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Novell, Inc.: File Server Performance – Novell NetWare 6 vs. Microsoft Windows 2000 Advanced Server

Test report prepared under contract from Novell, Inc.

Executive summary

Novell, Inc. commissioned eTesting Labs to compare the file serving performance of NetWare 6 Server to Windows 2000 Advanced Server. Results were obtained with opportunistic locking enabled on server configurations utilizing from one to eight processors. Other performance testing included disabling opportunistic locking at the eight processor level for both operating systems, and testing the performance levels of NetWare 5.1 using one to eight processors. The NSS file system (Novell's journaling file system) was used for the NetWare tests and the NTFS file system was used for the Windows 2000 Advanced Server tests.

Key findings

- NetWare 6 outperformed Windows 2000 Advanced Server. When comparing the best results for each operating system NetWare 6 outperformed Windows 2000 Advanced Server with almost twice the throughput (98.55% higher throughput).
- On average NetWare 6 outperformed Windows 2000 Advanced Server with 2.17 times the throughput (116.83% higher throughput).
- In comparing Windows 2000 Advanced Server's best performance (with five processors) to NetWare 6's lowest performance (with two processors), NetWare 6's results were 75.13% higher in throughput.
- In terms of performance scaling, Windows 2000 Advanced Server improved 47.12% when adding processors from one to five, but declined by 9.42% as processors increased from five to eight. Performance with NetWare 6 declined by 6.20% when moving from one processor to two, but improved by 13.38% between two to six processors before declining 1.97% again with seven and eight processors.

Opportunistic locking is an option, available in both NetWare 6.0 and Windows 2000 Advanced Server, that grants clients exclusive access permissions to files available on the shared server volumes. When opportunistic locking is enabled, the client is allowed to maintain locks on the files it accesses, and subsequent read and write requests relating to the locked files can be satisfied from a local cache. By allowing the read and write activity associated with a specific file to be cached locally on the clients, opportunistic locking can greatly enhance overall file serving performance by significantly reducing the number of read and write requests that require physical access to the server disk resources.

For our tests, we used a Compaq Proliant DL760 Server equipped with eight 900 MHz Pentium III processors, 2 GB of RAM and a Compaq StrorageWorks RAID Array 4100 connected to the server through a StorageWorks Fibre Channel and SAN Switch 16 for the data storage. We also used Ziff Davis Media's NetBench, version 7.02 to generate the load for the tests using a 60-client network testbed. We used the standard NetBench Enterprise Disk Mix test suite. We conducted the tests using different numbers of processors by configuring software switches for each operating system that allow us to control the number of processors actively used. With Windows 2000 Advanced Server, we edited the *boot.ini* file to reflect number of processors available. In NetWare, we used the "STOP PROCESSOR <processor number>" command to stop the availability of the individual processors after each reboot.

Tuning parameters used for both operating systems were obtained from the web site of both companies. Complete details of the equipment and configurations used during these tests are available in the Test Methodology section of this report as well as Appendix A.

When comparing the results from each operating system, we found that NetWare 6 outperformed Windows 2000 Advanced Server in all processor configurations tested. In addition, we averaged the overall throughput results in each test run and compared the best results with each operating system.

Figure 1 shows the results of tests where both NetWare 6 and Windows 2000 Advanced Server generated their maximum peak throughput values. Specifically, NetWare 6 generated its best overall performance using six processors with a peak throughput of 1026.833 Mbits/sec at the 8-client mix. Windows 2000 Advanced Server generated a peak performance of 515.981 Mbits/sec at the 24-client mix using five processors. In terms of maximum peak throughput at any number of processors, NetWare 6 generated throughput levels 98.55% higher than Windows 2000 Advanced Server.

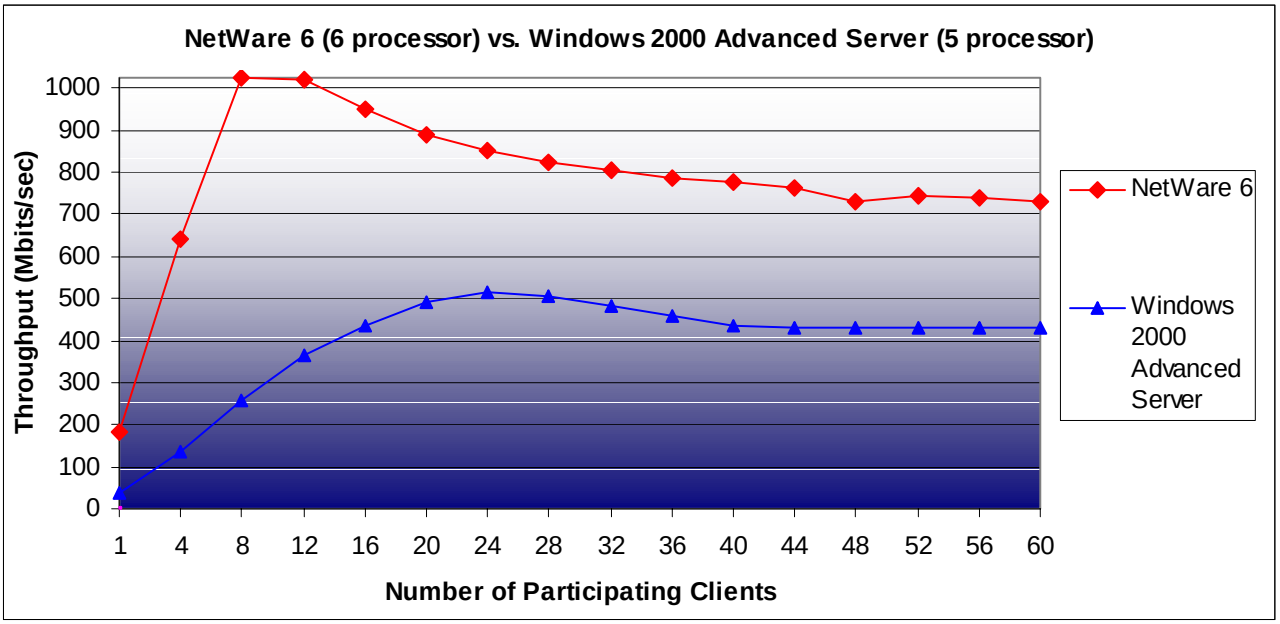

Figure 1: Comparison of Windows 2000 Advanced Server's best performance with NetWare 6's best

We then calculated the overall throughput across the course of the test, where we added the results for all of the client mixes and divided them by 16, the number of client mixes during the course of the test. NetWare 6's throughput performance averaged to 778.947 Mbits/sec. while Windows 2000 Advanced Server's performance averaged to 392.311 Mbits/sec.

Figure 2 shows the results of tests where NetWare 6 generated its lowest peak throughput values and where Windows 2000 Advanced Server generated its maximum peak throughput values. Specifically, NetWare 6 generated its lowest overall peak throughput performance of 891.436 Mbits/sec at the 12-client mix using two processors. Again, Windows 2000 Advanced Server generated a maximum peak throughput of 515.981 Mbits/sec using five processors at the 24-client mix. NetWare 6's lowest peak throughput was higher than Windows 2000 Advanced Server's best peak throughput by 75.13%. In looking at the overall throughput for this graph, NetWare 6's average performance at two processors was 687.047 and Windows 2000 Advanced Server's average performance of 392.311.

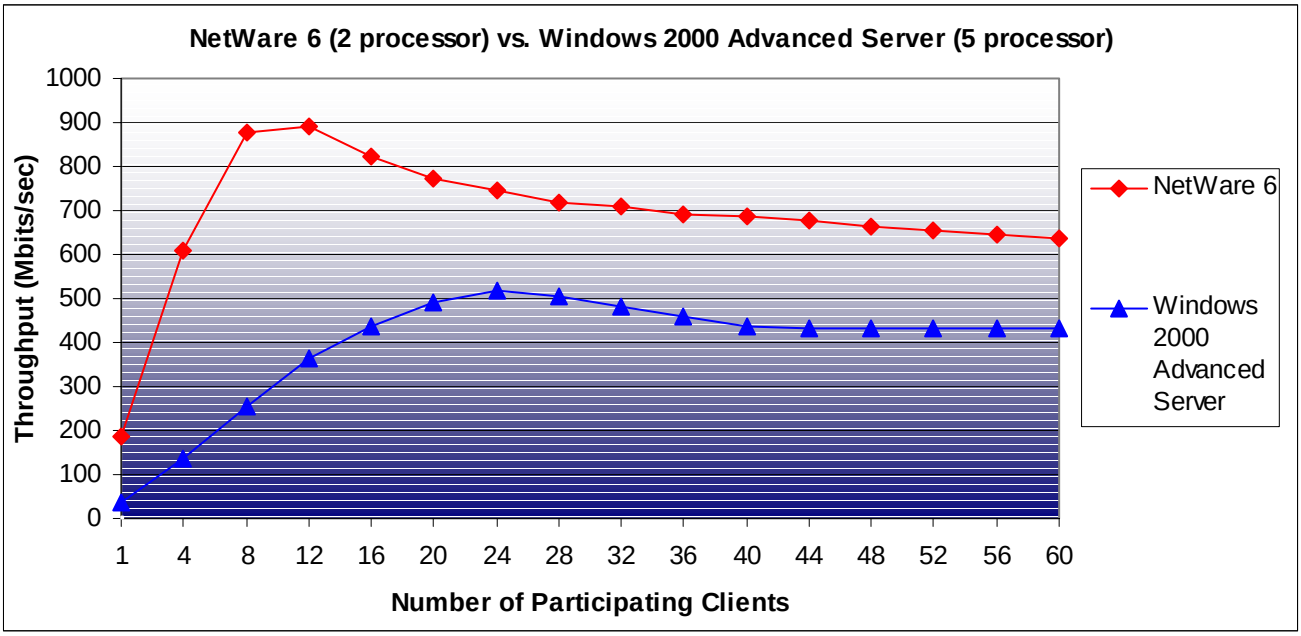

Figure 2: Comparison of Windows 2000 Advanced Server's best performance with NetWare 6's lowest

Novell, Inc. also wanted us to compare performance between the two operating systems with opportunistic locking disabled. As this is not the default configuration for Windows 2000 Advanced Server, and therefore was deemed a less critical comparison, we did not test with the processor scaling method as used in the opportunistic locking testing above. For the single test run on the non-opportunistic locking configuration, we used all eight processors available in the Compaq server. The results are shown in Figure 3 on the following page.

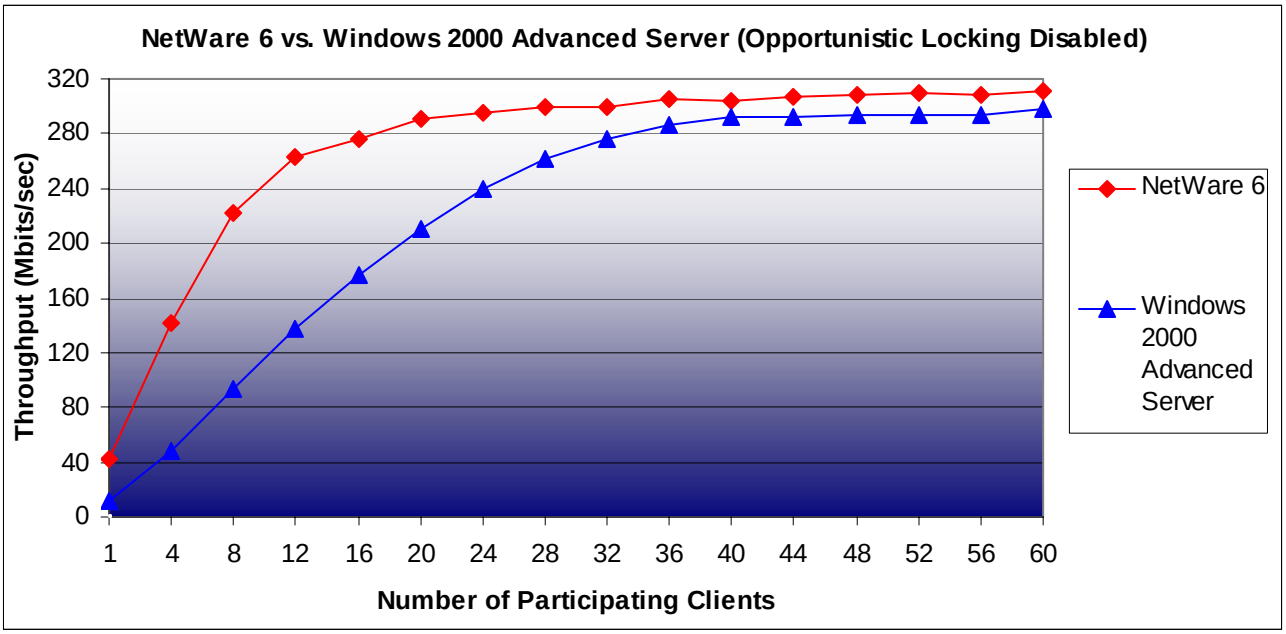

Figure 3: Performance comparison with Opportunistic Locking disabled at eight processors

In both cases, the peak throughput occurred during the 60 client-mix level. For NetWare 6, throughput reached 311.022 Mbits/sec. and for Windows 2000 Advanced Server, the level was 298.083 Mbits/sec. We did encounter a few client connection errors with NetWare 6, however. Details are in the Test Results section.

Testing methodology

Novell, Inc. commissioned eTesting Labs to compare the file server performance of NetWare 6 to Windows 2000 Advanced Server. Test configurations in this report included the use of opportunistic locking with separate test runs for each processor count for the server utilizing from one to eight processors. A single test run with Opportunistic Locking disabled for both NetWare 6 and Windows 2000 Advanced Server was also included. In addition, a full set of tests for all eight processor levels was run for NetWare 5.1. (It should be noted that NSS for NetWare 5.1 did not support Opportunistic Locking, so that feature was not utilized during those tests. The default Traditional File System for NetWare 5.1 does support Opportunistic Locking but TFS tests were not requested for this comparison.)

Opportunistic locking is an option, available in both NetWare 6.0 and Windows 2000 Advanced Server, that grants clients exclusive access permissions to files available on the shared server volumes. When opportunistic locking is enabled, the client is allowed to maintain locks on the files it accesses, and subsequent read and write requests relating to the locked files can be satisfied from a local cache. By allowing the read and write activity associated with a specific file to be cached locally on the clients, opportunistic locking can greatly enhance overall file serving performance by significantly reducing the number of read and write requests that require physical access to the server disk resources.

Opportunistic Locking is a setting that is commonly used in the real world for performance enhancement; it is not a "benchmark special" setting. It is enabled by default on Microsoft servers. Opportunistic Locking is on by default for NetWare servers and Novell Windows 2000/NT Clients. NetWare's Windows 9x clients default to the Opportunistic Locking setting as off.

The function improves performance overall, but can be disabled if necessary when it may cause data corruption or have other adverse affects on application performance. Situations where a customer may wish to disable the function include the use of applications where a database is shared to multiple users, such as Microsoft Access, or ACT! from Interact Commerce Corp. for example.

To disable opportunistic locking in Windows 2000 Server requires a registry edit as outlined in Microsoft's Knowledge Base article Q296264, *Configuring Opportunistic Locking in Windows 2000* (http://support.microsoft.com/default.aspx?scid=kb;en-us;Q296264), which will disable Opportunistic Locking for all clients connected to that server. NetWare clients have an Advanced client property setting that controls the Opportunistic Locking ability of the client, and can be selectively enabled and disabled on a client by client basis. Opportunistic Locking can also be disabled on the NetWare server if desired, at the *Client File Caching Enabled* prompt in the NCP Parameters section when using the Monitor function, eliminating the function for all clients on that server.

For our tests, we used a Compaq Proliant DL760 Server equipped with eight 900 MHz Pentium III processors, 2 GB of RAM and a Compaq StrorageWorks RAID Array 4100 connected to the server through a StorageWorks Fibre Channel and SAN Switch 16 for the data storage. We used Ziff Davis Media's NetBench, version 7.02 to generate file I/O requests to the file server using a 60-client network testbed. Once completed, NetBench compiles the performance measurements that include overall I/O throughput and average response time as well as individual scores for the clients in these categories. The results can help to measure, analyze, and predict how well a server can handle a load of file requests from a number of clients.

Because we were testing on an enterprise-class server, we used the standard NetBench Enterprise Disk Mix test suite during testing. We ran two iterations of the test script for each server configuration and averaged the results at each client load point to generate the results described in this report.

We conducted tests using different server processor configurations. We started with a single processor and performed successive test runs after incrementing the number of processors by one until all eight processors were employed. Complete details of the equipment are available in Appendix A.

Network Testbed Configuration

Below is a list of the systems in the network testbed used for the performance testing:

- Compaq Proliant DL760, 8 Pentium III 900/2 MB cache processors, 2 GB of RAM, Compaq NC6132 Gigabit Module Network Adapter, Compaq StorageWorks 64-Bit/66-MHz Fibre Host Bus Adapter.
- Compaq RAID Array 4100, 10 x 10 GB hard drives configured for RAID 0 and connected through a Compaq StorageWorks SAN Switch 16
- 60 Dell PowerEdge 350 systems, 1 Pentium III 866 MHz, 256 MB RAM, Windows 2000 Professional, Service Pack 2, Intel Ether Express Pro 100+ Network Adapters (clients)
- 1 Dell PowerEdge 350 system, 1 Pentium III 866 MHz, 256 MB RAM, Windows 2000 Professional, Service Pack 2, Intel Ether Express Pro 100+ Network Adapters (NetBench controller)
- 2 Extreme Summit 48 10/100 MB switches connected with fiber optic cables in each Gigabit port. We configured the Ethernet ports connecting the 60 testbed clients and the file server to auto-detect line speed and duplex mode resulting in connections of 100 mbps and full duplex.

The Compaq server and clients were connected using TCP/IP in the same class C subnet. Figure 4 below is a graphical representation of the network testbed. Details of the systems used are available in Appendix A.

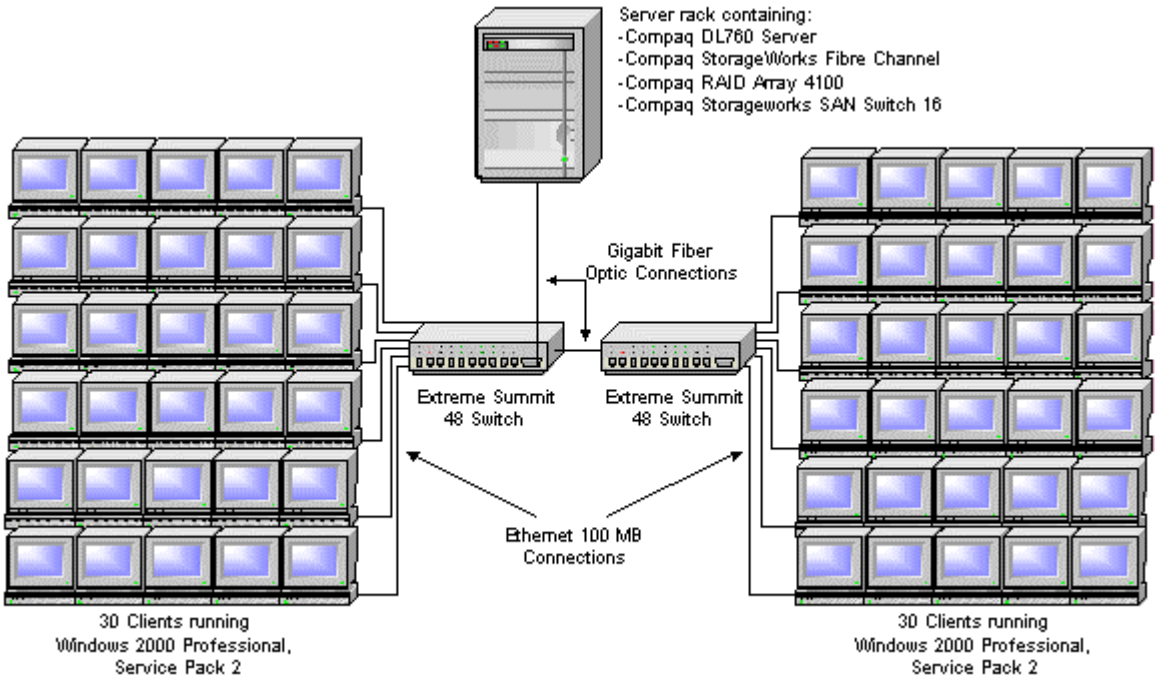

Figure 4: Network testbed used for testing NetWare 6 and Windows 2000 Advanced Server

Compaq Server configurations

The following is a list of configurations for the Compaq DL760:

- The RAID controller was placed on the fastest bus slot available.
- The RAID Array was configured for RAID 0 with the stripe size set at 64 KB, and 50/50 balancing for read and write access.

NetWare 6 Server configurations

Before beginning the testing, we made the following changes to the default NetWare 6 Server configuration based on Novell's recommendations:

For the NetWare 6 Server:

- In the Startup.ncf file, we commented out all references to IDE drivers and IDE CD-ROM support to keep NetWare from committing cycles to check the CD-ROM driver and other IDE devices not being used by the server during the course of the test.
- Set Immediate Purge of Deleted Files to "ON". The setting was chosen to keep the volumes from being filled up with records of deleted files, which NetBench would have created with the activity scripted. Novell recommended using the automatic purge setting to keep the server from having to overwrite the records in the volumes during the course of the test. According to Novell, when this option is set to "OFF", deleted documents would eventually be purged during the course of a normal business day when processor time was available. This setting only affects the behavior of NetWare's Traditional File System, not the NSS file system we used in our tests. Novell recommends changing the setting whenever benchmarking file I/O performance as a failsafe measure in case a tester is unsure which file system is being used.
- In the Autoexec.ncf file, we added the following options on the line for the Compaq NC6132 Gigabit Module Network Adapter (INTEL Pro1000 chipset):

  XSUMRX=1 XSUMTX=1 TXINTDELAY=40

For the NetWare 5.1 Server:

- After installing NetWare 5.1, we updated the operating system with Service Pack 3 from Novell's web site.
- In the Startup.ncf file, we commented out all references to IDE drivers and IDE CD-ROM support to keep NetWare from committing cycles to check the CD-ROM driver and other IDE devices not being used by the server during the course of the test.
- Set Immediate Purge of Deleted Files to "ON". The setting was chosen to keep the volumes from being filled up with records of deleted files, which NetBench would have created with the activity scripted. Novell recommended using the automatic purge setting to keep the server from having to overwrite the records in the volumes during the course of the test. According to Novell, when this option is set to "OFF", deleted documents would eventually be purged during the course of a normal business day when processor time was available. This setting only affects the behavior of NetWare's Traditional File System, not the NSS file system we used in our tests. Novell recommends changing the setting whenever benchmarking file I/O performance as a failsafe measure in case a tester is unsure which file system is being used.
- In the Autoexec.ncf file, we added the following options on the line for the Compaq NC6132 Gigabit Module Network Adapter (INTEL Pro1000 chipset):

  XSUMRX=1 XSUMTX=1 TXINTDELAY=40

- Added the following lines in the Autoexec.ncf file:

  NSS /CacheBalance=60
  NSS /NoSalvage=DATA1
  NSS /NoSalvage=DATA2
  NSS /NoSalvage=DATA3
  NSS /NoSalvage=DATA4

The first line regarding Cache Balance gives the NSS shared volumes on RAID Array the same amount of memory for its use on NetWare 5.1 as is automatically set on NetWare 6. The No Salvage setting for each volume causes the files to be purged immediately. For NetWare 6, the changes in the Autoexec.ncf were not necessary as the parameters can be set upon creation of the shared volumes.

For the RAID Array configuration:

- We created an NSS Pool followed by four logical drives of 25 GB each. We used this partition scheme to match the one used by Windows 2000 Advanced Server as recommended by Microsoft (see Windows 2000 Advanced Server configurations below).
- The automatic Backup and Salvage functions were turned off during creation of the volumes. The Salvage function is the same as the purge deleted file function as described above.

For the 60 testbed clients:

- We installed NetWare Client Version 4.81. (Just the minimal client without any extra product options.)
- We configured four groups of 15 clients each to mount a shared server volume on each of the four 25GB partitions described above.
- We edited the client database in the NetBench controller to add one client per partition with each subsequent client-mix. This served to spread the load generated by the NetBench clients during testing evenly across the four NSS volumes described above.

After each test run, the NetWare 6 Server was rebooted along with the 60 clients.

Windows 2000 Advanced Server configurations

We made the following installation procedures and changes to the default Windows 2000 Advanced Server configuration based on the recommendations described in the Windows 2000 Performance Tuning guide available on the Microsoft web site at the following URL:

http://www.microsoft.com/TechNet/prodtechnol/windows2000serv/maintain/optimize/perftune.asp

Windows 2000 Advanced Server installation and initial configuration

- We installed Windows 2000 Advanced Server on a newly formatted NTFS partition.
- We then installed Service Pack 2 downloaded from Microsoft's web site.
- Windows 2000 Advanced Server was configured as a stand-alone server without Active Directory. It was not configured as a domain controller.
- Using the Windows 2000 Advanced Server Disk Management function, we partitioned the data storage into four separate NTFS partitions of size 25GB.
- We configured four distinct groups of 15 clients each to mount a shared server volume on each of the four 25GB partitions described above. The result was that no more than 15 NetBench test clients ever simultaneously accessed a server volume.
- We edited the client database in the NetBench controller to add one client per partition with each subsequent client-mix. This served to spread the load generated by the NetBench clients during testing evenly across the four NTFS volumes described above.
- We verified the Application Response was set to "Optimize Performance for Background Services."
- We verified the File and Printer Sharing setting was set to optimize performance for file sharing.
- We edited the registry to add the following values:
  HKLM\SYSTEM\CurrentControlSet\Control\Session Manager\Memory Management:
  PagedPoolSize = dword:192000000 (decimal)
  HKLM\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters:
  TcpWindowSize=word:0xFFFF (hexadecimal)
- For each of the shared NTFS volumes, we set the Cache setting to "Automatic Caching for Documents."

Network Adapter configuration
Number of Receive Buffers = 768
Number of Coalesce Buffers = 512
Number of Transmit Descriptors = 512
Receive Checksum Offloading = On
Transmit Checksum Offloading = On

Before running each test

- We stopped sharing each data partition with the following commands made on the clients:
  net share VOL1 /delete
  net share VOL2 /delete
  net share VOL3 /delete
  net share VOL4 /delete
- We used 16 KB allocation size and NTFS for formatting the shared volumes by issuing the following command: format <drive>: /fs:ntfs /A:16K
- To map each of the clients to the four shared volumes, we entered the following commands on the four groups of clients:
  net use f: \\200.103.1.250\VOL1 /persistent:no (on clients in Group 1)
  net use f: \\200.103.1.250\VOL2 /persistent:no (on clients in Group 2)
  net use f: \\200.103.1.250\VOL3 /persistent:no (on clients in Group 3)
  net use f: \\200.103.1.250\VOL1 /persistent:no (on clients in Group 4)
- We increased the NTFS log file size to 64 MB for each volume by issuing the following command: chkdsk <drive>: /l:65536

Test results

NetWare 6 vs. Windows 2000 Advanced with Opportunistic Locking enabled

As discussed in the Executive Summary section, the collective throughput results show Novell NetWare 6 outperformed Windows 2000 Advanced Server in all tested configurations. The graphs of these results are shown below in Figures 4 and 5.

With NetWare 6, throughput levels peaked at a load between 8 to 12 clients with the highest peak attained running the server with 6 processors. The peaks ranged from 858.055 Mbits/sec. with 1 processor (729.618 Mbits/sec. overall average) to 1,026.833 Mbits/sec. when using 6 processors (778.947 Mbits/sec. overall average). In the tests with Windows 2000 Advanced Server, we observed peak throughputs at various client loads depending on the number of processors ranging from 325.175 Mbits/sec. with 1 processor (266.655 Mbits/sec. overall average) to 515.981 Mbits/sec. when configured with 5 processors (392.311 Mbits/sec. overall average).

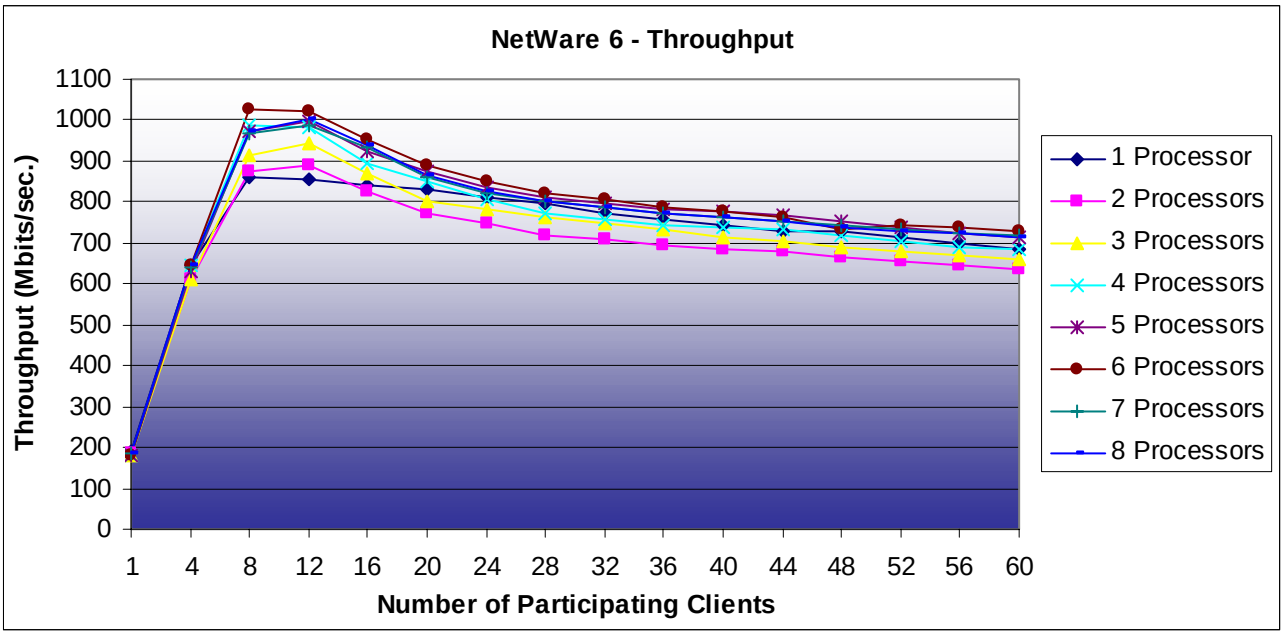

Figure 5: Throughput performance using Novell NetWare 6

In addition to reviewing the performance levels between operating systems, we evaluated the performance level achieved between the different processor configurations using each operating system.

With NetWare 6, we saw negative scaling when adding the second processor where overall average throughput moved from 729.618 to 687.047 Mbits/sec. The performance did improve from that point and continued up to the sixth processor level where the overall average throughput peaked at 778.947 Mbits/sec. With seven and eight processors, the performance leveled to 762.308 and then 763.901 Mbits/sec., respectively. NetWare 6 generated its peak throughput point of 1026.833 Mbits/sec at the 8 client-mix using 6 processors.

Windows 2000 Advanced Server continuously improved from one processor to five, increasing its overall average throughput from 266.655 to 392.311 Mbits/sec. Windows 2000 Advanced Server reached its peak throughput at five processors with 515.981 Mbits/sec. at the 24-client mix. From there, performance declined

slightly ending with the overall average performance of 358.533 Mbits/sec with eight processors. Figure 6 below graphs the results.

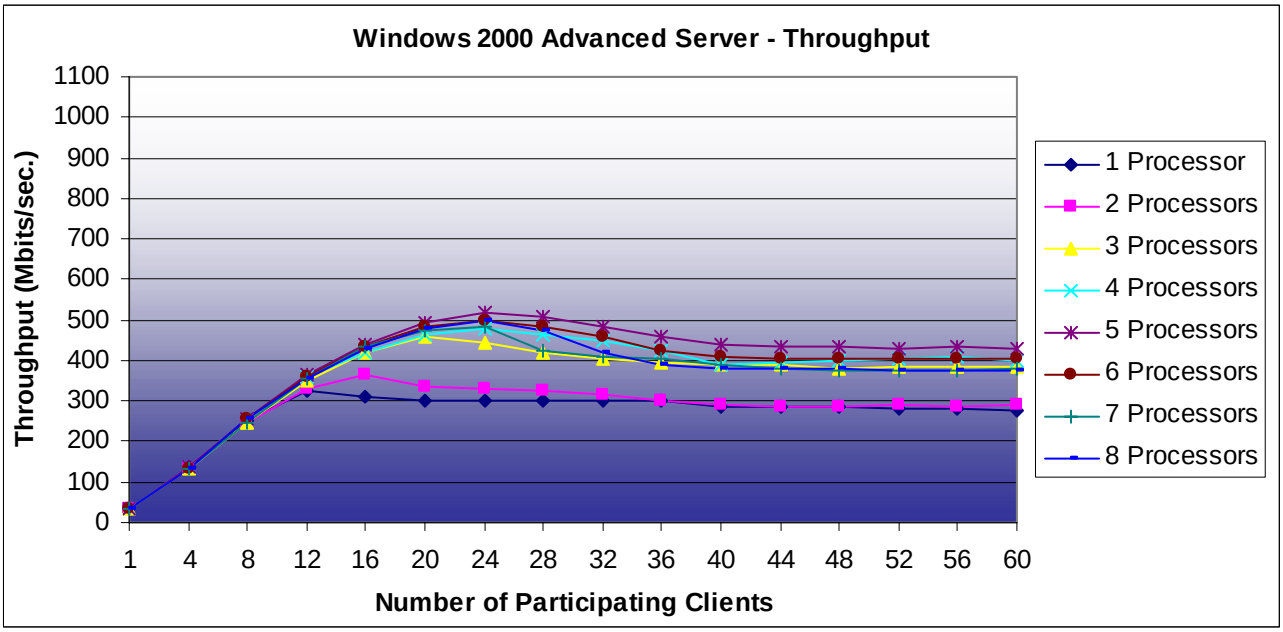

Figure 6: Throughput performance using Windows 2000 Advanced Server

Figure 7 below shows the detailed results of the average throughput over the course of the test with each processor configuration.

No. of processors used	NetWare 6 Results	Windows 2000 AS Results
1	729.618	266.655
2	687.047	278.614
3	715.950	350.576
4	743.530	367.597
5	767.140	392.311
6	778.947	375.189
7	762.308	353.926
8	763.901	358.533

Figure 7: Detailed results (Mbits/sec) comparison with each processor configuration

We evaluated the aspect of scaling between the two operating systems. In the case of Windows 2000 Advanced Server, we found normal positive scaling from one to five processors and negative scaling when adding the sixth to eighth processor. With NetWare 6, the one processor configuration generated a better overall average performance than the two and three processor configurations. More specifically, the overall average throughput with one processor was 729.618 Mbits/sec. When the second processor was added, the

result lowered to 687.047 Mbits/sec. followed by 715.950 Mbits/sec. with three processors. Figure 8 below isolates the results in a graph to illustrate these findings.

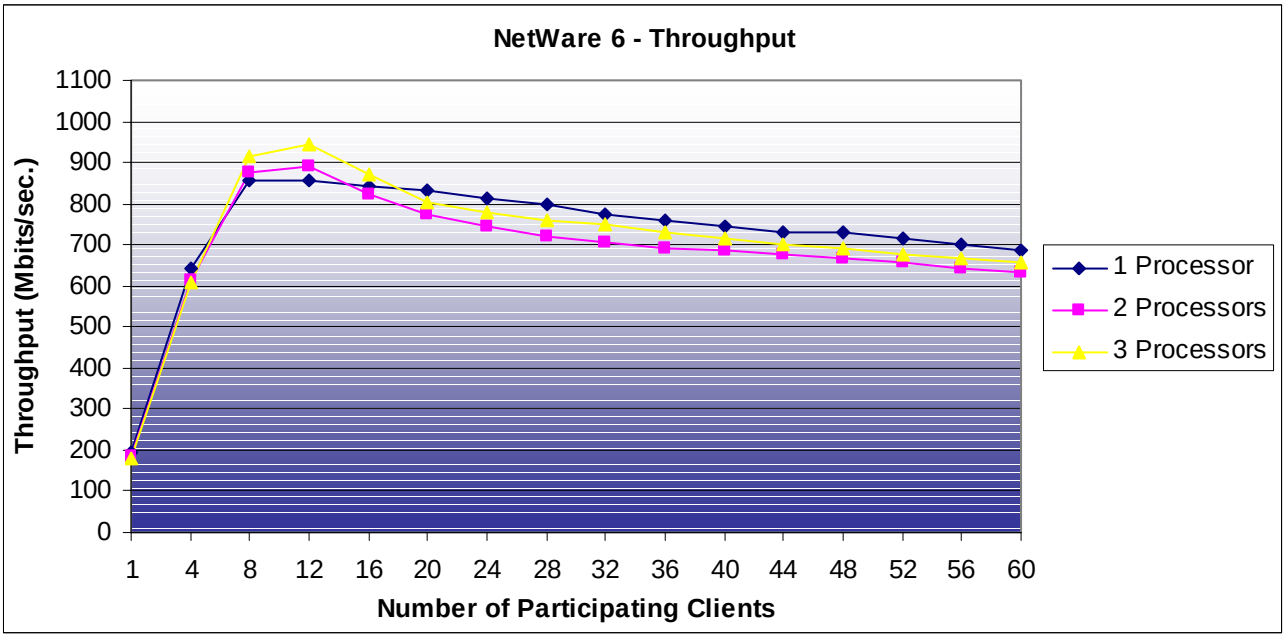

Figure 8: NetWare 6 performance results with one through three processors

We found that the peak throughput was higher with two and three processors (891.436 and 942.762 Mbits/sec., respectively). However, at the 16 client-mix, the performance levels become more equalized. Starting with the 20 client-mix, the throughput levels for the two and three processor configurations are below the one processor test results and remain so throughout the remainder of the test. See Figure 8 above.

Figures 9 through 24 on the following pages illustrate the differences between NetWare 6 and Windows 2000 Advanced Server in each processor configuration. The detailed throughput results are listed under each graph with the peak throughput number for each operating system indicated by boldface type.

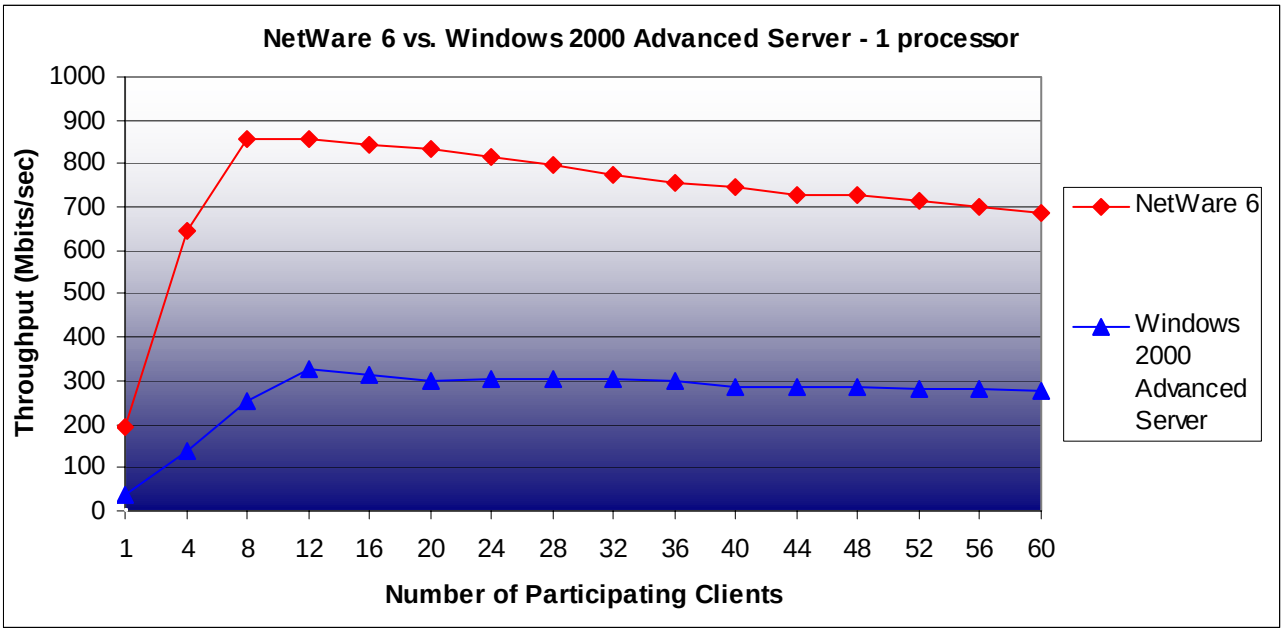

Figure 9: Throughput results of NetWare 6 and Windows 2000 AS using one processor

No. of Participating Clients	NetWare 6 Results	Windows 2000 AS Results
1	192.404	36.887
4	644.295	138.829
8	**858.055**	251.368
12	856.697	**325.175**
16	842.913	313.125
20	832.881	299.842
24	813.637	302.552
28	797.635	302.758
32	773.889	302.049
36	757.282	299.860
40	744.725	285.695
44	729.911	285.392
48	728.607	284.162
52	713.509	281.468
56	700.958	281.893
60	686.487	275.427

Figure 10: Detailed results (Mbits/sec) of NetWare 6 and Windows 2000 AS using one processor

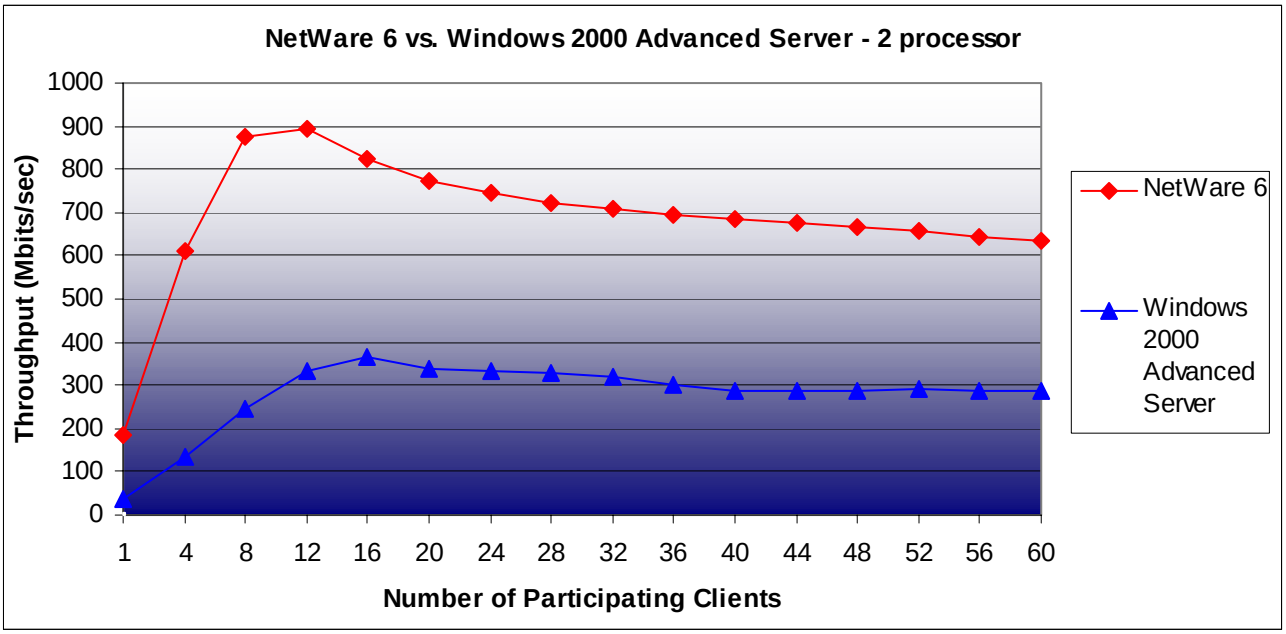

Figure 11: Throughput results of NetWare 6 and Windows 2000 AS using two processors

No. of Participating Clients	NetWare 6 Results	Windows 2000 AS Results
1	184.937	35.799
4	611.276	134.231
8	877.214	246.238
12	**891.436**	331.048
16	824.557	**363.854**
20	774.627	336.193
24	746.512	331.756
28	719.951	326.393
32	707.531	317.632
36	692.522	298.713
40	684.562	288.801
44	677.896	288.329
48	664.936	288.254
52	656.339	293.164
56	643.629	288.409
60	634.834	289.005

Figure 12: Detailed results (Mbits/sec) of NetWare 6 and Windows 2000 AS using two processors

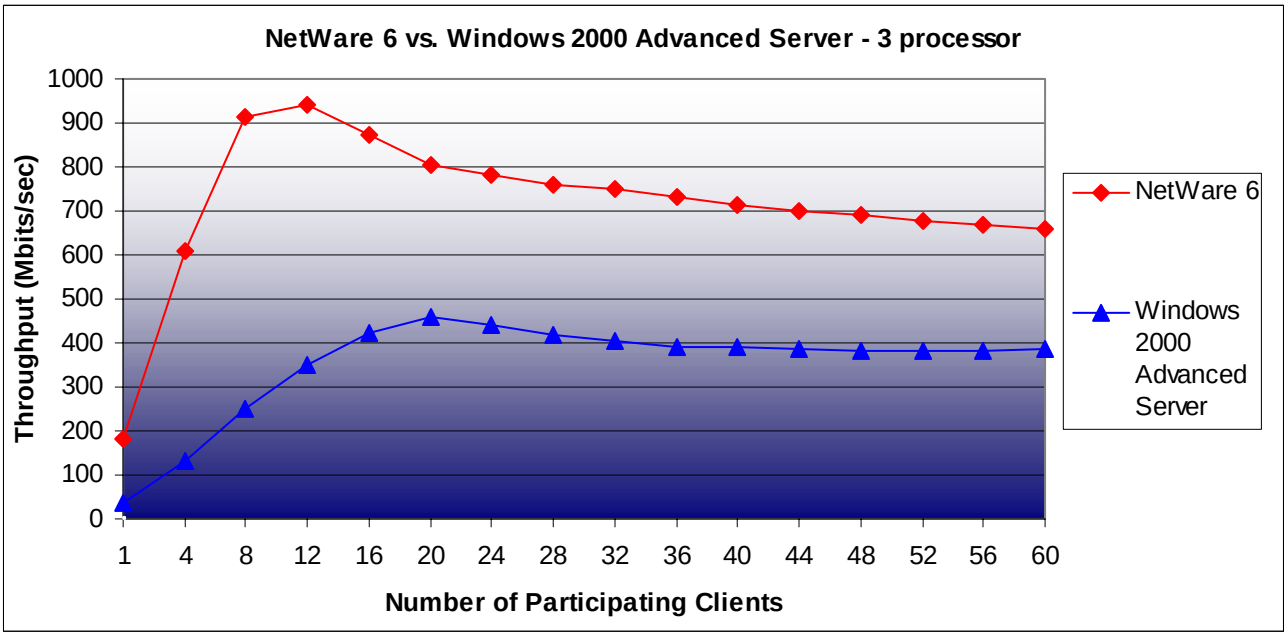

Figure 13: Throughput results of NetWare 6 and Windows 2000 AS using three processors

No. of Participating Clients	NetWare 6 Results	Windows 2000 AS Results
1	182.180	35.547
4	609.062	130.896
8	913.028	247.823
12	**942.762**	348.086
16	871.978	420.527
20	802.861	**457.812**
24	781.103	441.960
28	761.147	418.057
32	749.247	403.190
36	731.080	393.066
40	714.416	390.109
44	701.821	388.037
48	690.012	382.198
52	677.461	383.800
56	668.855	383.109
60	658.186	384.996

Figure 14: Detailed results (Mbits/sec) of NetWare 6 and Windows 2000 AS using three processors

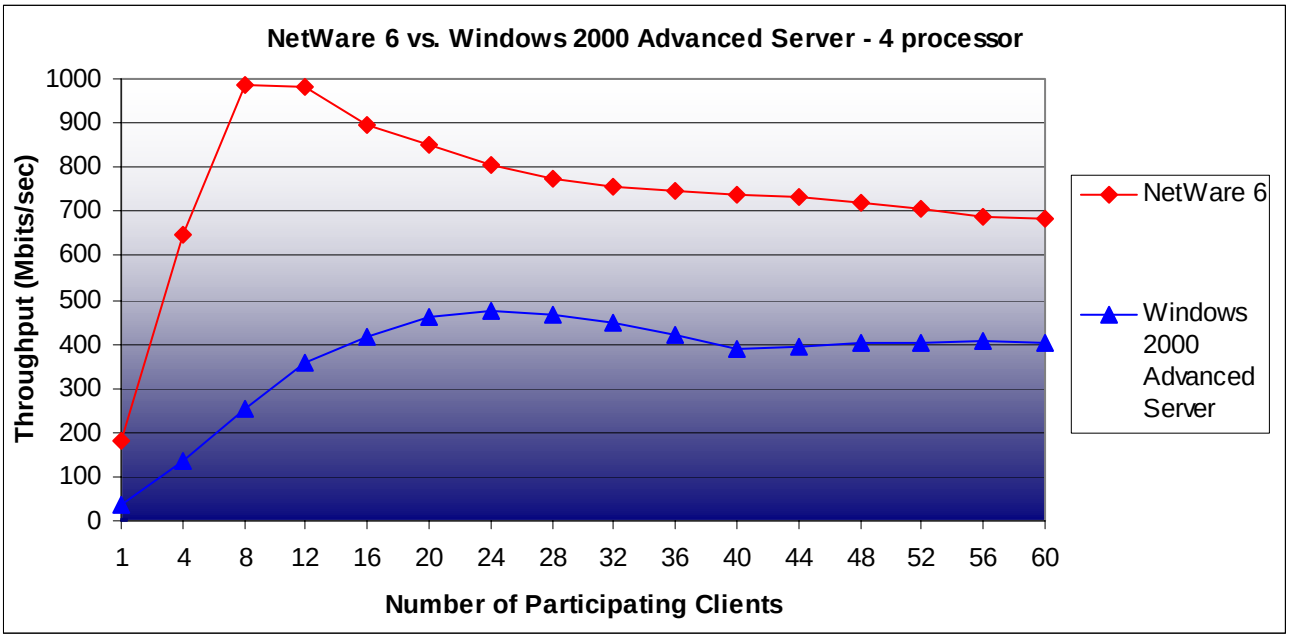

Figure 15: Throughput results of NetWare 6 and Windows 2000 AS using four processors

No. of Participating Clients	NetWare 6 Results	Windows 2000 AS Results
1	181.229	35.927
4	646.369	135.758
8	**988.217**	255.603
12	980.570	358.591
16	894.250	418.433
20	852.925	462.741
24	807.645	**476.885**
28	773.654	465.240
32	756.769	449.874
36	744.403	422.625
40	739.515	391.308
44	735.116	395.359
48	717.783	400.930
52	704.417	403.788
56	689.298	407.344
60	684.326	401.144

Figure 16: Detailed results (Mbits/sec) of NetWare 6 and Windows 2000 AS using four processors

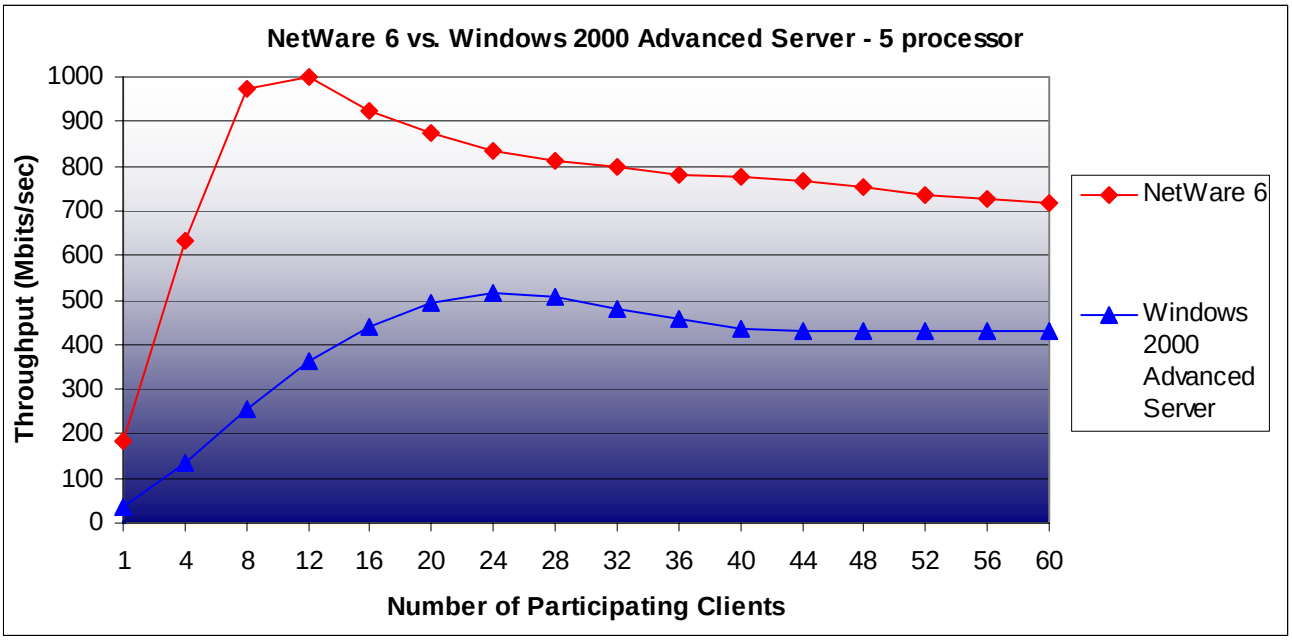

Figure 17: Throughput results of NetWare 6 and Windows 2000 AS using five processors

No. of Participating Clients	NetWare 6 Results	Windows 2000 AS Results
1	182.524	36.034
4	630.435	135.658
8	971.318	256.639
12	**998.329**	363.984
16	923.542	437.238
20	873.677	492.281
24	835.429	**515.981**
28	809.892	505.691
32	796.019	482.014
36	782.122	458.175
40	775.414	436.790
44	766.115	432.266
48	752.430	431.918
52	736.337	429.589
56	724.907	432.732
60	715.755	429.990

Figure 18: Detailed results (Mbits/sec) of NetWare 6 and Windows 2000 AS using five processors

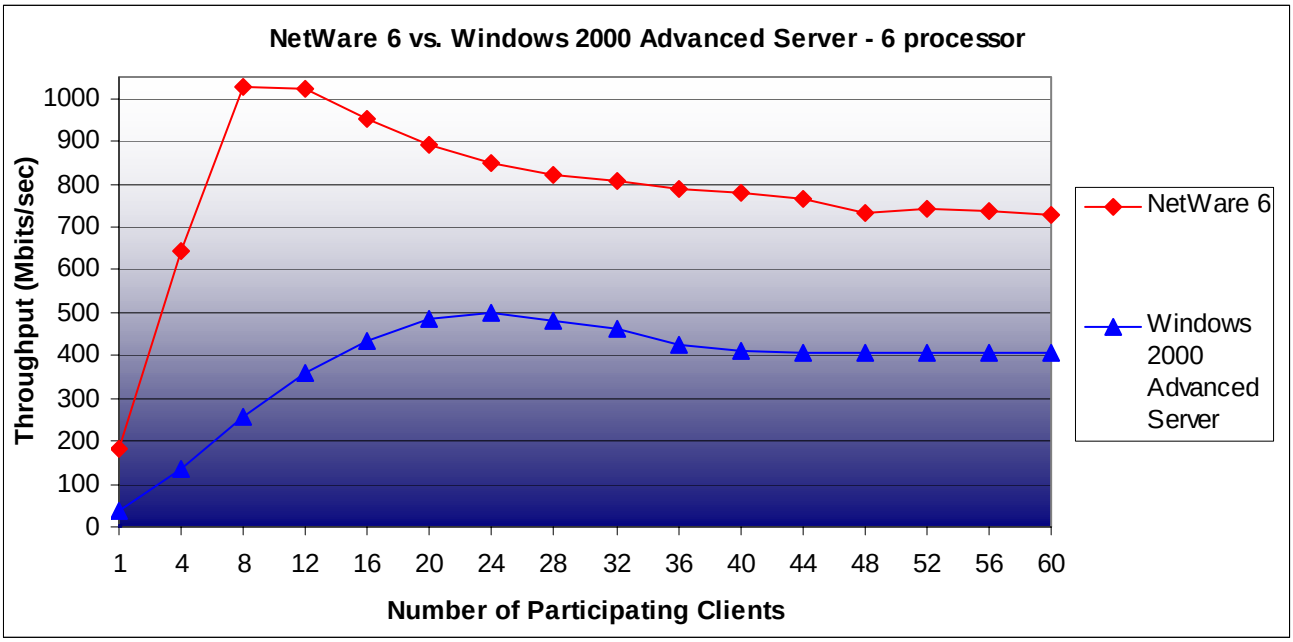

Figure 19: Throughput results of NetWare 6 and Windows 2000 AS using six processors

No. of Participating Clients	NetWare 6 Results	Windows 2000 AS Results
1	181.223	36.440
4	642.976	135.462
8	**1026.833**	255.958
12	1020.104	360.465
16	952.357	432.513
20	889.573	484.888
24	850.299	**499.413**
28	821.436	481.687
32	805.538	459.732
36	786.738	422.837
40	779.247	409.520
44	763.848	405.525
48	732.365	404.519
52	743.762	406.143
56	738.499	404.182
60	728.365	403.745

Figure 20: Detailed results (Mbits/sec) of NetWare 6 and Windows 2000 AS using six processors

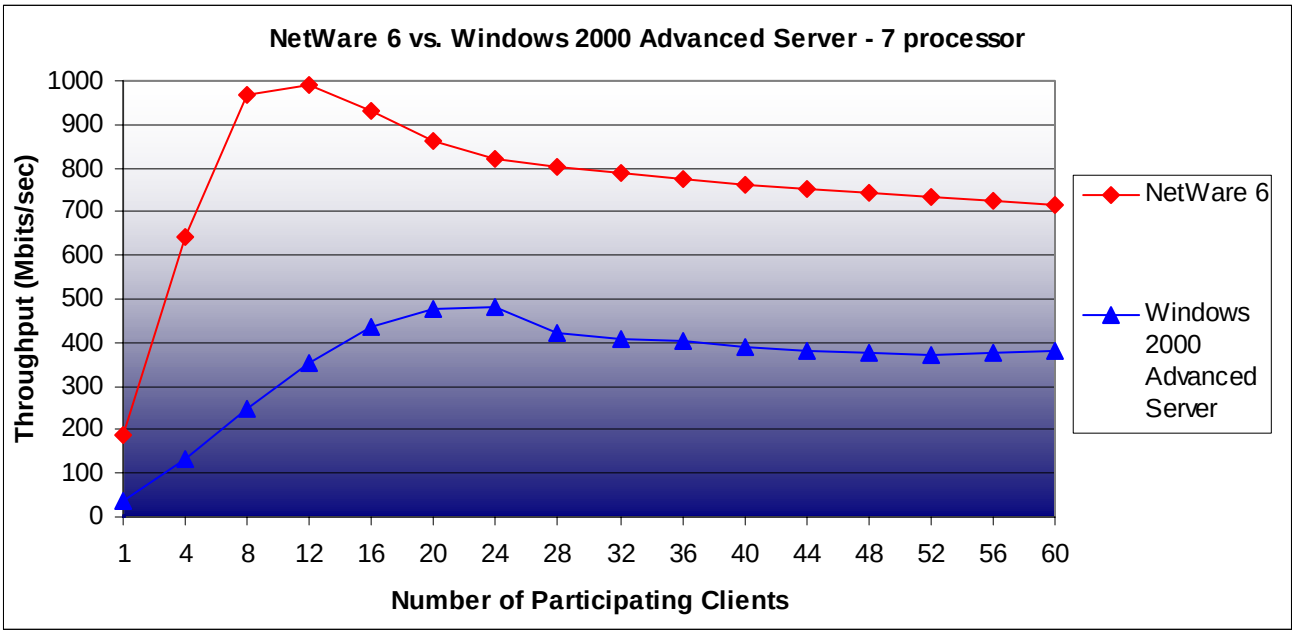

Figure 21: Throughput results of NetWare 6 and Windows 2000 AS using seven processors

No. of Participating Clients	NetWare 6 Results	Windows 2000 AS Results
1	186.225	34.946
4	640.377	131.192
8	968.014	246.326
12	**989.208**	353.735
16	933.445	436.487
20	861.370	474.915
24	821.698	**481.783**
28	801.054	422.639
32	788.415	408.816
36	774.361	402.101
40	761.278	387.697
44	753.543	379.831
48	743.765	374.588
52	732.118	373.747
56	724.503	375.215
60	717.556	378.805

Figure 22: Detailed results (Mbits/sec) of NetWare 6 and Windows 2000 AS using seven processors

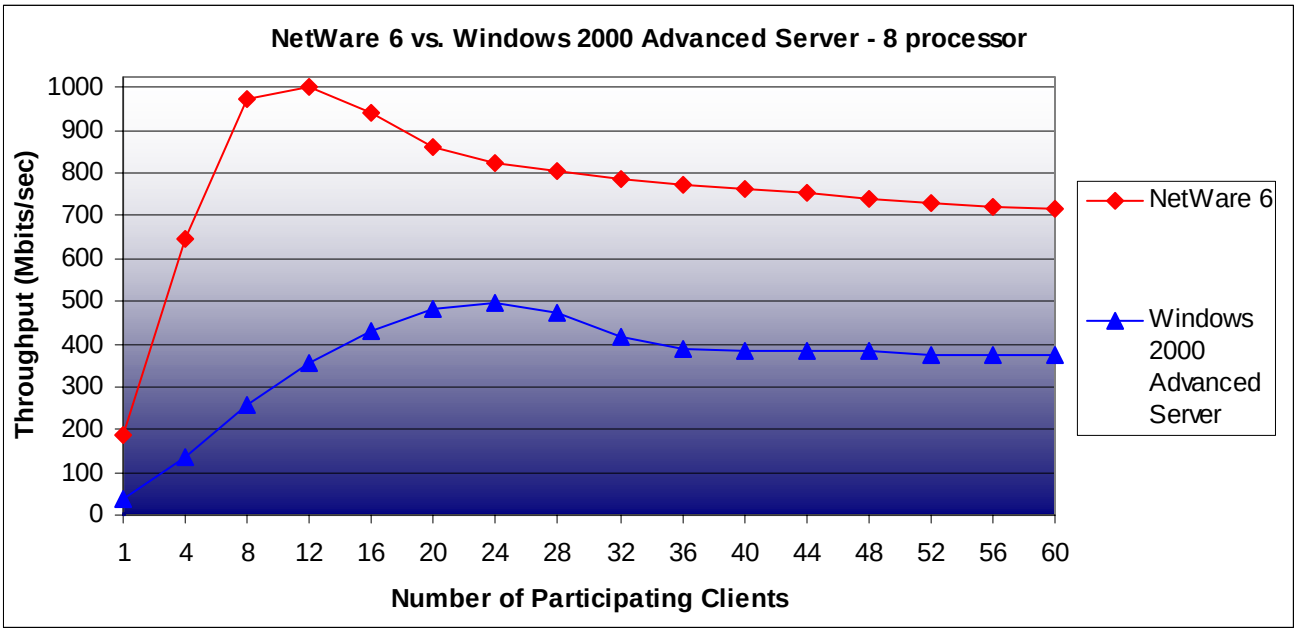

Figure 23: Throughput results of NetWare 6 and Windows 2000 AS using eight processors

No. of Participating Clients	NetWare 6 Results	Windows 2000 AS Results
1	185.872	35.721
4	643.942	135.508
8	974.989	255.230
12	**1002.581**	357.269
16	939.313	430.060
20	863.323	480.733
24	825.807	**495.917**
28	802.750	472.731
32	788.367	418.514
36	773.958	388.279
40	763.107	382.086
44	752.286	381.685
48	739.340	381.556
52	729.909	374.529
56	722.296	373.221
60	714.583	373.488

Figure 24: Detailed results (Mbits/sec) of NetWare 6 and Windows 2000 AS using eight processors

Performance Testing with Opportunistic Locking disabled

At Novell's request, we performed additional testing on both operating systems with the opportunistic locking function disabled. For this portion of testing, we attained the results using the full eight processors and did not scale the number of processors. Figure 25 below illustrates the results in a graph format.

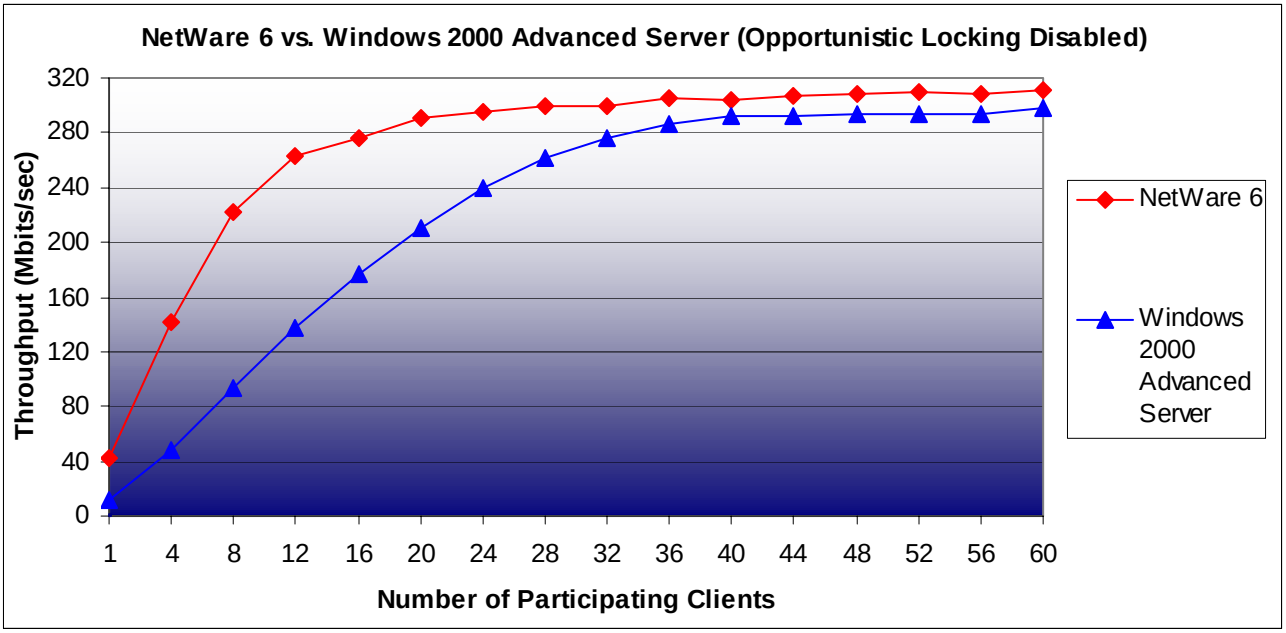

Figure 25: Performance comparison with Opportunistic Locking disabled at eight processors

In contrast to the opportunistic locking enabled testing, the peak throughput for both operating systems occurred at the end of the test during the 60 client-mix level. When using NetWare 6, the maximum throughput level was 311.022 Mbits/sec. With Windows 2000 Advanced Server installed, the throughput topped at 298.083 Mbits/sec.

We also averaged the throughput of all the client mix results to calculate an aggregate number for each operating system. For NetWare 6, the overall average throughput was 311.022 Mbits/sec. and for Windows 2000 Advanced Server, it was 219.196.

Figure 26 on the following page shows the detailed results for each client mix. The peak throughput results are bolded for each operating system.

No. of Participating Clients	NetWare 6 Results	Windows 2000 AS Results
1	42.401	12.265
4	142.258	47.611
8	222.647	93.404
12	263.076	137.247
16	276.319	177.027
20	290.256	211.075
24	295.875	239.699
28	299.056	262.093
32	300.111	276.248
36	304.877	287.021
40	303.837	291.564
44	307.242	292.395
48	308.507	293.733
52	309.712	293.527
56	307.779	294.145
60	**311.022**	**298.083**

Figure 26: Detailed results (Mbits/sec) using eight processors and disabling opportunistic locking.

Despite the higher performance numbers we experienced with NetWare 6 in this portion of testing, we did encounter a few errors where a client was unable to write to the shared volume caused by the amount of activity and the file server unable to accommodate every request from the clients. In both cases, the number of clients is not significant, but we did not receive the same errors with Windows 2000 Advanced Server. Figure 27 below shows the average error for both test runs performed.

No. of Participating Clients	NetWare 6 Errors
1	0.0
4	0.0
8	0.0
12	0.0
16	0.5
20	0.5
24	0.0
28	0.5
32	1.0
36	0.5
40	0.5
44	1.0
48	0.5
52	0.0
56	0.0
60	0.0

Figure 27: Average client errors in both test runs for NetWare 6

NetWare 5.1 Test Results

We also performed throughput testing on NetWare 5.1, and measured scaling for one through eight processors. This was done at Novell's request to provide a framework for comparing NSS on NetWare 6 to previous versions of NSS. Opportunistic locking was not enabled for these tests, as NSS for NetWare 5.1 did not support this function. The results are graphed in Figure 28 below.

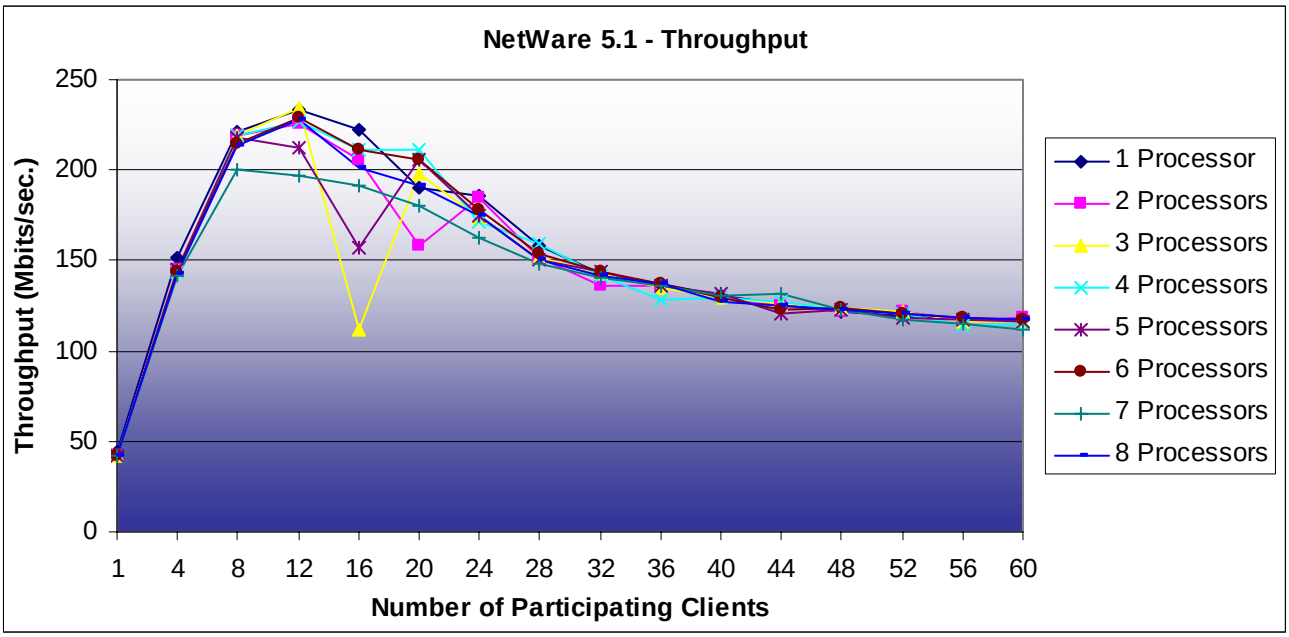

Figure 28: Performance results with NetWare 5.1 scaling one through eight processors

We did not see any significant performance enhancement when increasing the number of processors, especially during the last half of the test where the workload is at its heaviest. The greatest variation in performance we experienced occurred between the 8 to 24-client mix, with some dramatic dipping in throughput at the 16 and 20-client mix. The most extreme variation occurred during the test with three processors at the 16-client mix when the throughput went from 243.691 Mbits/sec. at the 12-client mix to 111.539 Mbits/sec. and back up to 198.116 Mbits/sec with 20 clients.

Another notable dip at the 16-client mix occurred during the test with five processors where the performance lowered to 156.747 Mbits/sec. from 212.170 Mbits/sec. with 12 clients and returned to 205.355 Mbits/sec. at the 20-client mix. When testing with two processors, we experienced another dip in performance, this time at the 20-client mix as throughput measured at 158.291 Mbits/sec. while the results were 205.393 and 184.425 Mbits/sec at the 16 and 24-client mix, respectively.

After these variations in the performance, starting with the 28-client mix, performances across all the number of processors equalize and stay within the same range.

We then calculated the overall average where we added the results of all the client mixes for each processor level and divided by 16, the number of client mixes. In reviewing the overall average results from one to eight processors, we found little difference in throughput. The highest performance occurred at the one processor level at the 151.222 Mbits/sec and the lowest was 141.797 at with seven processors. Figure 29 on the following page lists the detailed results with the averages at the bottom row.

No. of Clients	1 Proc	2 Proc	3 Proc	4 Proc	5 Proc	6 Proc	7 Proc	8 Proc
1	44.487	41.850	41.988	41.779	41.904	41.783	41.597	41.594
4	151.876	144.607	144.720	144.171	144.432	143.655	141.918	142.296
8	221.561	219.057	219.277	218.737	218.037	214.736	200.617	213.791
12	233.451	225.746	234.691	227.066	212.170	229.155	197.177	228.169
16	221.959	205.393	111.539	211.667	156.747	211.359	191.491	201.461
20	190.101	158.291	198.116	211.083	205.355	205.240	180.654	191.118
24	185.889	184.425	173.796	171.856	174.548	177.852	162.745	174.717
28	158.286	151.804	151.834	158.967	150.139	154.132	148.642	150.214
32	142.681	136.028	142.663	141.963	143.445	143.523	140.267	141.842
36	137.005	136.106	135.194	128.732	135.589	136.945	135.930	137.668
40	130.120	129.380	129.879	129.871	131.622	129.768	130.277	127.762
44	125.781	125.051	126.582	127.524	121.128	122.756	131.148	124.822
48	121.586	121.608	123.510	122.338	122.719	123.358	123.036	123.153
52	119.999	121.717	121.207	120.965	118.452	120.954	117.164	120.870
56	117.497	117.258	116.403	114.328	116.827	118.279	114.695	117.963
60	117.277	118.577	115.889	114.594	115.830	117.390	111.404	117.022
Overall Average	151.222	146.056	142.955	149.102	144.309	149.430	141.797	147.154

Figure 29: Detailed results of the tests scaling from one to eight processors using NetWare 5.1

Comparing the non-Opportunistic Locking 8 Processor results from NetWare 5.1 with the non-Opportunistic Locking NetWare 6 results shows that NSS on NetWare 6 outperforms NSS on NetWare 5.1 by as much as 36.31%. With Opportunistic Locking enabled, NSS on NetWare 6 has up to 339.4% greater throughput than NSS on NetWare 5.1.

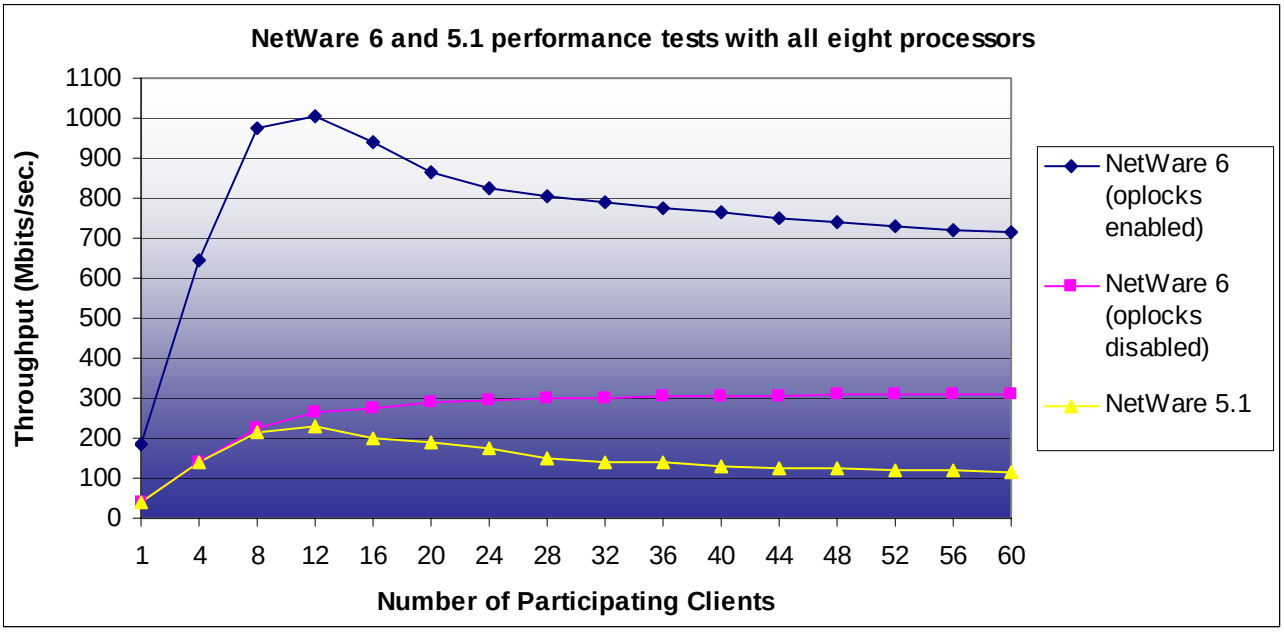

Figure 30: Comparison of NetWare 6 (with and without Opportunistic Locking) and NetWare 5.1

Appendix A

Equipment Disclosure Information

File Server Equipment	
Machine Type	Compaq Proliant DL760
Processors	8 x 900 MHz Pentium III
L2 Cache	2 MB
Memory	2 GB of RAM
Disk(s)	4 x 36 GB hard drives (Compaq 5300 Smart Array Controller)
Network Adapter(s)	Compaq NC6132 Gigabits Module Network Adapter
Host Bus Adapter	Compaq StorageWorks 64-Bit/66-MHz Fibre Host
OS	Windows 2000 Advanced Server, Service Pack 2 Novell NetWare 6

Figure 31: File Server hardware specifications

Disk RAID Array	
Machine Type	Compaq RAID Array 4100
Disk(s)	10 x 10 GB hard drives (RAID 0)
Connection Switch	Compaq StorageWorks SAN Switch 16

Figure 32: RAID Array hardware specifications

Client (60)	
Machine Type	Dell PowerEdge 350
Processors	1 Intel Pentium III 866 MHz
L2 Cache	256KB
Memory	256 MB
Disk(s)	Maxtor 10 GB 7,200 RPM
Network Adapter(s)	Intel Onboard Fast 100 MB Ethernet network port
OS	Windows 2000 Workstation, Service Pack 2

Figure 33: Client hardware specifications

Switch (2)	
Switch	1 48 port Extreme Summit48 switch
Segments	One subnet for all systems

Figure 34: Switch specifications

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