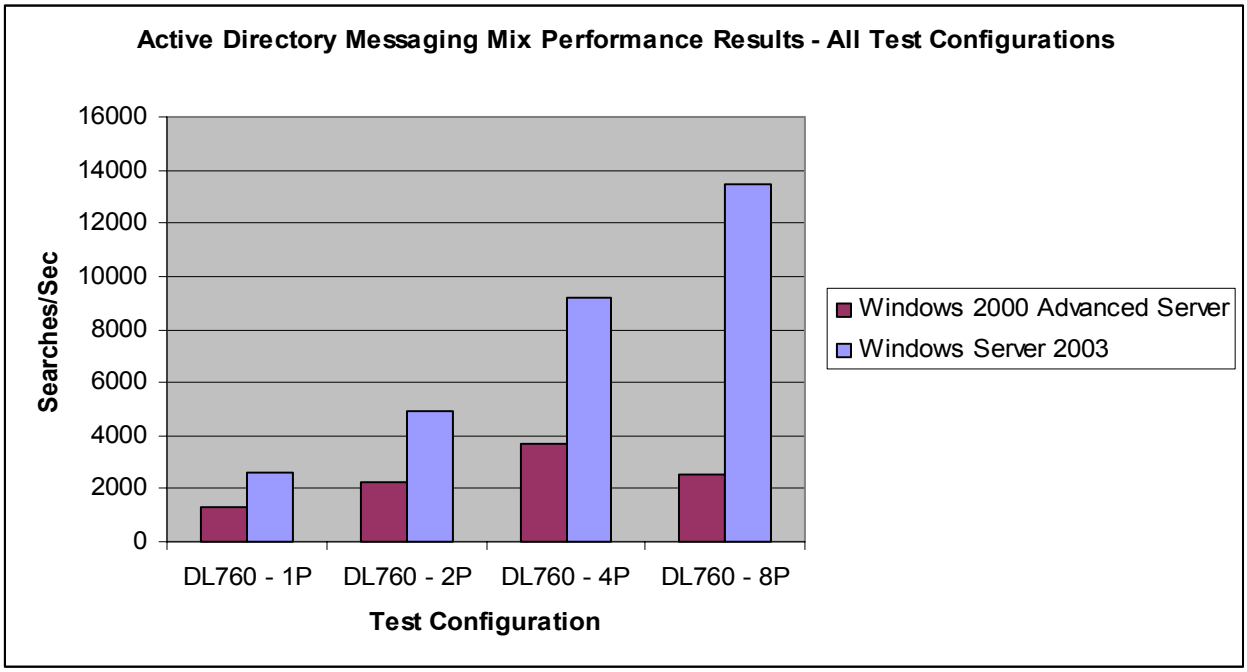

Figure 64. Active Directory Messaging Mix Performance Results – All Test Configurations

Figure 65 below shows the actual results of the DirectoryMark Messaging test mix for both Windows Server 2003 and Windows 2000 Advanced Server using all tested processor combinations. Additionally, figure 65 shows the percentage increase in searches/sec using Windows Server 2003 compared to Windows 2000 Advanced Server. In all test configurations Windows Server 2003 generated a minimum of 100 percent better performance compared to Windows 2000 Advanced Server and, when using eight processors, generated 439 percent better performance using the Messaging Mix compared to Windows 2000 Advanced Server.

Operating System	DL760 - 1P	DL760 - 2P	DL760 - 4P	DL760 - 8P
Windows Server 2003 (searches/sec)	2637	4889	9159	13482
Windows 2000 Advanced Server (searches/sec)	1307	2268	3677	2501
Percent Increase in Searches/Sec using Windows Server 2003	102%	116%	149%	439%

Figure 65. Directory Server Performance Test Results – Messaging Test

Figure 66 below shows the results of the DirectoryMark Addressing test mix for both Windows Server 2003 and Windows 2000 Advanced Server using all tested processor combinations. We found that Windows Server 2003 generated significantly better performance compared to Windows 2000 Advanced Server when testing with the Addressing Mix.

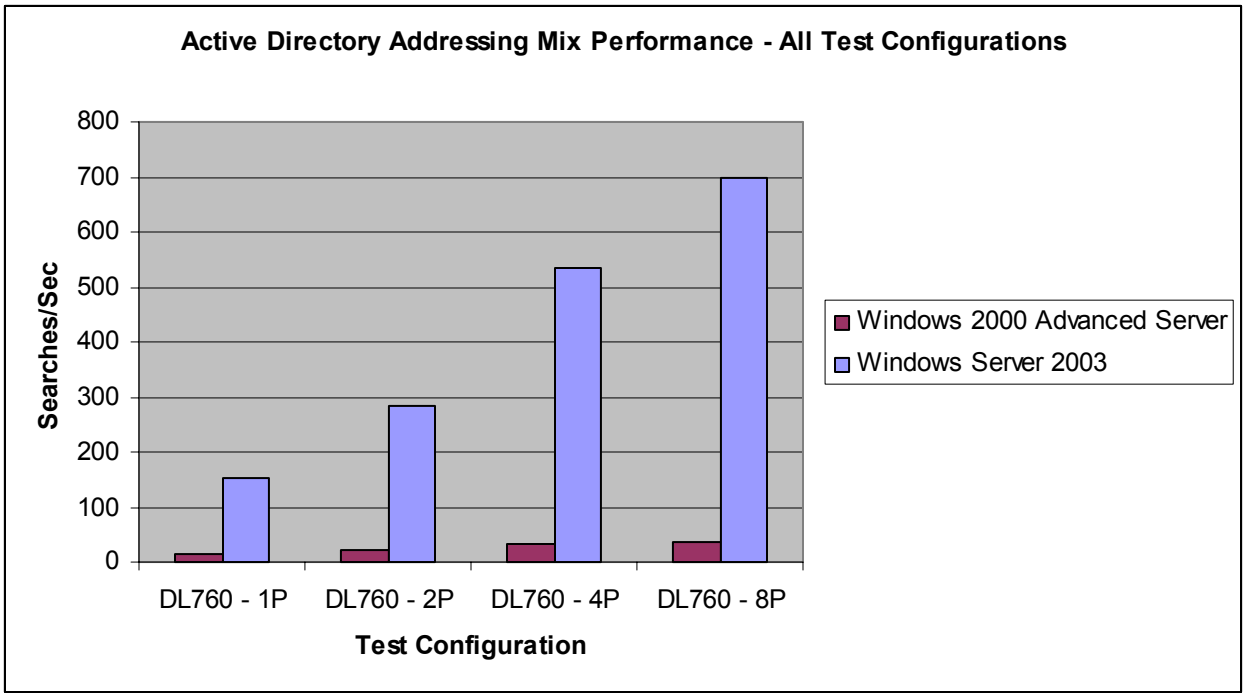

Figure 66. Active Directory Addressing Mix Performance – All Test Configurations

Figure 67 below shows the actual results of the DirectoryMark Addressing test mix for both Windows Server 2003 and Windows 2000 Advanced Server using all tested processor combinations. In all test configurations Windows Server 2003 generated a minimum of 926 percent (10.3x) better performance compared to Windows 2000 Advanced Server and, when using eight processors, generated 1786 percent (18.9x) better performance using the Addressing Mix compared to Windows 2000 Advanced Server SP3.

Operating System	DL760 - 1P	DL760 - 2P	DL760 - 4P	DL760 - 8P
Windows Server 2003 (searches/sec)	154	284	534	698
Windows 2000 Advanced Server (searches/sec)	15	22	32	37
Percent Increase in Searches/Sec using Windows Server 2003	926% (10.3x)	1190% (12.9x)	1569% (16.7x)	1786% (18.9x)

Figure 67. Directory Server Performance Test Results – Addressing Test

Appendix A. Test Server and Network Client Configuration Information

Network Testbed Clients	
Machine Type	Dell PowerEdge 350
BIOS	Intel
Processor(s)	Intel PIII 850MHz
Hard Drive	10GB IDE
Memory	256MB
L2 Cache	256K
Motherboard	Intel
Network Adapter(s)	Intel Pro100 Management Adapter
Video Card	NVIDIA GeForce2 MX
OS	Windows XP/SP1

Figure 68. Network Testbed Client Disclosure Information

DL760 – 8P Configuration Information	
Machine Type	Compaq DL760
BIOS	Compaq
Hard Drive	4 x 36GB 15,000 RPM Ultra3 SCSI
Processor(s)	8 x Intel 900Mhz Pentium III Xeon
Memory	4GB
L2 Cache	2MB
Motherboard	Intel
Network Adapter(s)	8 x Intel PRO 1000 MF Server Adapters
Video Card	ATI 3D RAGE II PCI
OS	Windows Server 2003, Windows 2000 Advanced Server with SP3, Windows NT 4.0 Enterprise Edition with SP6a

Figure 69. DL760 – 8P Server Disclosure Information

DL760 – 1, 2 , and 4P Configuration Information	
Machine Type	HP Proliant DL760
BIOS	Compaq
Hard Drive	4 x 36GB 15,000 RPM Ultra3 SCSI
Processor(s)	4 x Intel 900Mhz Pentium III Xeon
Memory	4GB
L2 Cache	2MB
Motherboard	Intel
Network Adapter(s)	4 x Intel PRO 1000 MF Server Adapters
Video Card	ATI 3D RAGE II PCI
OS	Windows Server 2003, Windows 2000 Advanced Server with SP3, Windows NT 4.0 Enterprise Edition with SP6a

Figure 70. DL760 – 1P, 2P, and 4P Server Disclosure Information

DL380 – 2P Configuration Information	
Machine Type	HP ProLiant DL380 G2
BIOS	Compaq
Processor(s)	2 x Pentium III 1.4 GHz
Hard Drive	6 x 36GB 15,000 RPM Ultra3 SCSI
Memory	2GB
L2 Cache	512K
Motherboard	Intel
Network Adapter(s)	2 x Intel PRO 1000 MF Server Adapters
Video Card	ATI 3D RAGE II PCI
OS	Windows Server 2003, Windows 2000 Advanced Server with SP3, Windows NT 4.0 Enterprise Edition with SP6a

Figure 71. DL380-2P Server Disclosure Information

Appendix B. Operating System Installation and Configuration for NetBench and WebBench Testing

This section describes the basic steps we performed to install each of the operating systems used during these tests. Regardless of the operating system used, we configured the RAID subsystems on each server the same way for all testing using HP's SmartStart 6.0 utility and selecting the defaults as shown in figure 72 below.

RAID Controller Parameter	Value
Expanded Priority	Low
Rebuild Priority	Low
Cache Ratio	50% READ / 50% WRITE
Stripe Size	128K

Figure 72. Default RAID Controller Parameters

For the DL760 server configured with eight processors, we configured the 28 drives connected to the SmartArray 5300 controller into four logical RAID 0 data volumes of approximately 121 GB each. Each logical volume was created using the default RAID controller parameters listed in figure 72. After installing the specific operating system, we used the disk management utilities to create two basic volumes on each of the four 121GB logical RAID 0 volumes for a total of eight volumes of approximately 60GB each. Each of the eight volumes was formatted as an NTFS volume using a 64K byte block size and quick format.

For the DL760 server configured with four processors, we configured the 28 drives connected to the SmartArray 5300 controller into four logical RAID 0 data volumes of approximately 121 GB each. Each logical volume was created using the default RAID controller parameters listed in figure 72. After installing the specific operating system, we used the disk management utilities to create one basic volume on each of the four 121GB logical RAID 0 volumes for a total of four volumes of approximately 121GB each. Each of the four volumes was formatted as an NTFS volume using a 64K byte block size and quick format.

Additionally, for the DL760 servers, we configured one of the four physical drives connected to the embedded SmartArray 5i as a volume of approximately 36GB using default RAID controller parameters. The operating system was installed on this single 36GB volume.

For the DL380 server configured with two processors, we configured four drives connected to the SmartArray 5i controller into a single logical RAID 0 data volume of approximately 140 GB using the default RAID

controller parameters described above. After installing the specific operating system, we used the disk management utilities to create four basic volumes on the single logical RAID 0 volume each approximately 36GB. We formatted each volume as an NTFS volume using a 32K byte block size and quick format.

For the DL380 server, we configured one of the six physical drives into a logical volume of approximately 36GB using the default RAID controller parameters. The operating system was installed on this volume.

Regardless of the server or operating system used, we increased the size of the NTFS log file to 64K bytes for each data volume using the following command:

```
Chkdsk /x <drive>: /l:65536
```

The following sections describe the specific steps we took to install the operating systems used in these tests.

Windows Server 2003

Microsoft provided a fully functional copy of Windows Server 2003 for these tests. To install this operating system, we performed the following steps:

- Using SmartStart 6.0, selected Microsoft .NET as the operating system to install and began the installation process
- During installation, configured the network parameters to match the client testbed segments.
- Installed the intfltr.sys processor affinity module and configured it such that each network adapter in the server was bound to one and only one processor.
- Configured the RAID subsystem as described above.

Windows 2000 Advanced Server with Service Pack 3

- Using SmartStart 6.0, selected Windows 2000 Advanced Server as the operating system to install and began the installation process
- During installation, configured the network parameters to match the client testbed segments.
- After installation, installed Service Pack 3.
- Installed updated Intel network adapter drivers(version 6.2.21.0).
- Set Number of Coalesce Buffers = 512 for each NIC
- Set Number of Receive Buffers = 768 for each NIC
- Set Number of Transmit Descriptors = 512 for each NIC
- Installed the intfltr.sys processor affinity module and configured such that each network adapter in the server was bound to one and only one processor.
- Configured the RAID subsystem as described above.

Windows NT 4.0 Enterprise Edition with Service Pack 6a

- Using SmartStart 6.0, selected Windows NT 4.0 Enterprise Edition as the operating system to install and began the installation process.
- During installation, configured the network parameters to match the client testbed segments.
- After installation, installed the NT 4.0 Option Pack. This installed Service Pack 3 and Internet Information Server(IIS) version 4.0.
- Installed Service Pack 6a.
- Installed NT 4.0 hot fixes.
- Installed updated network adapter drivers (version 6.2.21.0).
- Set Number of Coalesce Buffers = 512 for each NIC
- Set Number of Receive Buffers = 768 for each NIC
- Set Number of Transmit Descriptors = 512 for each NIC
- Installed the intbind.sys processor affinity module and configured such that each network adapter in the server was bound to one and only one processor.

- Configured the RAID subsystem as described above.

Appendix C. Operating System Installation and Configuration for DirectoryMark Testing

This section describes the basic steps we performed to install each of the operating systems used during the DirectoryMark tests. Regardless of the operating system used, we configured the RAID subsystems on each server the same way for all testing using HP's SmartStart 6.0 utility and selecting the defaults as shown in figure 73 below.

RAID Controller Parameter	Value
Expanded Priority	Low
Rebuild Priority	Low
Cache Ratio	50% READ / 50% WRITE
Stripe Size	128K

Figure 73. Default RAID Controller Parameters

For the DL760 server configured with eight processors, we configured the 28 drives connected to the SmartArray 5300 controller into four logical RAID 0 data volumes of approximately 121 GB each. Each logical volume was created using the default RAID controller parameters listed in figure 73. After installing the specific operating system, we used the disk management utilities to create one basic volumes on each of the four 121GB logical RAID 0 volumes for a total of four volumes of approximately 121GB each. Each of the four volumes was formatted as an NTFS volume using a 64K byte block size and quick format.

For the DL760 server configured with four processors, we configured the 28 drives connected to the SmartArray 5300 controller into four logical RAID 0 data volumes of approximately 121 GB each. Each logical volume was created using the default RAID controller parameters listed in figure 73. After installing the specific operating system, we used the disk management utilities to create one basic volume on each of the four 121GB logical RAID 0 volumes for a total of four volumes of approximately 121GB each. Each of the four volumes was formatted as an NTFS volume using a 64K byte block size and quick format.

Additionally, for the DL760 servers, we configured one of the four physical drives connected to the embedded SmartArray 5i as a volume of approximately 36GB using default RAID controller parameters. The operating system was installed on this single 36GB volume.

Regardless of the server or operating system used, we increased the size of the NTFS log file to 64K bytes for each data volume using the following command:

```
Chkdsk /x <drive>: /l:65536
```

The following sections describe the specific steps we took to install the operating systems used in these tests.

Windows Server 2003

Microsoft provided a fully functional copy of Windows Server 2003 for these tests. To install this operating system, we performed the following steps:

- Using SmartStart 6.0, selected Microsoft .NET as the operating system to install and began the installation process
- During installation, configured the network parameters to match the client testbed segments.
- Configured the RAID subsystem as described above.

Windows 2000 Advanced Server with Service Pack 3

- Using SmartStart 6.0, selected Windows 2000 Advanced Server as the operating system to install and began the installation process
- During installation, configured the network parameters to match the client testbed segments.
- After installation, installed Service Pack 3.
- Installed updated Intel network adapter drivers (version 6.2.21.0).
- Configured the RAID subsystem as described above.

Appendix D. Web Server Performance Tunings

For the Web server performance testing, we performed a series of operating system and Web server tunings as specified by documentation provided from Microsoft. This information is generally available to the public and can be found on the Microsoft Web site.

Windows Server 2003

Web server performance testing under Windows Server 2003 Enterprise Edition consisted of making the following registry modifications to the server systems under test:

- Set HKLM\System\CurrentControlSet\Services\InetInfo\Parameters\MaxCachedFileSize to 1048576 bytes.
- Set HKLM\System\CurrentControlSet\Services\HTTP\Parameters\UriMaxUriBytes to 1048576 bytes.
- Set HKLM\System\CurrentControlSet\Control\FileSystem\NtfsDisableLastAccess to 1.
- Set HKLM\System\CurrentControlSet\Services\tcpip\Parameters\MaxHashTableSize to 65535.

We made the following registry changes on the testbed client systems running Windows XP Professional and Service Pack 1:

- Set HKLM\System\CurrentControlSet\Services\tcpip\Parameters\MaxHashTableSize to 65535.
- Set HKLM\System\CurrentControlSet\Services\tcpip\Parameters\MaxUserPort to 65534.
- Set HKLM\System\CurrentControlSet\Services\tcpip\Parameters\TcpWindowSize to 65536.

Additionally, we made the following changes to the default configuration of Internet Information Server (IIS) 6.0 for use with all tests:

- Set the CentralBinaryLoggingEnabled option to “TRUE” in the IIS Metabase.
- Using the Microsoft Management Console, removed script and execute access from the document root directory that contained only static content.
- Using the Microsoft Management Console, disabled the “Index This Resource” property for the main Web server.
- Using the Microsoft Management Console, disabled access logging for the web server.
- Created a virtual directory called “cgi-bin” to store the WebBench ISAPI and CGI based dynamic content for all tests.
- Set the Application Protection property to “Low (IIS Process)” for the “cgi-bin” virtual directory.

Windows 2000 Advanced Server with Service Pack 3

Web server performance testing under Windows 2000 Advanced Server with Service Pack 3 consisted of making the following registry modifications to the server systems under test:

- Set HKLM\System\CurrentControlSet\Services\InetInfo\Parameters\ObjectCacheTTL to 3600 seconds

- Set HKLM\System\CurrentControlSet\Services\InteInfo\Parameters\MaxCachedFileSize to 1048576 bytes.
- Set the Application Response parameter to “Optimize Performance for Applications”.
- Set the File and Printer Sharing for Microsoft Networks parameter to “Optimize Performance for Applications”.

We made the following registry changes on the testbed client systems running Windows XP Professional and Service Pack 1:

- Set HKLM\System\CurrentControlSet\Services\tcpip\Parameters\MaxHashTableSize to 65535.
- Set HKLM\System\CurrentControlSet\Services\tcpip\Parameters\MaxUserPort to 65534.
- Set HKLM\System\CurrentControlSet\Services\tcpip\Parameters\TcpWindowSize to 65536.

Additionally, we made the following changes to the default configuration of Internet Information Server (IIS) 5.0 for use with all tests:

- Using the Microsoft Management Console, set the Internet Information Services performance parameter to 100,000+ hits per day.
- Using the Microsoft Management Console, removed script and execute access from the document root directory that contained only static data.
- Using the Microsoft Management Console, disabled the “Index This Resource” property for the main web server.
- Using the Microsoft Management Console, disabled access logging for the web server.
- Created a virtual directory called “cgi-bin” to store the WebBench ISAPI and CGI based dynamic content for all tests.
- Set the Application Protection property to “Low (IIS Process)” for the “cgi-bin” virtual directory.

Windows NT 4.0 Enterprise Edition with Service Pack 6a

Web server performance testing under Windows NT 4.0 Enterprise Edition with Service Pack 6a consisted of making the following registry modifications to the server systems under test:

- Set HKLM\System\CurrentControlSet\Services\InetInfo\Parameters\ObjectCacheTTL to 3600 seconds
- Set HKLM\System\CurrentControlSet\Services\InetInfo\Parameters\MaxCachedFileSize to 1048576 bytes.
- Set the Application Response parameter to “Optimize Performance for Applications”.
- Set the File and Printer Sharing for Microsoft Networks parameter to “Optimize Performance for Applications”.

Additionally, we made the following changes to the default configuration of Internet Information Server (IIS) 4.0 for use with all tests:

- Using the Microsoft Management Console, set the Internet Information Services performance parameter to 100,000+ hits per day.
- Using the Microsoft Management Console, removed script and execute access from the document root directory that contained only static data.
- Using the Microsoft Management Console, disabled the “Index This Resource” property for the main web server.
- Using the Microsoft Management Console, disabled access logging for the web server.
- Set the Application Protection property to “Low (IIS Process)” for the “cgi-bin” virtual directory.

We made the following registry changes on the testbed client systems running Windows XP Professional and Service Pack 1.

- Set HKLM\System\CurrentControlSet\Services\tcpip\Parameters\MaxHashTableSize to 65535.
- Set HKLM\System\CurrentControlSet\Services\tcpip\Parameters\MaxUserPort to 65534.
- Set HKLM\System\CurrentControlSet\Services\tcpip\Parameters\TcpWindowSize to 65536.

Appendix E. File Server Performance Tunings

For the File server performance testing, we performed a series of operating system and testbed client tunings as specified by documentation provided from Microsoft. This information is generally available to the public and can be found on the Microsoft Web site.

Windows Server 2003

File server performance testing under Windows Server 2003 consisted of making the following registry modifications to the server systems under test:

- HKLM\System\CurrentControlSet\Control\SessionManager\MemoryManagement\PagedPoolSize set to 192,000,000.
- HKLM\System\CurrentControlSet\Control\FileSystem\NtfsDisable8dot3NameCreation to 1.
- Created HKLM\System\CurrentControlSet\Control\FileSystem\Disablelastaccess and set to 1.
- Created HKLM\System\CurrentControlSet\Services\tcpip\Parameters\NumTcbTablePartitions and set to 8.
- Created HKLM\System\CurrentControlSet\Services\tcpip\Parameters\TcpAckFrequency and set to 13.

We made the following registry changes on the testbed client systems running Windows XP Professional and Service Pack 1:

- Created HKLM\System\CurrentControlSet\Services\tcpip\Parameters\TcpAckFrequency and set to 13.
- HKLM\System\CurrentControlSet\Services\Lanmanworkstation\Parameters\DisableByteRangeLockingOnReadOnlyFiles set to 1.
- HKLM\System\CurrentControlSet\Services\Lanmanworkstation\Parameters\DormantFileLimit set to 100.
- HKLM\System\CurrentControlSet\Services\Lanmanworkstation\Parameters\ScavengerTimeLimit set to 100.

Windows 2000 Advanced Server with Service Pack 3

File server performance testing under Windows 2000 Advanced Server with Service Pack 3 consisted of making the following registry modifications to the server systems under test:

- Set the Application Response parameter to “Optimize Performance for Background Services”. This is the default value of this option.
- Set the File and Printer Sharing for Microsoft Networks parameter to “Optimize Performance for File Sharing”. This is the default value of this option.
- HKLM\System\CurrentControlSet\Control\SessionManager\MemoryManagement\PagedPoolSize set to 192,000,000.

We performed no additional tuning on the Windows 2000 Professional SP3 clients used for these tests.

Windows NT 4.0 Enterprise Edition with Service Pack 6a

File server performance testing under Windows NT 4.0 Enterprise Edition with Service Pack 6a and hot fixes consisted of making the following registry modifications to the server systems under test:

- Set the Application Response parameter to “Optimize Performance for Background Services”. This is the default value of this option.
- Set the File and Printer Sharing for Microsoft Networks parameter to “Optimize Performance for File Sharing”. This is the default value of this option.
- HKLM\System\CurrentControlSet\Control\SessionManager\MemoryManagement\PagedPoolSize set to 192,000,000.

We performed no additional tuning on the NT 4.0 Workstation clients used for these tests.

Appendix F. Active Directory Server Performance Tunings

For the Directory server performance testing, we performed a series of operating system and client tunings as specified by Microsoft for both Windows Server 2003 and Windows 2000 Advanced Server SP3.

Windows Server 2003

LDAP Directory server performance testing under Windows Server 2003 consisted of making the following registry modifications to the server systems under test:

- HKLM\SYSTEM\CurrentControlSet\Services\NTDS\Parameters\DSA Heuristics set to 1
- HKLM\SYSTEM\CurrentControlSet\Services\NTDS\RID Values\RID Block Size set to 32768
- HKLM\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters\MaxUserPort set to 65534
- HKLM\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters\TcpWindowSize set to 65535

Windows 2000 Advanced Server with Service Pack 3

File server performance testing under Windows 2000 Advanced Server with Service Pack 3 consisted of making the following registry modifications to the server systems under test:

- HKLM\SYSTEM\CurrentControlSet\Services\NTDS\Parameters\DSA Heuristics set to 1
- HKLM\SYSTEM\CurrentControlSet\Services\NTDS\RID Values\RID Block Size set to 32768
- HKLM\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters\MaxUserPort set to 65534
- HKLM\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters\TcpWindowSize set to 65535

We made the following registry changes on the HP DL760 client system running Windows Server 2003.

- HKLM\SYSTEM\CurrentControlSet\Services\ldap\ldapclientintegrity set to 0
- HKLM\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters\MaxUserPort set to 65534
- HKLM\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters\TcpWindowSize set to 65535

Appendix D. Network Testbed Diagrams

Figures 19-21 below show the testbed configurations for testing the servers described above for all processor configurations.

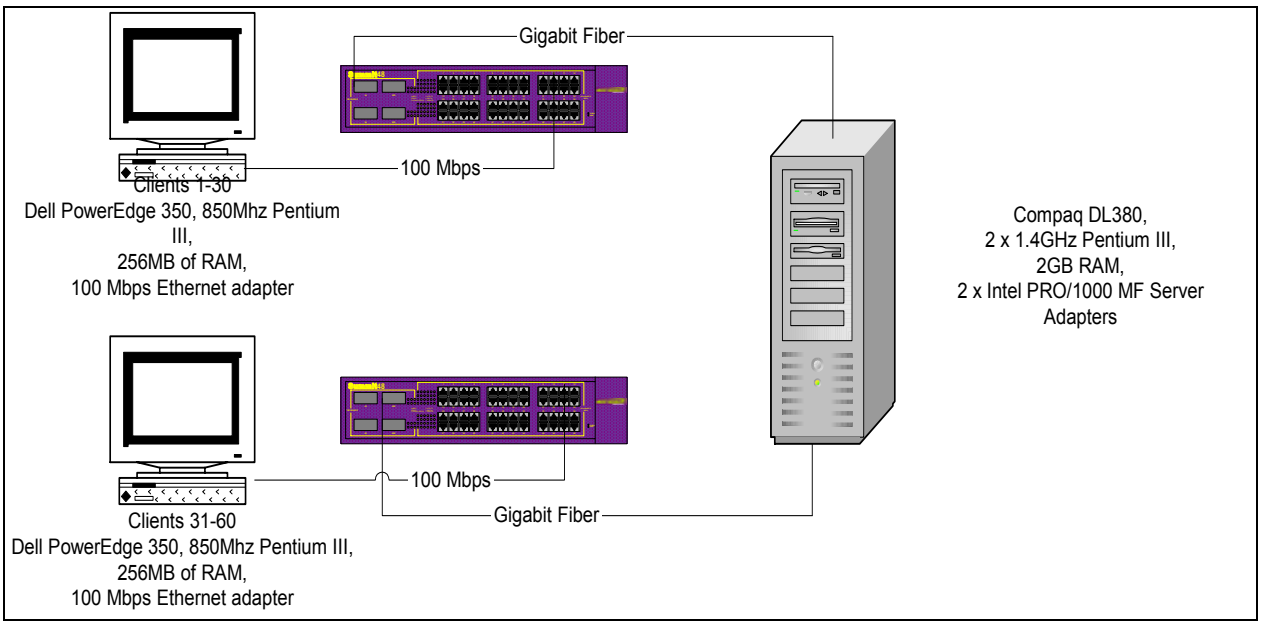

Figure 74. DL380 Test Configuration

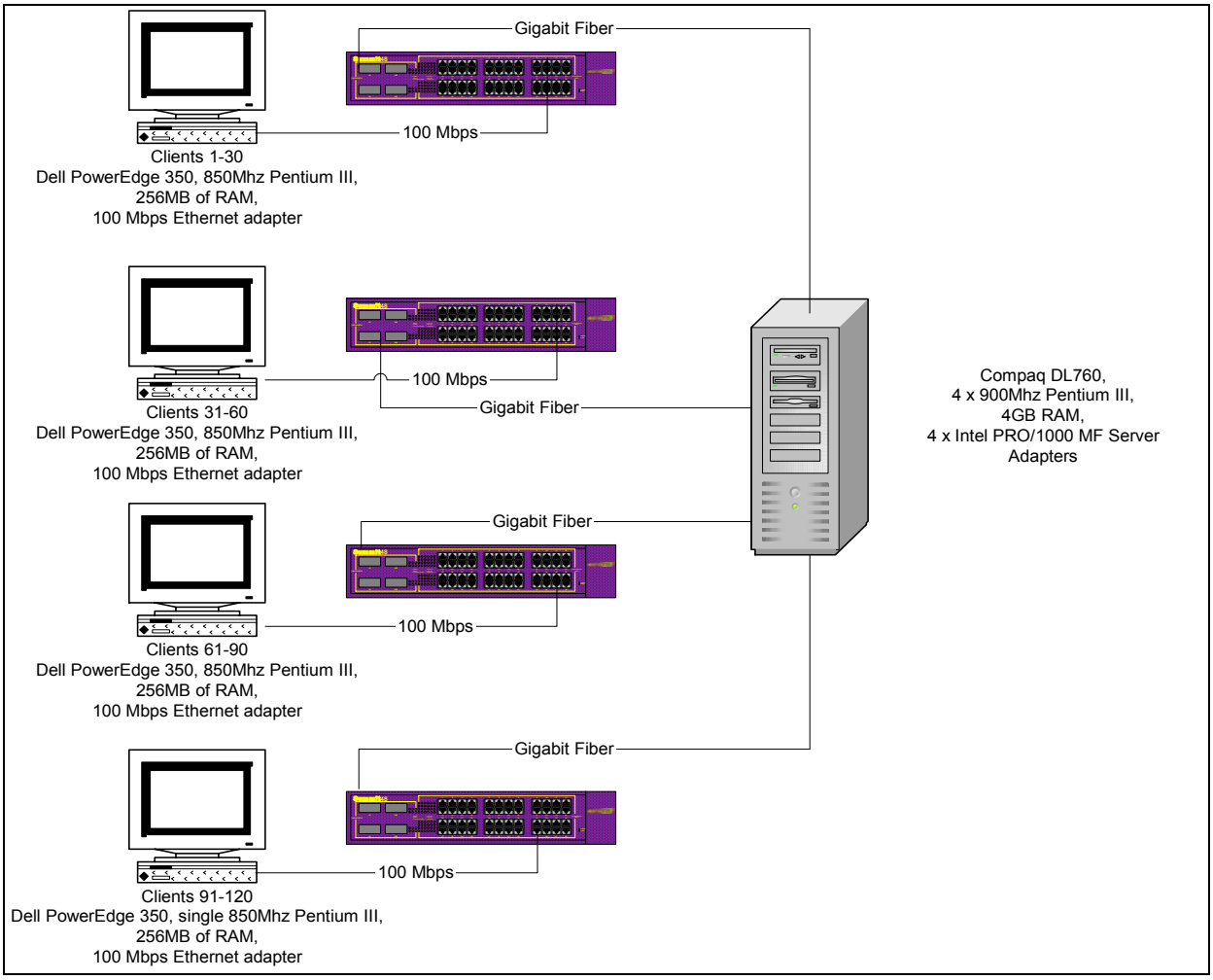

Figure 75. DL760 Test Configuration using 1, 2 and 4 Processors

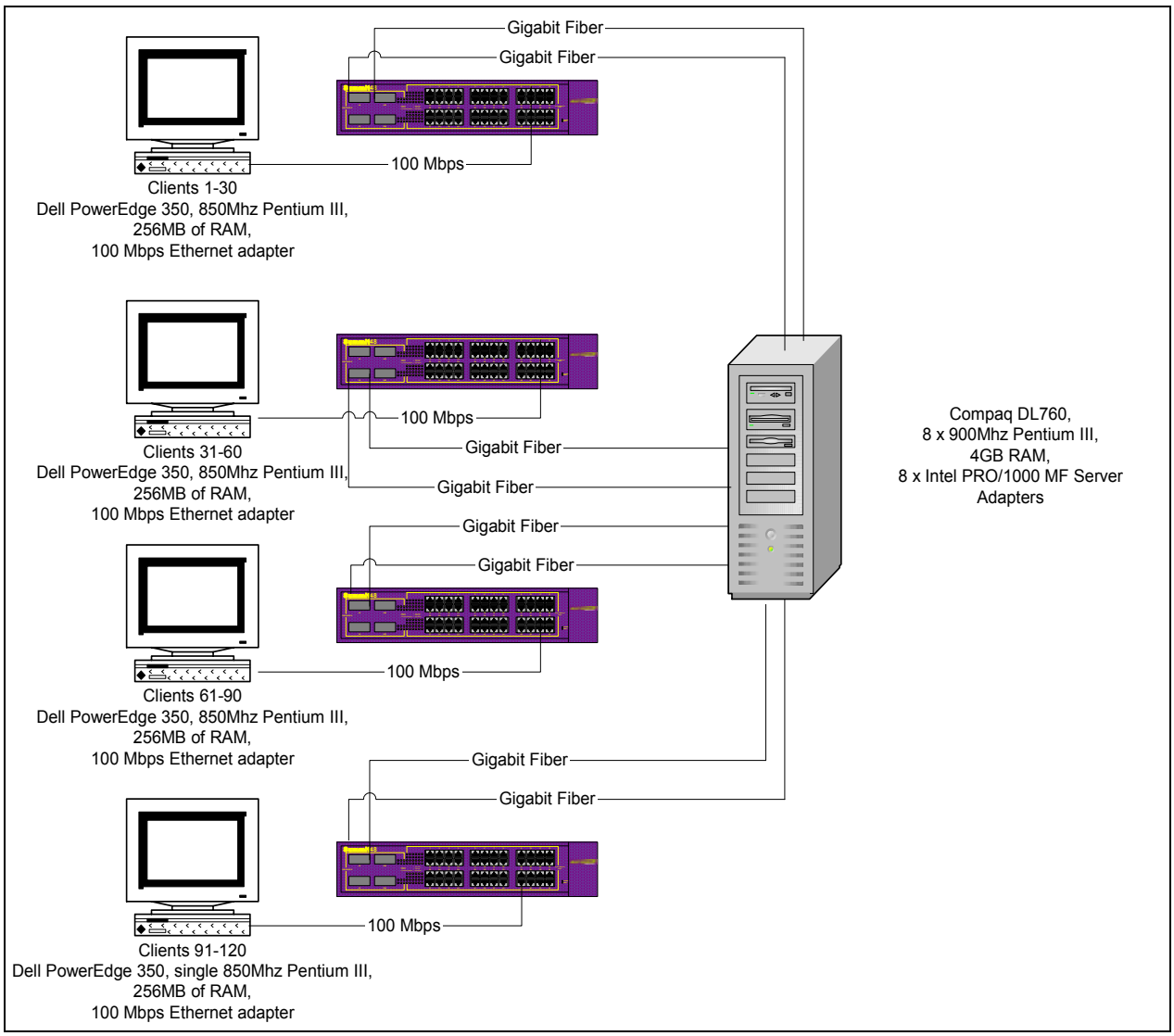

Figure 76. DL760 Test Configuration using 8 Processors

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