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Microsoft Windows Server 2003 Standard Edition vs. Samba 3.0 and Red Hat Enterprise Linux ES 3.0 File Server Performance Comparison

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 File serving performance of the following server operating system configurations running on a variety of server hardware and processor configurations:

Windows Server 2003 Standard Edition
Samba 3.0 and Red Hat Enterprise Linux ES 3.0

For these tests, Microsoft supplied two server systems as follows:

Hewlett Packard DL380 G3 server configured with two 2.8GHz Pentium 4 processors, 4GB of RAM and an Intel PRO/1000 MT Dual Port Gigabit Server Adapter.

Dell PowerEdge 500SC server configured with one 1GHz Pentium III processor, 1GB of RAM and an onboard Intel 100 Mbps Ethernet network adapter and 1 Intel PRO/100 Fast Ethernet 100 Mbps network adapter.

For the File server performance tests, we used Ziff Davis Media's NetBench 7.02 benchmarking software. NetBench uses large numbers of physical test clients to generate a file I/O based workload using the CIFS protocol 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.

Key findings
<ul style="list-style-type: none">□ Windows Server 2003 Standard Edition delivered approximately 46 percent better peak File server throughput compared to Samba 3.0 running on the departmental-class HP DL 380 server configuration we tested.□ Windows Server 2003 Standard Edition delivered approximately 24 percent better peak File server throughput compared to Samba 3.0 running on the workgroup-class Dell PowerEdge 500SC server configuration we tested.□ Adding the software update to the Windows Server 2003 Standard Edition generated 59 percent better peak File server throughput compared to Samba 3.0 running on the workgroup-class Dell PowerEdge 500SC server configuration we tested with "strict sync=no".□ Adding the software update to the Windows Server 2003 Standard Edition generated 60 percent better peak File server throughput compared to Samba 3.0 running on the departmental-class HP DL380 server configuration we tested with "strict sync=no".

The File server performance testing consisted of executing the standard NetBench Enterprise Disk Mix test suites against each server described above configured with each of the operating systems described above. For the File Server performance testing using Samba 3.0 and Red Hat Enterprise Linux ES 3.0, we used the default Samba services (version 3.0.0.14) installed during the operating system installation on each server. Samba is an application that allows Windows based systems to map and use shared volumes residing on Linux systems using the CIFS protocol. Using Samba, Windows based clients can map shared volumes on the Linux server and use them as if they resided on a Windows-based server.

Testing Configurations

The goal of the testing was to compare the performance of Windows Server 2003 Standard Edition to Samba 3.0 running under Red Hat Enterprise Linux ES 3.0 using different configurations of both Samba 3.0 and Windows Server 2003 Standard Edition that modify the default behavior surrounding how each environment responds to requests by clients to commit their data to stable storage.

Under normal circumstances in both Windows Server 2003 Standard Edition and Samba 3.0 running under Red Hat Enterprise Linux ES 3.0, standard write operations requested by clients are sent out to the disk subsystem for subsequent committal to the physical disk medium. Because write operations are expensive, the disk subsystem may cache the data and then wait some period of time before actually committing this data to the physical drives. However, there are times when a client will issue a write operation along with instructions that the data is to be immediately committed to the disk. In the SMB protocol, setting the `SMB_COM_FLUSH` flag on a data write operation instructs the file system to immediately commit all data and file information associated with the write operation to stable storage before returning control to the requesting user. This operation guarantees that the data associated with the write operation is actually on the drives and will be available in the event of an untimely system failure.

By default, the `SMB_COM_FLUSH` setting in Windows Server 2003 Standard Edition results in the immediate flushing of the data associated with the write operation to the disk subsystem. In contrast, the default configuration of Samba 3.0 under Red Hat Enterprise Linux ES 3.0 allows Samba to put off flushing the data associated with the write operation until a more convenient time potentially improving overall file server performance.

Using Samba 3.0 and Red Hat Enterprise Linux ES 3.0, it is possible to configure Samba to force it to immediately honor requests to commit the data associated with a write operation to stable storage each time before returning control to the requesting user. The following share level Samba configuration option provides this functionality:

strict sync – When set to “yes”, this share-level option instructs Samba to honor all requests to perform disk synchronization when requested to do so by a client. Default setting is “no”.

Recently, Microsoft released a software update for Windows Server 2003 Standard Edition that when employed changes the default behavior of the system allowing the file server the option of delaying the immediate synchronization of the data associated with a write operation to the disk subsystem in the event that `SMB_COM_FLUSH` flag has also been set. Delaying the synchronization of the data to the disk subsystem can significantly improve overall file server performance. For complete details regarding this Microsoft software update, please refer to the following URL and Microsoft Knowledge Base article.

<http://support.microsoft.com/default.aspx?scid=kb;en-us;840390&Product=winsvr2003>

For these tests, we utilized two servers representing different business scenario types in use today. The Dell PowerEdge 500SC system contained a single processor and single IDE disk drive to store both the operating system and all the file server data. This system represents a functional, but otherwise lower-end File Server system potentially constrained because of the limits of the disk subsystem. The HP DL380 server contains dual Pentium 4 processors and 4 x 36.4GB 10,000RPM Wide Ultra SCSI drives configured as a RAID 0 data volume with the operating system installed on a separate 36.4GB 10,000RPM Wide Ultra SCSI drive. This

system represents a higher end departmental-class File Server system not necessarily challenged by a slow disk subsystem. Please refer to the Test Methodology section and Appendix A for complete details regarding the server systems used for these tests.

By changing the way each operating environment handles the commitment of data to stable storage, we can not only compare the performance of Windows Server 2003 Standard Edition to Samba 3.0 in their default configurations, but can also compare the performance where both the Windows and Samba configurations are required to immediately commit the data to stable storage as well as when both are permitted to ignore the request to commit data to stable storage until a more opportune time. These test cases are described in figure 1 below:

Server Class	Default Test Configuration	Both Configurations Ignore	Both Configurations Honor
Department/Medium Business (dual processor; disk array)	Windows Server 2003 immediately honors client requests to commit data to stable storage. Samba 3.0 can ignore client requests to immediately commit data to stable storage.	Both Windows Server 2003 and Samba 3.0 are allowed to ignore client requests to immediately commit data to stable storage	Both Windows Server 2003 and Samba 3.0 immediately honor client requests to commit data to stable storage
Small Business (single processor; single disk)	Windows Server 2003 immediately honors client requests to commit data to stable storage. Samba 3.0 can ignore client requests to immediately commit data to stable storage.	Both Windows Server 2003 and Samba 3.0 are allowed to ignore client requests to immediately commit data to stable storage	Both Windows Server 2003 and Samba 3.0 immediately honor client requests to commit data to stable storage

Figure 1. Test Case summary

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.

Test Results When Servers are Permitted to Ignore Client Requests to Commit Data

This section provides the test results when configuring Windows Server 2003 Standard Edition with the Microsoft provided software update described above to allow Windows to delay the synchronization of data to stable storage when a write operation is combined with the SMB_COM_FLUSH flag. Additionally, in this section we compare these results to those generated using Samba 3.0 and Red Hat Enterprise Linux ES 3.0 configured with the “strict sync” configuration option set to the default value of “no”. This configuration allowed both products tested to ignore the immediate client request to synchronize the data and to turn over the request to the disk subsystem to perform the synchronization operation at a later time potentially improving overall file server performance.

We found that applying the software update to Windows Server 2003 Standard Edition generated significantly better peak and sustained throughput levels during the testing on both the HP DL380 and the Dell PowerEdge 500SC server configurations compared Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” parameter set to the default value of “no”.

Figure 2 below shows that using Windows Server 2003 Standard Edition with the software update installed generated 59 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to the default value of “no” on the Dell PowerEdge 500SC system.

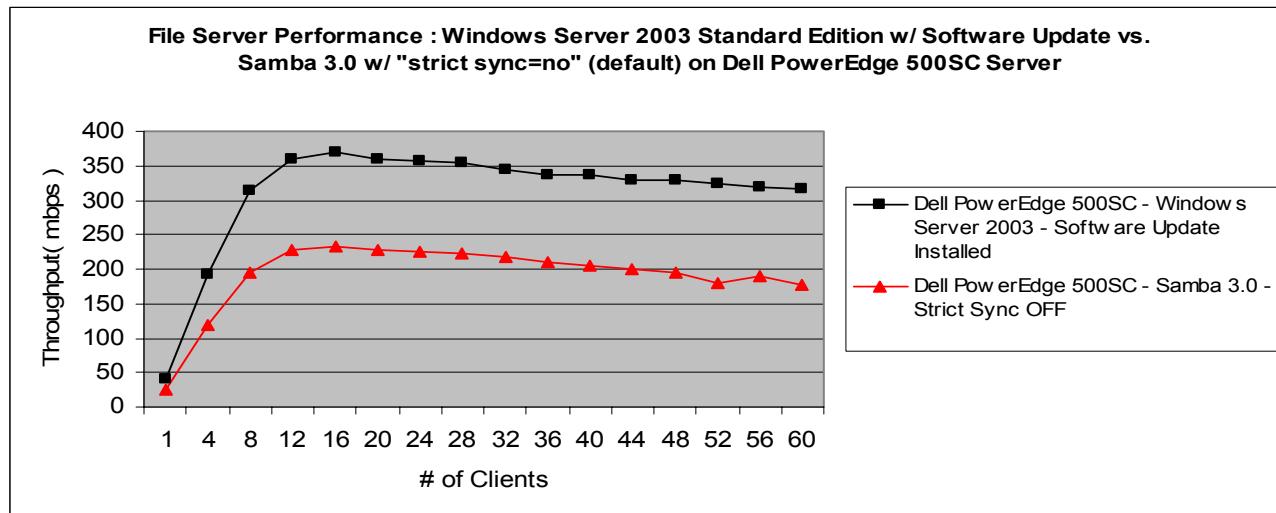


Figure 2. Windows Server 2003 Standard Edition with software update vs. Samba 3.0 with “strict sync=no” (default) on Dell PowerEdge 500SC Server

Additionally, figure 3 shows that Windows Server 2003 Standard Edition with the software update installed generated 60 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to the default value of “no” on the HP DL380 system.

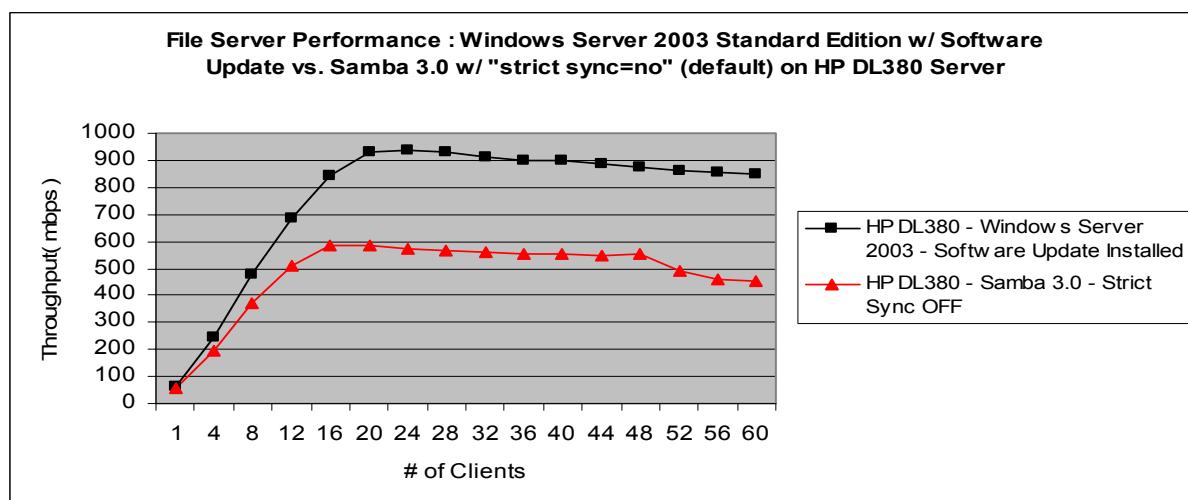


Figure 3. Windows Server 2003 Standard Edition with software update vs. Samba 3.0 with “strict sync=no” (default) on HP DL380 Server

Test Results When Servers are Required to Honor Client Requests to Commit Data

This section provides the test results when configuring Windows Server 2003 Standard Edition without the Microsoft provided software update to allow Windows to delay the synchronization of data to stable storage when a write operation is combined with the SMB_COM_FLUSH flag. Additionally, in this section we compare these results to those generated using Samba 3.0 and Red Hat Enterprise Linux ES 3.0 configured with the “strict sync” configuration option set to “yes”. This configuration forced both products tested to immediately honor the client request to synchronize the data to stable storage.

We found that applying the software update to Windows Server 2003 Standard Edition increased the peak throughput generated by approximately 10 percent compared to Windows Server 2003 Standard Edition without the software update installed on the HP DL380 server and approximately 28 percent compared to Windows Server 2003 Standard Edition without the software update installed on the Dell PowerEdge 500SC. Additionally, both Windows Server 2003 Standard Edition configurations generated significantly better peak and sustained throughput levels on both the HP DL380 and the Dell PowerEdge 500SC server configurations compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” parameter set to the value of “yes”.

Specifically, figure 4 below shows that using Windows Server 2003 Standard Edition with no software update installed generated 61 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to “yes” on the Dell PowerEdge 500SC system.

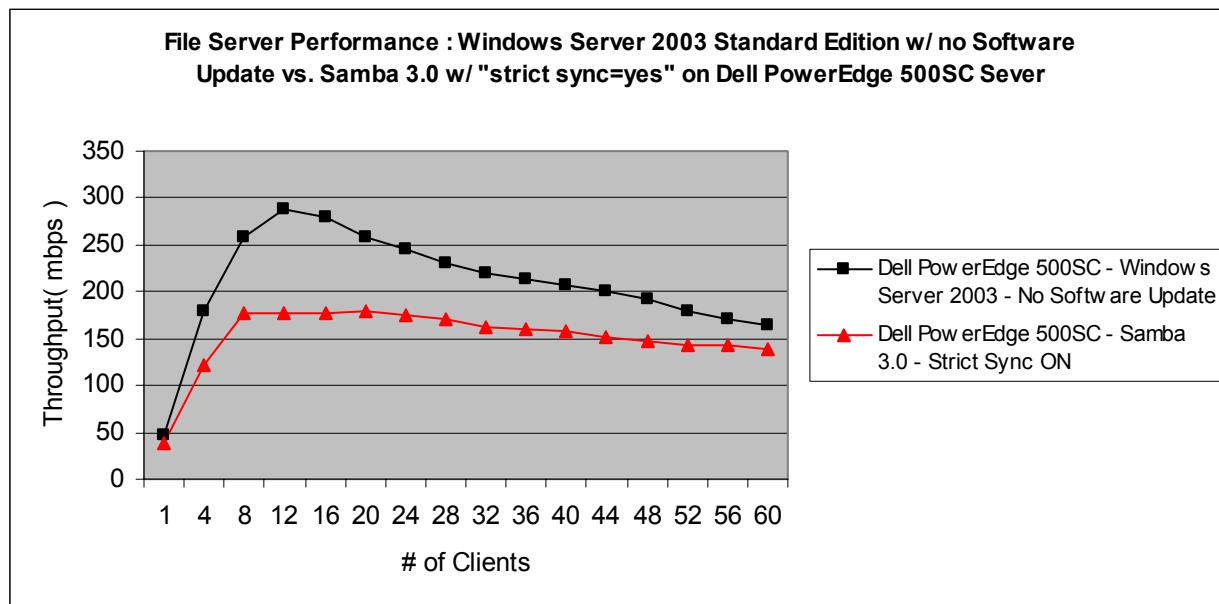


Figure 4. Windows Server 2003 Standard Edition without software update vs. Samba 3.0 with “strict sync=yes” on the Dell PowerEdge 500SC Server

Additionally, figure 5 below shows that Windows Server 2003 Standard Edition with no software update installed generated 55 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to “yes” on the HP DL380 system.

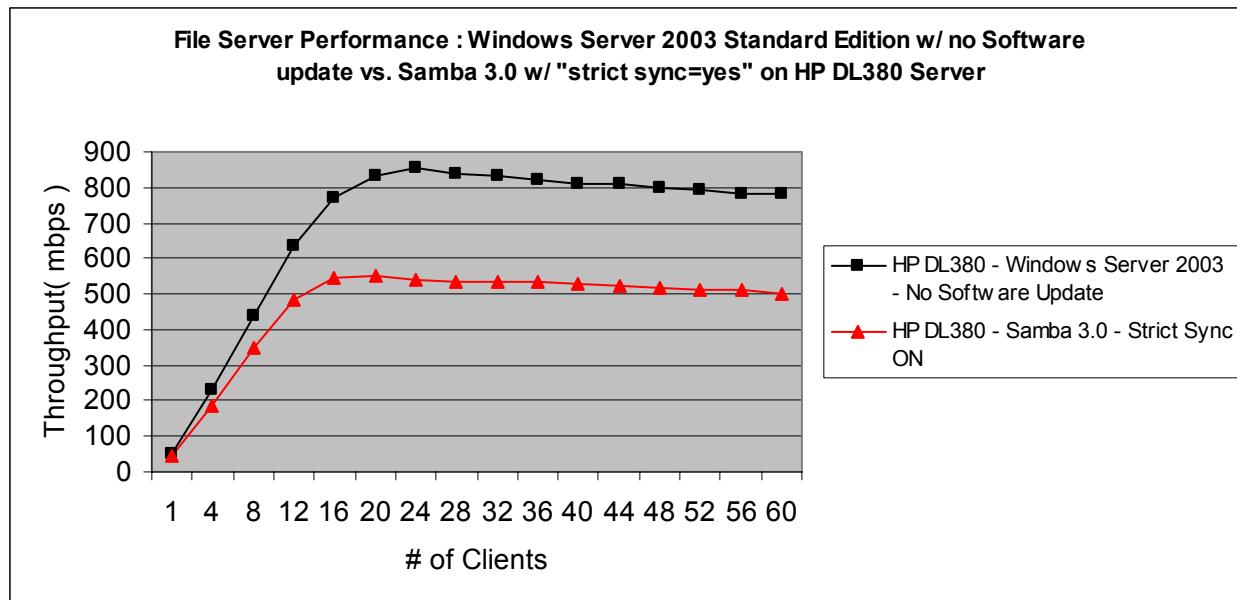


Figure 5. Windows Server 2003 Standard Edition without software update vs. Samba 3.0 with “strict sync=yes” on the HP DL380 Server

Test Results With Default Server Configurations

This section provides the test results when configuring Windows Server 2003 Standard Edition without the Microsoft provided software update to allow Windows to delay the synchronization of data to stable storage when a write operation is combined with the SMB_COM_FLUSH flag. Additionally, in this section we compare these results to those generated using Samba 3.0 and Red Hat Enterprise Linux ES 3.0 configured with the “strict sync” configuration option set to the default value of “no”.

This configuration forces Windows Server 2003 Standard Edition to immediately honor client requests to synchronize data to stable storage and allows Samba 3.0 and Red Hat Enterprise Linux ES 3.0 to ignore the immediate client request to synchronize by turning over the request to the disk subsystem for processing at a later time.

Specifically, figure 6 below shows that using Windows Server 2003 Standard Edition without the software update installed generated 24 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to the default value of “no” on the Dell PowerEdge 500SC system.

However, we found that as the load on the server increased over the course of the testing, Samba 3.0 and Red Hat Enterprise Linux ES 3.0 did a better job of maintaining those peak throughput levels on the Dell PowerEdge 500SC system compared to Windows Server 2003 Standard Edition without the software update installed.

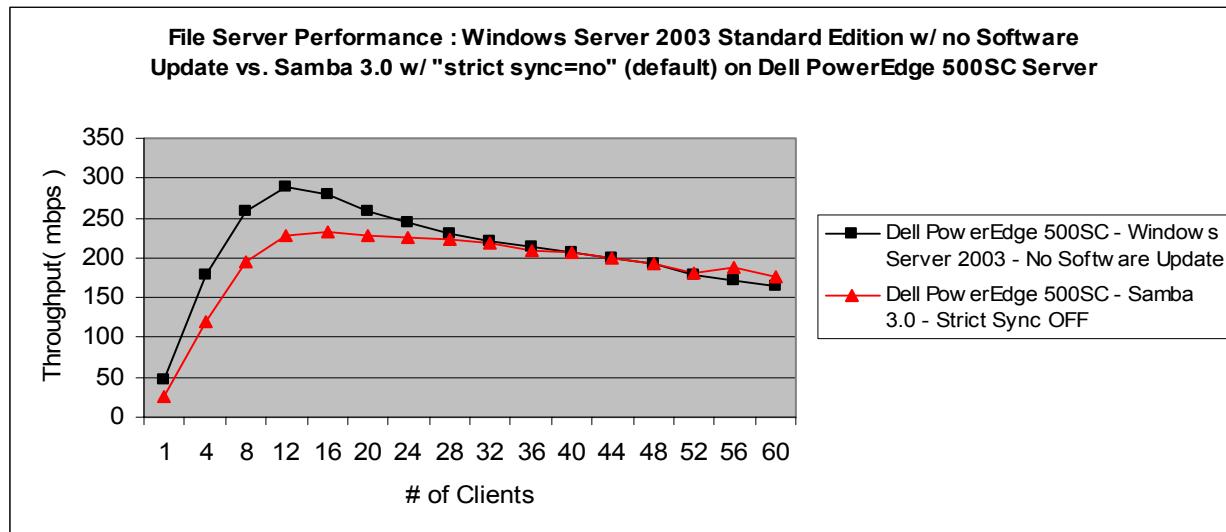


Figure 6. Windows Server 2003 Standard Edition without software update vs. Samba 3.0 with “strict sync=no (default) on the Dell PowerEdge 500SC Server

Additionally, figure 7 below shows that Windows Server 2003 Standard Edition without the software update installed generated 46 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to the default value of “no” on the HP DL380 system.

Additionally, we noticed a discernable “dip” in the throughput performance when running Samba 3.0 in this configuration on the HP DL380 system at loads of 52 clients and above. We ran this test multiple times with the server and client tunings described in this report as well as with no server or client tunings and always saw the drop off in performance towards the end of the test suite. It was interesting that this only occurred when running the standard NetBench enterprise test suite that runs for 10 minutes per each test mix. We did not see this behavior when running the tuning version of the same test suite using 5-minute test mixes on the identical configuration.

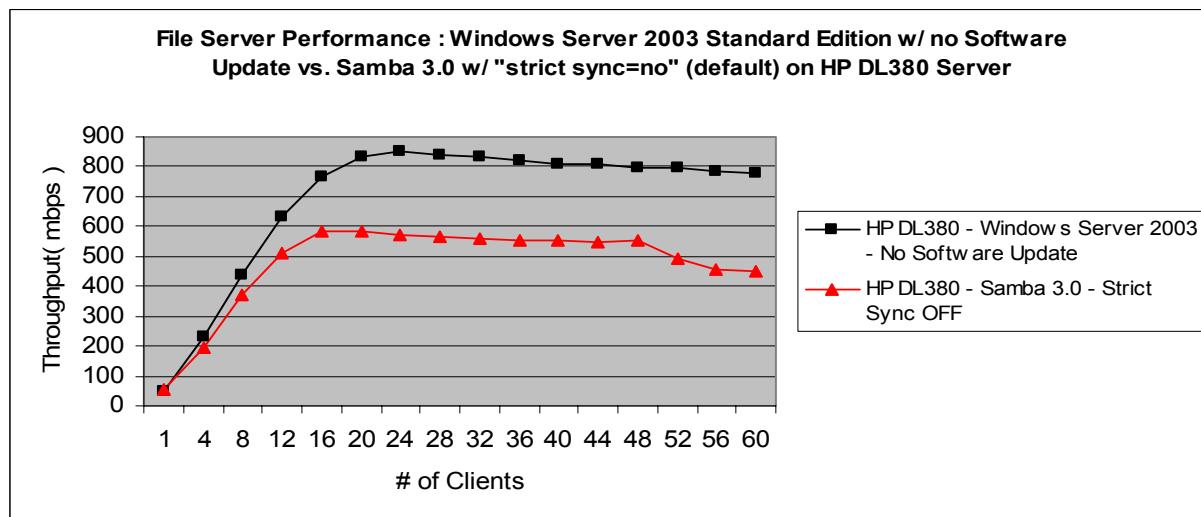


Figure 7. Windows Server 2003 Standard Edition without software update vs. Samba 3.0 with “strict sync=no (default) on the HP DL380 Server

Testing methodology

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

Windows Server 2003 Standard Edition
Samba 3.0 and Red Hat Enterprise Linux ES 3.0

Microsoft supplied the server hardware for these tests. Specifically, we used the following systems:

HP DL380 G3 server configured with two 2.8GHz Pentium 4 processors, 4GB of RAM and one Intel PRO/1000 MT Dual Port Gigabit Server Adapter. This system contained an embedded SmartArray 5300 RAID controller connected to four 36.4GB 10,000RPM Wide Ultra SCSI disk drives and two 72.8GB 10,000RPM Wide Ultra SCSI disk drives.

Dell PowerEdge 500SC server configured with one 1.0GHz Pentium III processor, 1GB of RAM and two Intel 100 Mbps network adapters, one onboard and the other mounted in a PCI slot. The system was equipped with one 20GB IBM Deskstar IDE drive.

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

120 Dell PowerEdge 350 systems configured with a single 850Mhz Pentium III processor, 256MB of RAM, 10GB IDE hard drive and single 100 Mbps Ethernet adapter.

File Server Performance Testing

Samba is an application that allows Windows based systems to map and use shared volumes residing on Linux systems using the CIFS protocol. Using Samba, Windows based clients can map shared volumes on the Linux server and use them as if they resided on a Windows-based server.

Under normal circumstances in both Windows Server 2003 Standard Edition and Samba 3.0, standard write operations requested by clients are sent out to the disk subsystem for subsequent committal to the physical disk medium. Because write operations are expensive, the disk subsystem may cache the data and then wait some period of time before actually committing this data to the physical drives. However, there are times when a client will issue a write operation along with instructions that the data is to be immediately committed to the disk. In the SMB protocol, setting the SMB_COM_FLUSH flag on a data write operation instructs the file system to immediately commit all data and file information associated with the write operation to stable storage before returning control to the requesting user. This operation guarantees that the data associated with the write operation is actually on the drives and will be available in the event of an untimely system failure.

By default, setting the SMB_COM_FLUSH flag using Windows Server 2003 Standard Edition results in the immediate flushing of the data associated with the write operation to the disk subsystem. In contrast, the default configuration of Samba 3.0 under Red Hat Enterprise Linux ES 3.0 allows Samba to put off flushing the data associated with the write operation until a more convenient time thereby potentially improving overall file server performance.

Using Samba 3.0 and Red Hat Enterprise Linux ES 3.0, it is possible to configure Samba to force it to immediately honor requests to synchronize the data associated with a write to stable storage each time before returning control to the requesting user. The following share level Samba configuration option provide this functionality:

strict sync – When set to “yes”, this share-level option instructs Samba to honor all requests to perform disk synchronization when requested to do so by a client. Default setting is “no”.

Recently, Microsoft released a software update for Windows Server 2003 Standard Edition that when employed changes the default behavior of the system allowing the file server the option of delaying the immediate synchronization of the data associated with a write operation to the disk subsystem in the event that SMB_COM_FLUSH flag has also been set. Delaying the synchronization of the data to the disk subsystem can significantly improve overall file server performance. For complete details regarding this Microsoft software update, please refer to the following URL and Microsoft Knowledge Base article.

<http://support.microsoft.com/default.aspx?scid=kb;en-us;840390&Product=winsvr2003>

The goal of the testing was to compare the performance of Windows Server 2003 Standard Edition and Samba 3.0 running under Red Hat Enterprise Linux ES 3.0 using different configurations that modify the default behavior surrounding how each platforms responds to requests by clients to commit their data to stable storage.

As a result, we conducted the following set of tests against Windows Server 2003 Standard Edition and Samba 3.0 using the standard NetBench Enterprise disk mix test suite.

- Windows Server 2003 Standard Edition with no software update installed
- Windows Server 2003 Standard Edition with software update installed
- Red Hat Enterprise Linux ES 3.0 running Samba version 3.0 with “strict sync” Samba configuration option set to default value of “no”(this is the default configuration)
- Red Hat Enterprise Linux ES 3.0 running Samba version 3.0 with “strict sync” Samba configuration option set to “yes” .

For the tests using Windows Server 2003 Standard Edition, Microsoft provided a modified svr.sys file to add the capability to delay the synchronization of the data to stable storage. We used the “sfpcopy” utility to replace the default svr.sys file under Windows Server 2003 Standard Edition with the modified svr.sys file. In addition to replacing the svr.sys file we created the following DWORD registry value and set it to the value of 1:

HKLM\CurrentControlSet\Services\lanmanserver\Parameters\TreatHostAsStableStorage.

If this value is set to a non-zero value, then the file server itself is treated as “stable storage” and the SMB server will immediately respond to the SMB_COM_FLUSH commands without writing the data to disk. If this value is set to zero, or if the value does not exist, then the SMB server will write data to disk in response to SMB_COM_FLUSH commands before responding.

For the File Server performance tests, we used Ziff Davis Media’s NetBench 7.02 benchmarking software. NetBench uses large numbers of physical test clients to generate a file I/O based workload using the CIFS protocol 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.

On both servers, we used the standard NetBench 7.02 Enterprise Disk Mix test suite to conduct all testing. The standard NetBench Enterprise Disk Mix test suite uses 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.

For all testing, the test suite described above was 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.

Operating System and File System Tuning

For the File server performance testing using Windows Server 2003 Standard Edition, we performed a series of operating system and testbed client tunings as specified by documentation provided from Microsoft. For all File server performance testing, the 120 network test clients ran Windows XP and Service Pack 1. This included installing a set of post Windows XP Service Pack 1 client redirector hot fixes received from Microsoft. Installation of the updated redirector software consisted of replacing the original mrxsmb.sys and rdbss.sys files in the C:\windows\system32\drivers directory on all the NetBench testbed clients with updated files provided by Microsoft.

Additionally, we spent considerable time investigating and testing potential performance tuning options for improving the File server performance on Red Hat Enterprise Linux ES 3.0 using Samba 3.0. While investigating tuning options for Samba, we looked at a number of items including previous competitive tests comparing Windows operating systems to Linux, as well as a variety of books and Web sites with information about tuning the performance of Samba. We gathered what appeared to be the most likely candidates to maximize the performance of Samba on our test configurations and then spent several days running a series of tests designed to determine which, if any of these tuning options actually made a difference in our File server performance tests using Samba.

Please refer to Appendix B of this report for details on how we installed and configured each of the operating systems listed above for the File Server performance testing.

Test Network Configuration

We created two distinct and separate test networks each using 60 physical clients. We connected the first 60-node network to the HP DL380 server containing two processors and the dual port network adapter. We connected all 60 clients through two Extreme Networks Summit48 switches (30 clients per switch) using 100 Mbps, full duplex connections. We configured the 60 clients into two distinct subnets each containing 30 clients. To connect the gigabit fiber optic network ports on the Extreme Summit48 switches to the gigabit copper ports on the HP DL380, we used an Extreme Networks Summit5i switch. We created two VLANs on the Summit5i switch. We connected a gigabit copper port from the Intel PRO/1000MT Gigabit Server Adapter and a gigabit fiber port from one of the Summit48 switches to each VLAN. This setup provided connectivity between the NetBench clients and the File server.

We connected the second 60-node network to the Dell PowerEdge 500SC server containing the two 100 Mbps network adapters in the same manner as described above. Both 100 Mbps network adapters were connected to the copper network ports on the Extreme Networks Summit5i switch.

Please refer to Appendix D of this report for a diagram of the network configuration used during these tests.

Test results

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

Test Results When Servers are Permitted to Ignore Client Requests to Commit Data

This section provides the test results when configuring Windows Server 2003 Standard Edition with the Microsoft provided software update described above to allow Windows to delay the synchronization of data to stable storage when a write operation is combined with the SMB_COM_FLUSH flag. Additionally, in this section we compare these results to those generated using Samba 3.0 and Red Hat Enterprise Linux ES 3.0 configured with the “strict sync” configuration option set to the default value of “no”. This configuration allowed both products tested to ignore the immediate client request to synchronize the data and to turn over the request to the disk subsystem to perform the synchronization operation later potentially improving overall file server performance.

We found that applying the software update to Windows Server 2003 Standard Edition generated significantly better peak and sustained throughput levels during the testing on both the HP DL380 and the Dell PowerEdge 500SC server configurations compared Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” parameter set to the default value of “no”.

Figure 8 below shows that using Windows Server 2003 Standard Edition with the software update installed generated 59 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to the default value of “no” on the Dell PowerEdge 500SC system.

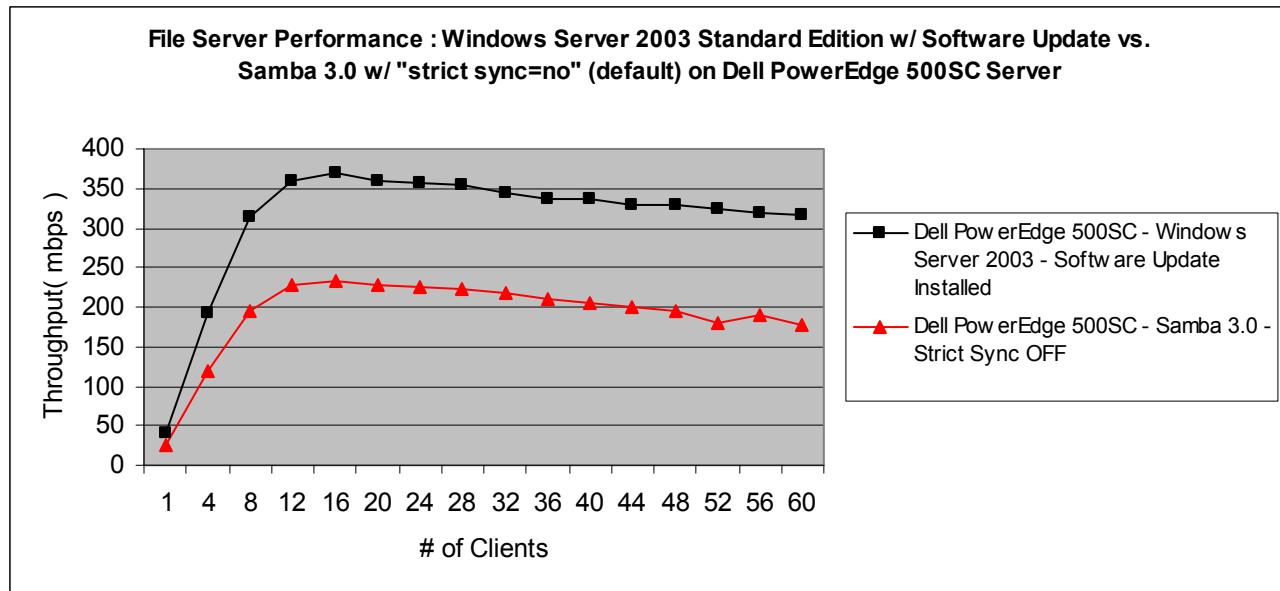


Figure 8. Windows Server 2003 Standard Edition with software update vs. Samba 3.0 with “strict sync=no (default) on Dell PowerEdge 500SC Server

Additionally, figure 9 shows that Windows Server 2003 Standard Edition with the software update installed generated 60 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to the default value of “no” on the HP DL380 system.

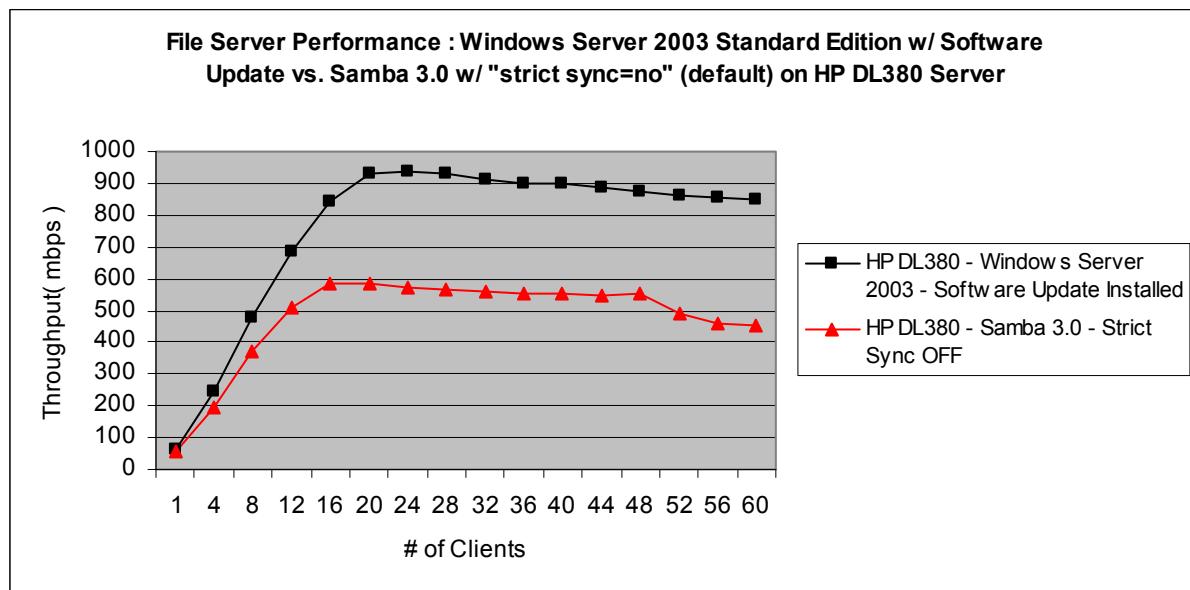


Figure 9. Windows Server 2003 Standard Edition with software update vs. Samba 3.0 with “strict sync=no” (default) on HP DL380 Server

Test Results When Servers are Required to Honor Client Requests to Commit Data

This section provides the test results when configuring Windows Server 2003 Standard Edition without the Microsoft provided software update to allow Windows to delay the synchronization of data to stable storage when a write operation is combined with the SMB_COM_FLUSH flag. Additionally, in this section we compare these results to those generated using Samba 3.0 and Red Hat Enterprise Linux ES 3.0 configured with the “strict sync” configuration option set to “yes”. This configuration forced both products tested to immediately honor the client request to synchronize the data to stable storage.

We found that applying the software update to Windows Server 2003 Standard Edition increased the peak throughput generated by approximately 10 percent compared to Windows Server 2003 Standard Edition without the software update installed on the HP DL380 server and approximately 28 percent compared to Windows Server 2003 Standard Edition without the software update installed on the Dell PowerEdge 500SC. Additionally, both Windows Server 2003 Standard Edition configurations generated significantly better peak and sustained throughput levels on both the HP DL380 and the Dell PowerEdge 500SC server configurations compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” parameter set to the value of “yes”.

Specifically, figure 10 below shows that using Windows Server 2003 Standard Edition with no software update installed generated 61 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to “yes” on the Dell PowerEdge 500SC system.

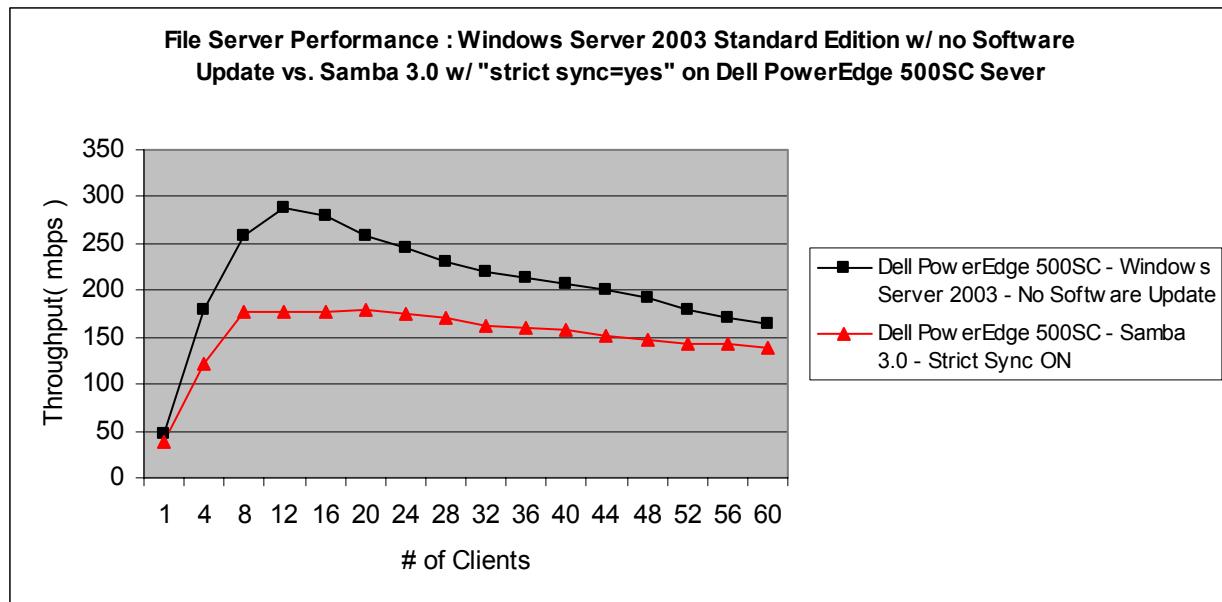


Figure 10. Windows Server 2003 Standard Edition without software update vs. Samba 3.0 with “strict sync=yes” on the Dell PowerEdge 500SC Server

Additionally, figure 11 below shows that Windows Server 2003 Standard Edition with no software update installed generated 55 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to “yes” on the HP DL380 system.

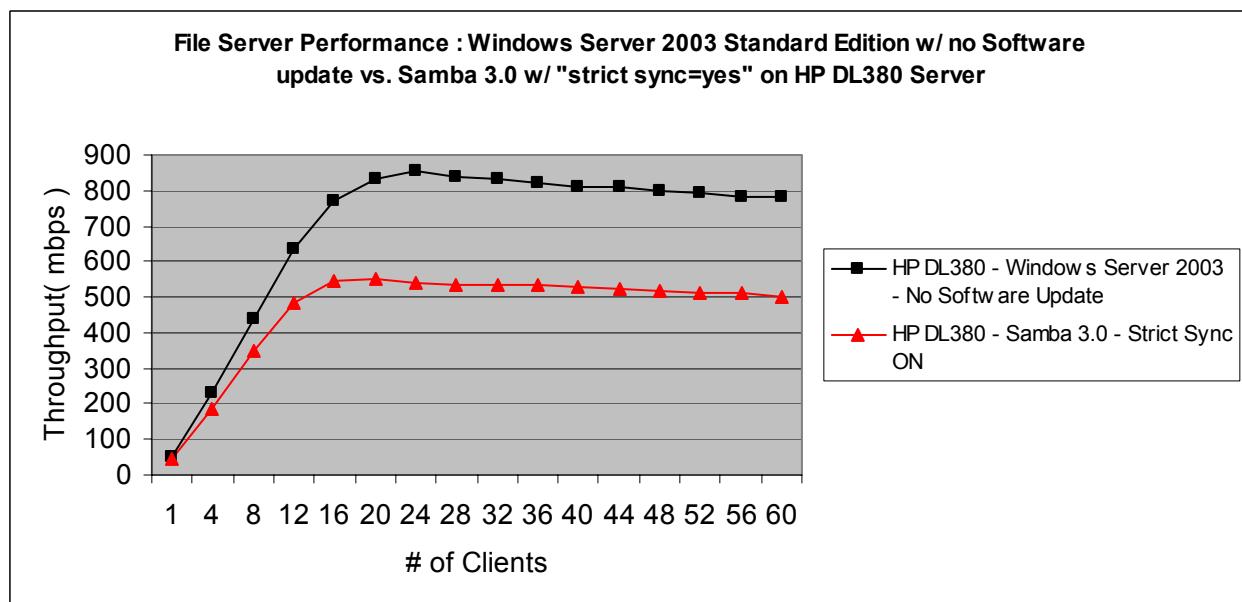


Figure 11. Windows Server 2003 Standard Edition without software update vs. Samba 3.0 with “strict sync=yes” on the HP DL380 Server

Test Results With Default Server Configurations

This section provides the test results when configuring Windows Server 2003 Standard Edition without the Microsoft provided software update to allow Windows to delay the synchronization of data to stable storage when a write operation is combined with the SMB_COM_FLUSH flag. Additionally, in this section we compare these results to those generated using Samba 3.0 and Red Hat Enterprise Linux ES 3.0 configured with the “strict sync” configuration option set to the default value of “no”.

This configuration forces Windows Server 2003 Standard Edition to immediately honor client requests to synchronize data to stable storage and allows Samba 3.0 and Red Hat Enterprise Linux ES 3.0 to ignore the immediate client request to synchronize the data.

Specifically, figure 12 below shows that using Windows Server 2003 Standard Edition without the software update installed generated 24 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to the default value of “no” on the Dell PowerEdge 500SC system.

However, we found that as the load on the server increased over the course of the testing, Samba 3.0 and Red Hat Enterprise Linux ES 3.0 did a better job of maintaining those peak throughput levels on the Dell PowerEdge 500SC system compared to Windows Server 2003 Standard Edition without the software update installed.

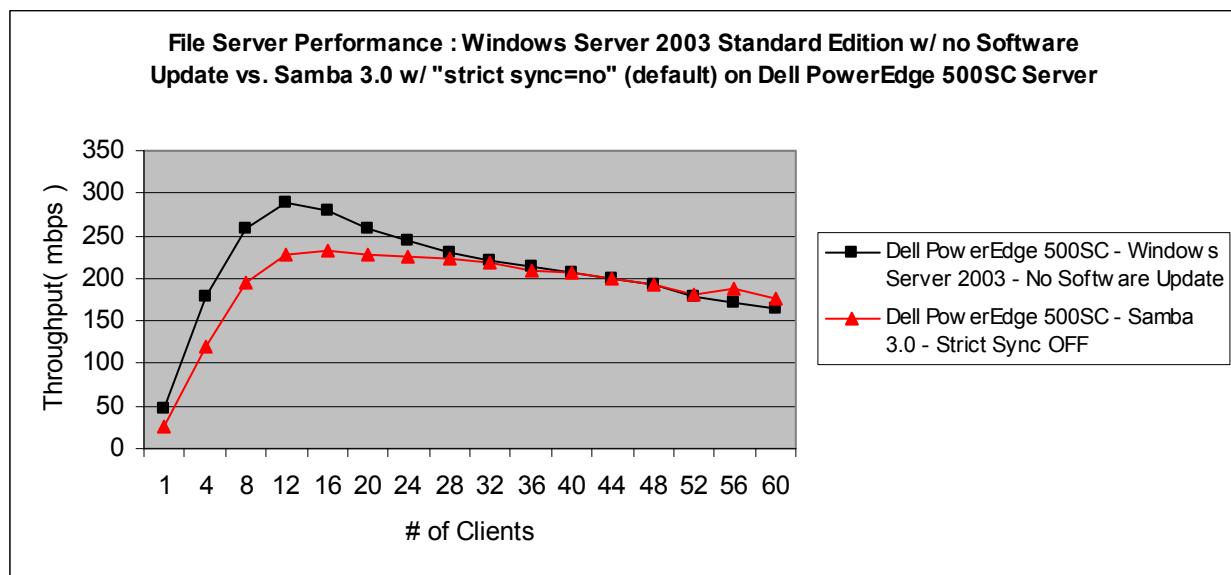


Figure 12. Windows Server 2003 Standard Edition without software update vs. Samba 3.0 with “strict sync=no (default) on the Dell PowerEdge 500SC Server

Additionally, figure 13 below shows that Windows Server 2003 Standard Edition without the software update installed generated 46 percent better peak file server throughput when compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with the “strict sync” Samba configuration parameter set to the default value of “no” on the HP DL380 system.

Additionally, we noticed a discernable “dip” in the throughput performance when running Samba 3.0 in this configuration on the HP DL380 system at loads of 52 clients and above. We ran this test multiple times with the server and client tunings described in this report as well as with no server or client tunings and always saw the drop off in performance towards the end of the test suite. It was interesting that this only occurred when running the standard NetBench enterprise test suite that runs for 10 minutes per each test mix. We did

not see this behavior when running the tuning version of the same test suite using 5-minute test mixes on the identical configuration.

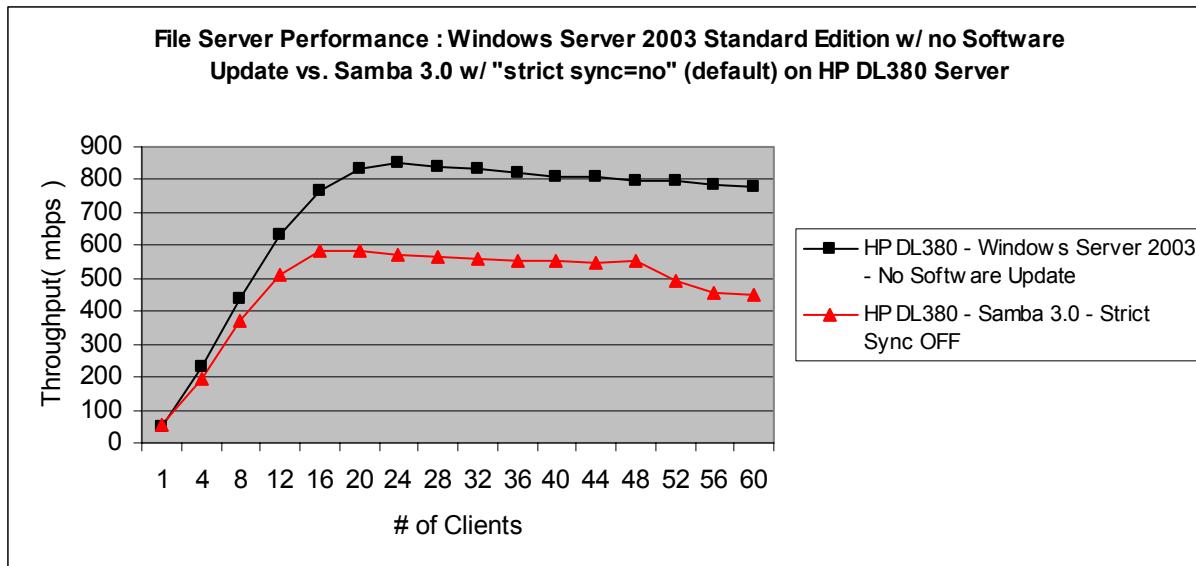


Figure 13. Windows Server 2003 Standard Edition without software update vs. Samba 3.0 with “strict sync=no (default) on the HP DL380 Server

Figure 14 below shows the actual peak NetBench File server performance throughput results in Megabits per second (Mbps) generated using Windows Server 2003 Standard Edition and Samba 3.0 and Red Hat Enterprise Linux ES 3.0 on both the HP DL380 and Dell 500SC servers for all test configurations. These results show that Windows Server 2003 Standard Edition delivered between 24 and 61 percent better peak File Serving throughput compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 in these test configurations.

Operating System	HP DL380	Dell PowerEdge 500SC
Windows Server 2003 Standard Edition with software update installed	935.770 Mbps	370.34 Mbps
Windows Server 2003 Standard Edition – No software update	853.966 Mbps	288.494 Mbps
Samba 3.0 and Red Hat Enterprise Linux ES 3.0 - Strict Sync OFF(default)	586.389 Mbps	232.376 Mbps
Samba 3.0 and Red Hat Enterprise Linux ES 3.0 - Strict Sync ON	549.465 Mbps	178.945 Mbps
Percent Improvement In Peak Throughput using Windows Server 2003 Standard Edition with no software update (default) compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with Strict Sync OFF (default)	46%	24%
Percent Improvement In Peak Throughput using Windows Server 2003 Standard Edition With software update installed compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with Strict Sync OFF (default)	60%	59%
Percent Improvement In Peak Throughput using Windows Server 2003 Standard Edition with no software update (default) compared to Samba 3.0 and Red Hat Enterprise Linux ES 3.0 with Strict Sync ON	55%	61%
Percent Improvement In Peak Throughput using Windows Server 2003 Standard Edition With software update installed compared to Windows Server 2003 with no software update installed (default)	10%	28%

Figure 14. Peak File Server Performance – Windows Server 2003 Standard Edition vs. Samba 3.0 and Red Hat Enterprise Linux ES 3.0

Appendix A. Test Server and Network Client Configuration Information

Network Testbed Clients	
Machine Type	Dell PowerEdge 350
Processor(s)	1 x 850MHz Pentium III
Hard Drive(s)	10GB IDE 7200
Memory	256MB
L2 Cache	256K
Motherboard	Intel
Network Adapter(s)	Intel Pro100 Management Adapter
Video Card	NVIDIA GeForce2 MX
OS	Windows XP/SP1

Figure 15. Network Testbed Client Disclosure Information

HP DL380 G3 Server Configuration Information	
Machine Type	HP DL380 G3
Processor(s)	2 x Intel Pentium 4 2.8 GHz
Hard Drive(s)	2 x Compaq 72.8GB Wide Ultra SCSI (10K) 4 x Compaq 36.4GB Wide Ultra SCSI (10K)
Memory	4GB
L2 Cache	512KB
Motherboard	Intel
Network Adapter(s)	1 x Intel PRO/1000 MT Dual Port Server Adapter
OS	Windows 2003 Server Standard Edition/ Red Hat Enterprise Server 3.0

Figure 16. DL380 2P Server Disclosure Information

Dell PowerEdge 500SC Server Configuration Information	
Machine Type	Dell PowerEdge 500SC
Processor(s)	1 x Intel Pentium III 1.0GHz
Hard Drive	20GB IBM Deskstar IDE
Memory	1GB
L2 Cache	256KB
Motherboard	Intel
Network Adapter(s)	1 x Intel 100 Mbps Onboard Ethernet Adapter 1 x Intel Pro/100 PCI Ethernet Adapter
OS	Windows 2003 Server Standard Edition/ Red Hat Enterprise Server 3.0

Figure 17. Dell PowerEdge 500SC Server Disclosure Information

Appendix B. Operating System Installation and Configuration

This Appendix 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 the HP DL380 server the same way for all testing using HP's SmartStart 6.4 utility and selecting the defaults as shown in figure 18 below.

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

Figure 18. Default RAID Controller Parameters

For the HP DL380 server, we configured the four 36.4GB drives connected to the SmartArray 5300 controller into a single RAID 0 partition. We divided the RAID 0 partition into four logical RAID 0 data volumes of approximately 33.1GB each. Each logical volume was created using the default RAID controller parameters listed in figure 18. During installation of the specific operating system, we used the appropriate disk management utilities to create one volume on each of the four 33.1GB logical RAID 0 volumes. We used a separate 33.1GB drive for the operating system.

Figure 19 below shows the file system parameters used for each of the operating systems tested on the HP DL380 server configured with two processors.

Operating System	# of Volumes	Volume Size	Format Type	Block Size
Windows Server 2003 Standard Edition	4	33.1GB	NTFS	32K bytes
Red Hat Enterprise Linux ES 3.0	4	33.1GB	ext3	default

Figure 19. File system parameters for the HP DL380 server

For the Dell PowerEdge 500SC server, we created a separate partition for the operating system and the shared volume on the single IDE drive. After installing the specific operating system, we used the disk management utilities to create one volume on the second partition. In both cases, the shared volume totaled 9GB in size.

Figure 20 below shows the file system parameters used for each of the operating systems tested on the Dell PowerEdge 500SC server.

Operating System	# of Volumes	Volume Size	Format Type	Block Size
Windows Server 2003 Standard Edition	1	9GB	NTFS	32K bytes
Red Hat Enterprise Linux ES 3.0	1	9GB	ext3	default

Figure 20. File system parameters for the Dell PowerEdge 500SC server

For all Windows Server 2003 Standard Edition configurations tested, 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 Standard Edition

We installed a fully functional shipping version of Windows Server 2003 Standard Edition for these tests. To install the operating system, we performed the following steps:

For the HP DL380 G3 server:

Using SmartStart 6.4, selected Microsoft Server 2003 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.
Used Microsoft's web-based update process to update all security patches, critical updates, and updated the network adapter drivers for the Intel PRO/1000 MT Dual Port Gigabit Server Adapter

For the Dell PowerEdge 500SC server:

Using Dell's OpenManagement Software, selected Microsoft Server 2003 as the operating system to install and began the installation process
During installation, configured the network parameters to match the client testbed segments.
Used Microsoft's web-based update process to update all security patches, critical updates, and updated the network adapter drivers for both the Intel Pro100 network adapters.

Additionally, we conducted testing after applying a software update to the tuned Windows Server 2003 Standard Edition installation on both the HP DL380 and Dell PowerEdge 500SC servers. This software update changes the way the Windows Server 2003 Standard Edition responds to SMB_COM_FLUSH commands. The current behavior of the SMB_COM_FLUSH command causes the SMB server to write all of the data and allocation information for a particular file (or all files open for a particular connection) to be written to disk. This software update replaces the original svr.sys file on the server and creates a new DWORD registry value as follows:

HKLM\CurrentControlSet\Services\lanmanserver\Parameters\TreatHostAsStableStorage

If this value is set to a non-zero value, then the file server itself is treated as "stable storage," and the SMB server will immediately respond to SMB_COM_FLUSH commands without writing data to disk. If this value is set to zero, or if the value does not exist, then the SMB server will write data to disk in response to SMB_COM_FLUSH commands before responding. For complete details regarding this Microsoft software update, please refer to the following URL and Microsoft Knowledge Base article.

<http://support.microsoft.com/default.aspx?scid=kb;en-us;840390&Product=winsvr2003>

Red Hat Enterprise Linux ES 3.0

Red Hat Enterprise Linux ES 3.0 is the offering from Red Hat targeted to small to medium sized businesses. The list below shows the basic steps we performed to install Red Hat Enterprise Linux ES 3.0 for the File Server performance testing on both the HP DL380 and Dell PowerEdge 500SC systems.

Configured the RAID subsystem as described above.
Rebooted server to start installation process
Selected recommended default installation option and accepted all pre-selected items
Selected the kernel-enterprise and kernel-smp (HP DL380 only) packages to load kernel sources

Downloaded and installed the latest Linux version of the Intel network adapter drivers available from Intel Web site (version 5.2.2).

During installation, configured the network parameters to match the client testbed segments. We checked the Red Hat Web site for available updates and errata for the Red Hat Enterprise Linux ES 3.0 product and loaded all available updates using the Red Hat Network process.

To maximize File Server performance on the HP DL380 server running Red Hat Enterprise Linux ES 3.0, we configured the processor affinity feature available through the operating system to bind individual IRQ values associated with individual network interface cards (NIC's) in the server under test to a specific processor in the server under test. In our test configuration, a unique IRQ value was associated with each of the NIC's in the server. This allowed us to map each of the NIC's in the server to a separate processor for optimal performance through use of the processor affinity feature.

When testing the HP DL380 server running Red Hat Enterprise Linux ES 3.0, we used the Enterprise SMP kernel. Specific kernel version numbers used during the testing were 2.4.21-9.0.1-EL for the single processor Dell PowerEdge 500SC and 2.4.21-9.0.1-ELsmp for the dual processor HP DL380.

Appendix C. File Server Performance Tuning

The following sections describe the specific changes we made to the default operating system configurations for each platform tested.

Windows Server 2003 Standard Edition

File server performance tuning under Windows Server 2003 Standard Edition consisted of making the following registry modifications to the server systems under test. Except where noted below, server tunings were identical for all test configurations using Windows Server 2003 Standard Edition.

HKLM\System\CurrentControlSet\Control\SessionManager\MemoryManagement\PagedPoolSize set to 192,000,000.
HKLM\System\CurrentControlSet\Control\FileSystem\NtfsDisable8dot3NameCreation set to 1.
Created HKLM\System\CurrentControlSet\Control\FileSystem\Disablelastaccess and set to 1.
Created HKLM\System\CurrentControlSet\Services\tcpip\Parameters\TcpAckFrequency and set to 13 on the HP DL380 server.
Created HKLM\System\CurrentControlSet\Services\tcpip\Parameters\TcpAckFrequency and set to 5 on the Dell PowerEdge 500SC server

In addition to the server tunings above, we installed a number of Microsoft provided registry modifications on the NetBench clients. These client-based registry changes are recommended by Microsoft for improving the performance of Windows Server 2003 Standard Edition systems. The registry changes are as follows:

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.
Created HKLM\System\CurrentControlSet\Services\tcpip\Parameters\TcpAckFrequency and set to 13 on all testbed client systems when testing with the HP DL380 server.
Created HKLM\System\CurrentControlSet\Services\tcpip\Parameters\TcpAckFrequency and set to 5 on all testbed client systems when testing with the Dell PowerEdge 500SC server

Finally, we installed a set of post Windows XP Service Pack 1 client redirector hot fixes received from Microsoft. Installation of the updated redirector software consisted of replacing the original mrxsmb.sys and rdbss.sys files in the C:\windows\system32\drivers directory on all the NetBench testbed clients with updated files provided by Microsoft.

Samba 3.0 and Red Hat Enterprise Linux ES 3.0

Before conducting the testing using Samba 3.0 and Red Hat Enterprise Linux ES 3.0, we conducted a number of preliminary test runs using different configurations to determine which options might best maximize the file serving performance of this configuration. For the tuning test runs we created a NetBench test suite using the standard Enterprise Disk Mix workload, but shortened the run time of each mix from 10 minutes to 5 minutes. This reduced the total test run time from over three hours down to approximately 1.5 hours. Using this shortened test suite generates test results comparable to the standard Enterprise Disk Mix test used to generate the numbers presented in this report.

We started by generating a set of baseline results on both the HP DL380 and the Dell PowerEdge 500SC systems after installing the Red Hat Enterprise Linux ES 3.0 software and performing an update using the Red Hat Network. For these baseline tests we used NetBench clients with a standard Windows XP

Professional/SP1 image with no other modifications. Figure 21 shows the results of the baseline tests on both server platforms.

As expected, these tests showed that the HP DL380 server with dual processors and RAID configuration generated significantly better peak and sustained throughput compared to the Dell PowerEdge 500SC server configured with a single processor and disk drive.

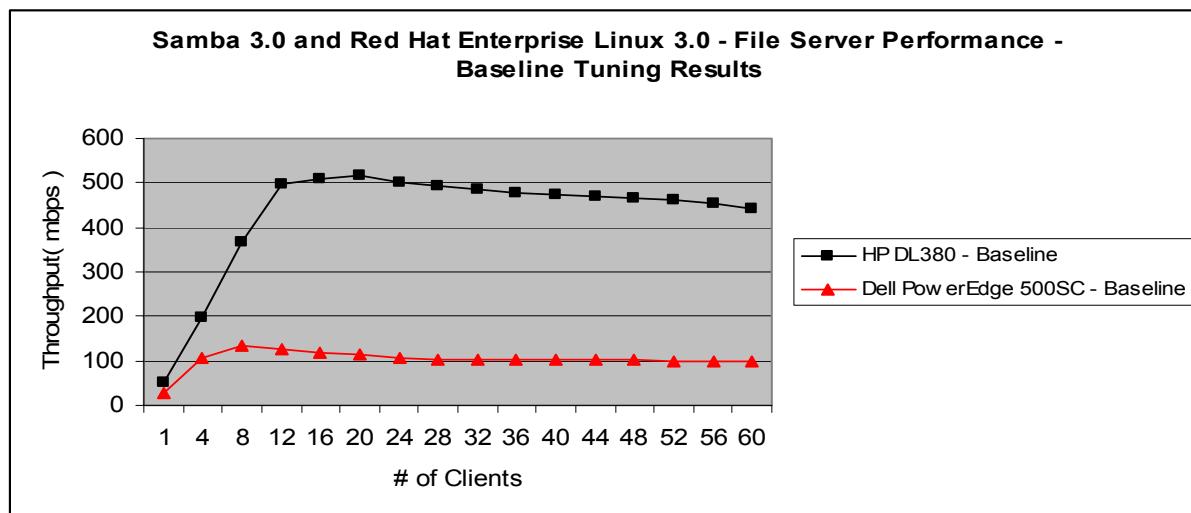


Figure 21. Samba 3.0 and Red Hat Enterprise Linux ES 3.0 Baseline Tuning Results

After generating the baseline results for both servers using Samba 3.0 and Red Hat Enterprise Linux ES 3.0, we configured the NetBench clients with updated network redirector software provided by Microsoft and ran an additional set of tests. Installation of the updated redirector software consisted of replacing the original mrxsmb.sys and rdbss.sys files in the C:\Windows\System32\Drivers directory on all the NetBench testbed clients with updated files provided by Microsoft. Figure 22 below shows the results of these tests. These tests showed that updating the Windows XP Professional network redirector on the test NetBench test clients slightly improved the overall results on both the HP DL 380 and Dell PowerEdge 500SC servers.

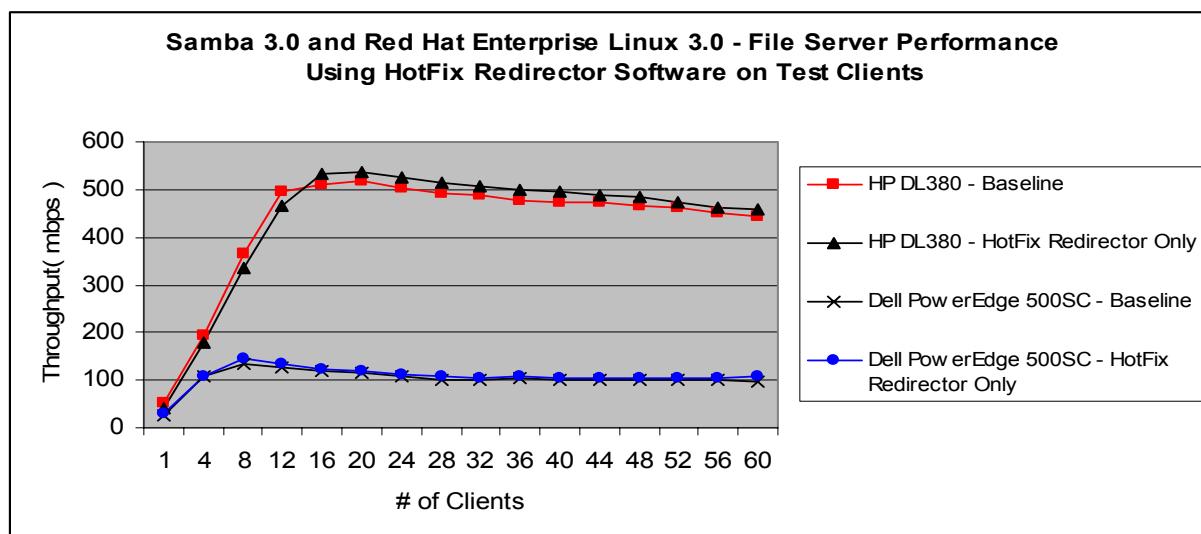


Figure 22. Samba 3.0 and Red Hat Enterprise Linux ES 3.0 Updated Redirector Tuning Results

We then installed a number of Microsoft provided registry modifications on the NetBench clients and conducted additional testing. These client-based registry changes are recommended by Microsoft for improving the performance of Windows Server 2003 Standard Edition systems. The registry changes are as follows:

```
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.
```

Figure 23 shows the results of these tests compared to the initial baseline results and results generated using the updated client redirector software. These results showed that using the combination of an updated redirector and the registry changes described above improved the performance of the HP DL380 system compared to both the baseline and after adding the updated redirector software to the baseline client configuration. Additionally, we found that adding both the updated redirector and client registry entries did not significantly impact the overall performance when running on the Dell system using Samba 3.0 and Red Hat Enterprise Linux ES 3.0.

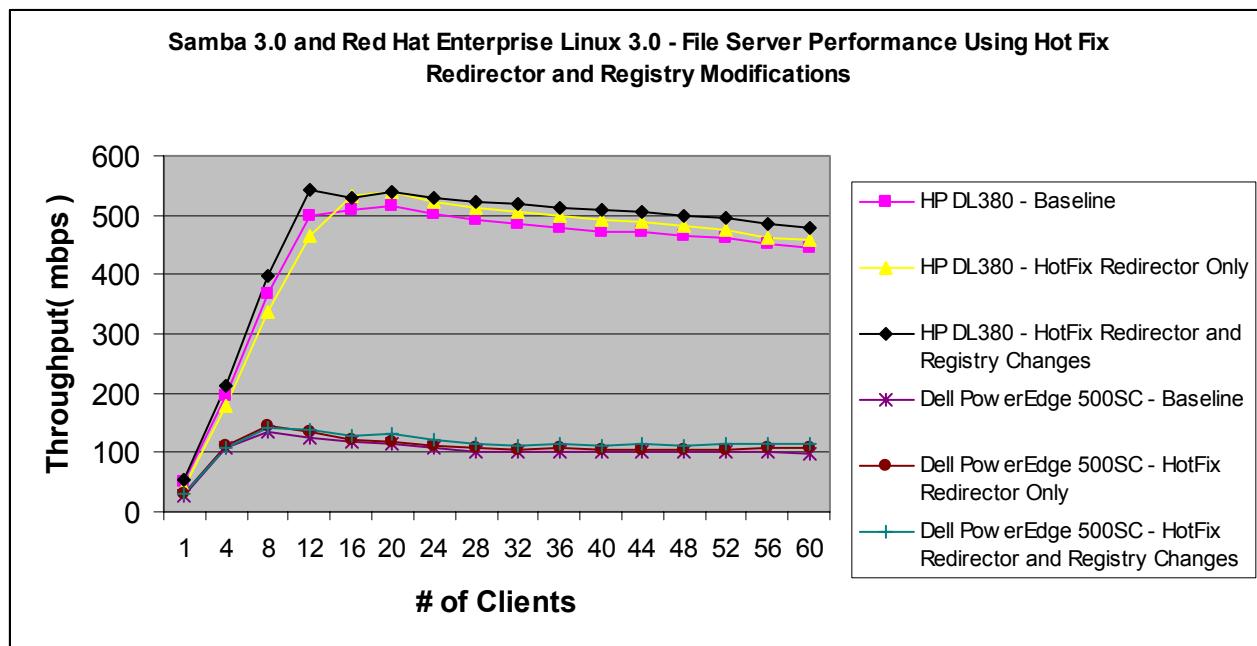


Figure 23. Samba 3.0 and Red Hat Enterprise Linux ES 3.0 Updated Redirector and Hotfixes Tuning Results

After making the client tunings described above, we then conducted a set of tests that modified operating system, file system and Samba parameters in an effort to improve the performance even further. For these tests, we considered our baseline for comparison to be the test results generated using both the updated redirector and client based registry modifications.

Our initial test involved adding the “noatime” parameter to each line of the /etc/fstab file related to mounting a data volume used in these tests. Providing this option instructs the file system not to update the access information for files that are simply read. This can improve overall file server performance by reducing the overall number of write operations performed. For the Dell system, this involved only a single data volume as only one drive was used for the testing. For the HP DL 380, this involved adding the noatime option to each of

the four data volumes used in the test. Figure 24 below shows the test results after adding the noatime parameter when mounting each data volume. We found that adding the noatime parameter improved the peak throughput on both servers under test. At heavier client loads, the performance improvement was still visible but not as pronounced.

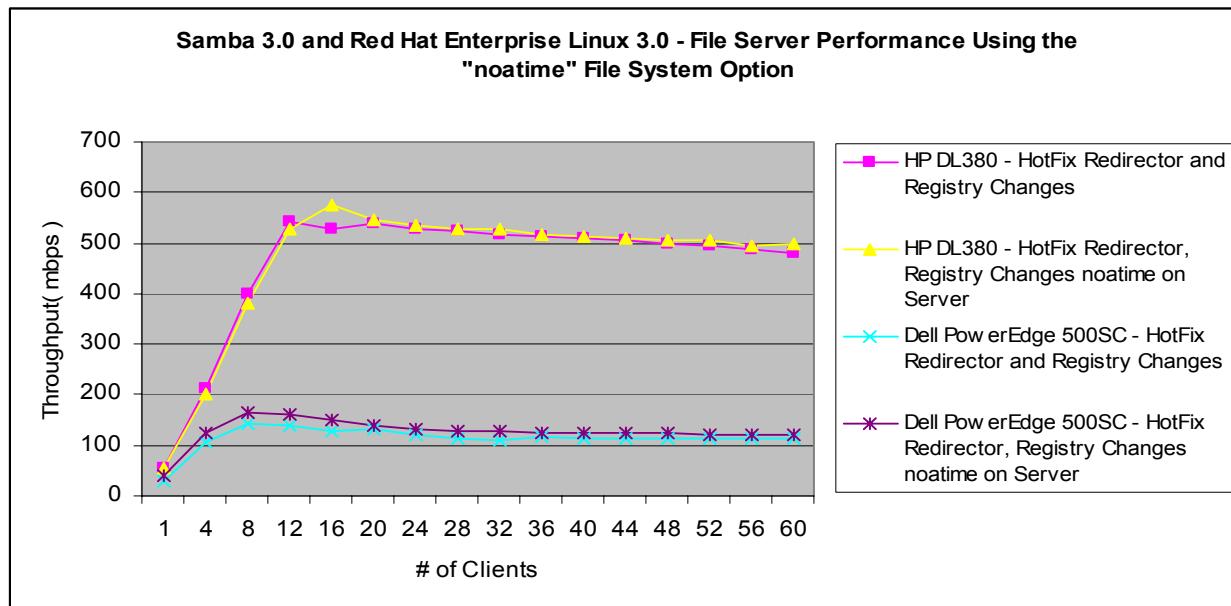


Figure 24. Samba 3.0 and Red Hat Enterprise Linux ES 3.0 Tuning using noatime

The next test involved adding the “data=writeback” parameter to each line of the /etc/fstab file related to mounting a data volume used in these tests. Writeback is one of three journaling options available for the ext3 file system. When selected, no data is journaled during normal operations potentially improving overall file server performance at the possible expense of data being lost as the result of a server crash. Figure 25 shows the test results when adding the “data=writeback” parameter for the data volumes used in the testing. For the Dell system, this involved only a single data volume as only one drive was used for the testing. For the HP DL 380, this involved adding the noatime option to each of the four data volumes used in the test.

The results show a significant improvement in the peak throughput values obtained on the Dell PowerEdge 500SC compared to the baseline performance when using only the client redirector and registry modifications. Performance improvements were noticeable on the HP DL380 server using this option, but less pronounced when compared to those observed on the Dell PowerEdge 500SC server. In addition to improving peak performance, using the “data=writeback” option generally improved the performance at all client load points during the testing. This was especially true on the Dell PowerEdge 500SC system containing only one IDE drive.

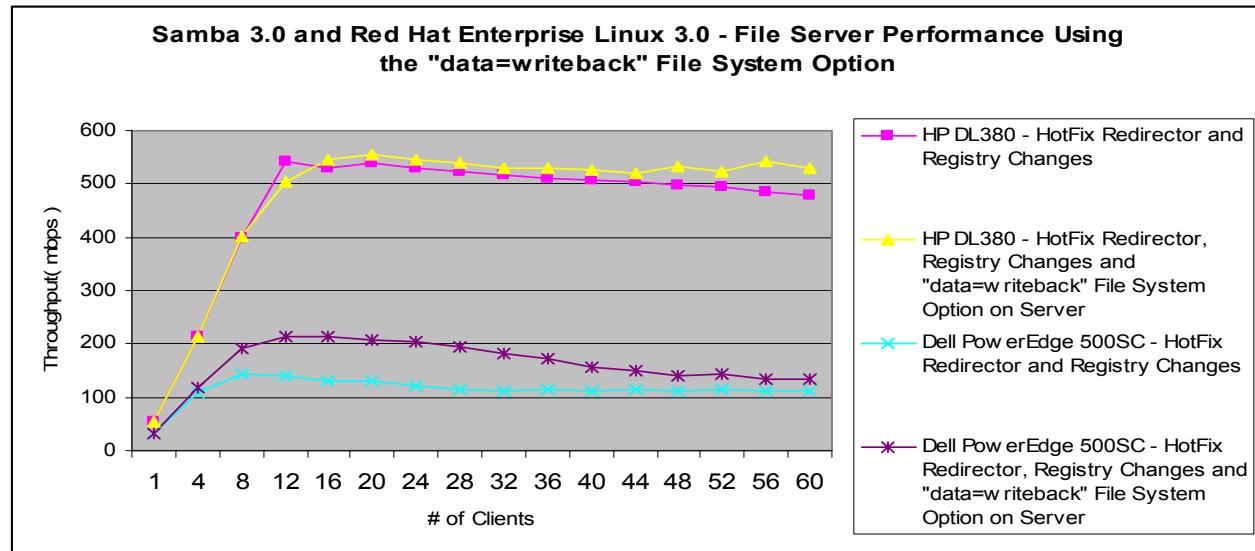


Figure 25. Samba 3.0 and Red Hat Enterprise Linux ES 3.0 Performance using data=writeback

We then modified several bdflush daemon parameters as shown in figure 26 below to allow the file system to increase the percentage of dirty buffers in the buffer cache before flushing the data to disk and increase the maximum amount of time the file system can wait before flushing the dirty buffers to disk. Writing data to the disk subsystem is a costly operation and delaying this operation can improve overall file server performance. We modified these parameters by changing them in the /proc/sys/vm/bdflush variable before each test run using the following command:

```
Echo "80 5000 0 0 500 30000 80 50 0" > /proc/sys/vm/bdflush
```

Parameter #	Description	Default Value	Modified Value
1	The maximum percentage of dirty buffers in the buffer cache to activate bdflush	50	80
2	The maximum number of dirty buffers that bdflush can write to disk in one operation	500	5000
3	Not Currently Used	0	0
4	Not Currently Used	0	0
5	The minimum rate at which kupdate will wake and flush	500	500
6	The maximum time to wait before writing out a dirty buffer to disk	3000	30000
7	The percentage of buffer cache that is dirty before bdflush activates synchronously	80	80
8	The percentage of buffer cache that is unused which will stop bdflush	50	50
9	Not Currently Used	0	0

Figure 26. Default and modified bdflush parameters

Figure 27 shows the results of testing with the modified bdflush parameters. Testing with the modified bdflush parameters showed an improvement in the peak throughput values obtained on both systems compared to the performance using just the baseline client tunings. In addition to improving peak performance, modifying the bdflush parameters slightly improved the performance at all client load points during the HP DL380 server.

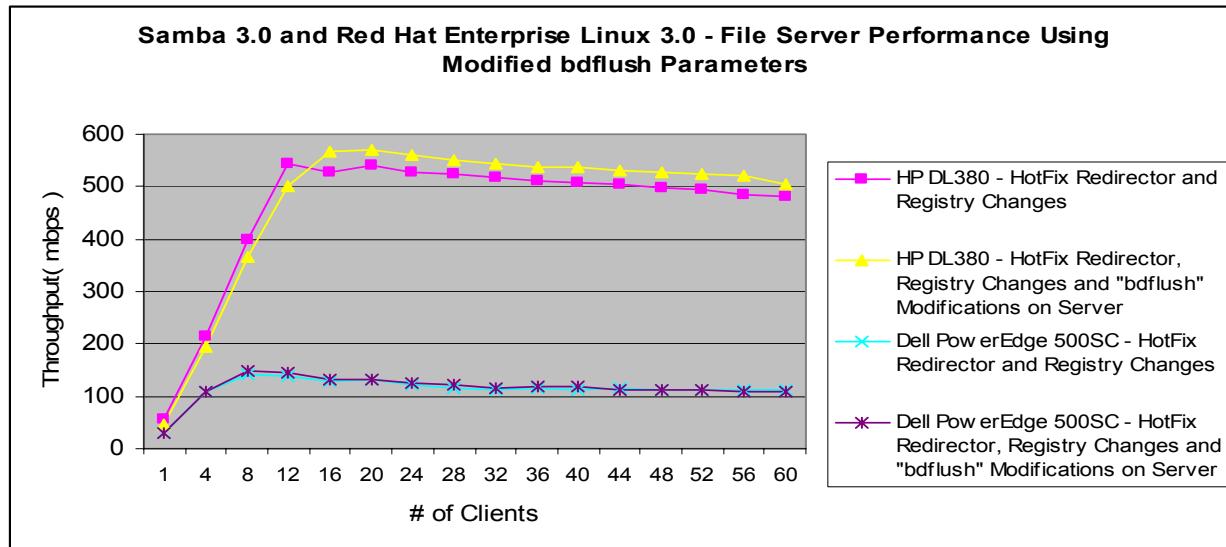


Figure 27. Samba 3.0 and Red Hat Enterprise Linux ES 3.0 Performance using bdflush modifications

The next tuning test run consisted of modifying the SO_SNDBUF and SO_RCVBUF parameters in the Samba configuration file. For this test we increased the values of each of the SO_SNDBUF and SO_RCVBUF from the default of 8192 to 16384. The results of this test are shown in figure 28 below. We found that increasing the values of each of the SO_SNDBUF and SO_RCVBUF from the default of 8192 to 16384 had no significant performance impact on either server under test compared to results generated using the baseline client tuning options.

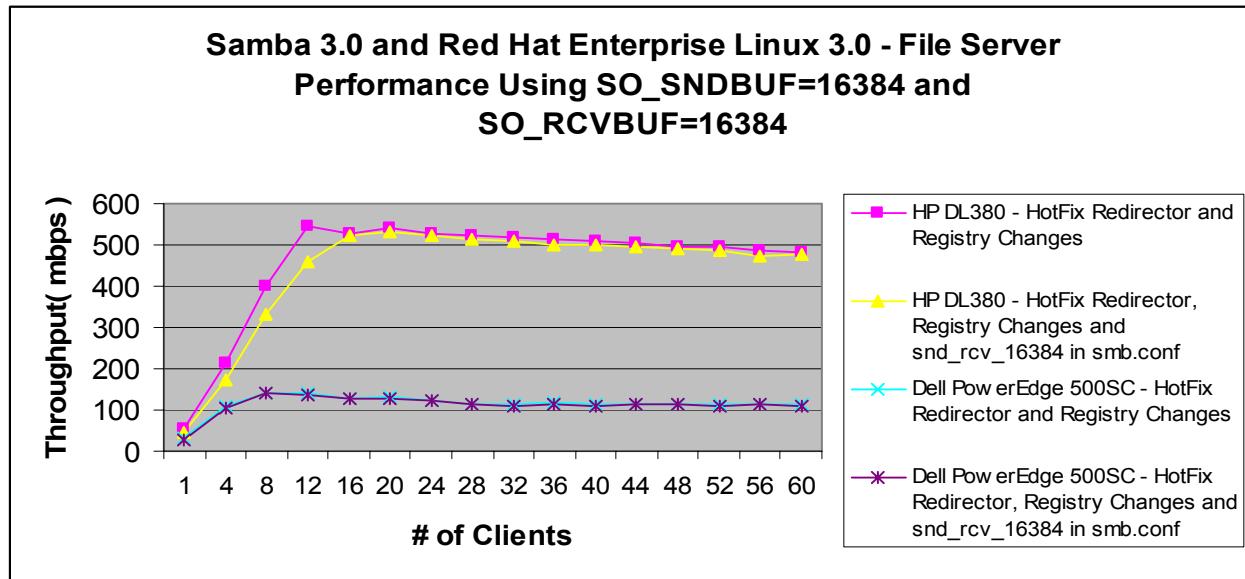


Figure 28. Samba 3.0 and Red Hat Enterprise Linux ES 3.0 Performance using SO_SNDBUF and SO_RCVBUF modifications

Finally, we conducted an additional test combining all the client, file system and Samba tuning options described in the section above. Figure 29 below shows the results of this final test. For both the HP DL380 and the Dell PowerEdge 500SC systems, combining all the tuning options simultaneously generated the best overall peak throughput compared to any of the tuning options alone. Specifically, for the HP DL380, using

the combined tuning options generated over 13 percent better peak throughput performance compared to the untuned baseline configuration. For the Dell PowerEdge 500SC configuration, using the combined tuning options generated approximately 73 percent better peak throughput performance compared to the untuned baseline configuration.

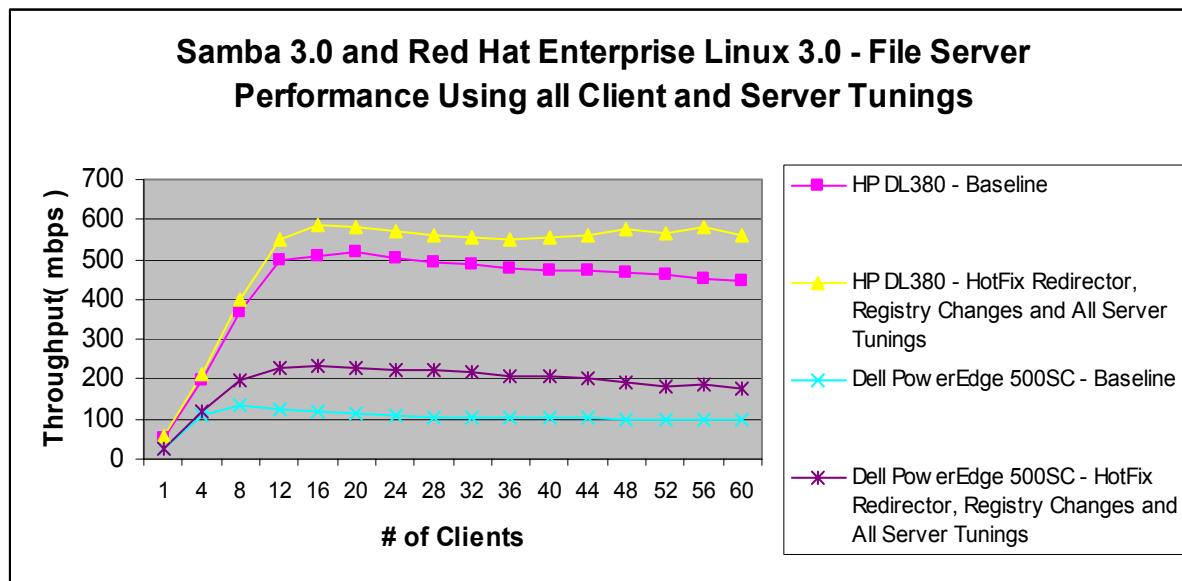


Figure 29. Samba 3.0 and Red Hat Enterprise Linux ES 3.0 Performance using all client and server tunings

As a result of the tuning tests described above, we made the following tuning options to both the HP DL380 and Dell PowerEdge 500SC servers when testing with Samba 3.0 and Red Hat Enterprise Linux ES 3.0:

- Set Samba logging level to 0 to disable logging functions
- Set the socket option SO_SNDBUF to 16384
- Set the socket option SO_RCVBUF to 16384
- Changed default bdflush values as described in figure 17 above
- Added the “noatime” and “data=writeback” options when mounting all data volumes used for testing.
- In the HP DL380 server, we verified that the interrupt associated with each of the NIC’s in the server were bound to exactly one processor using the processor affinity features of the Red Hat Enterprise Linux ES 3.0 operating system.

In addition to the server tunings above, we made the following registry modifications on the NetBench clients when testing with Samba 3.0.

- 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.

Finally, we installed a set of post Windows XP Service Pack 1 client redirector hot fixes received from Microsoft. Installation of the updated redirector software consisted of replacing the original mrxsmb.sys and rdbss.sys files in the C:\windows\system32\drivers directory on all the NetBench testbed clients with updated files provided by Microsoft.

Appendix D. Test Network Diagrams

Figure 30 below shows the testbed configurations for testing the servers described above.

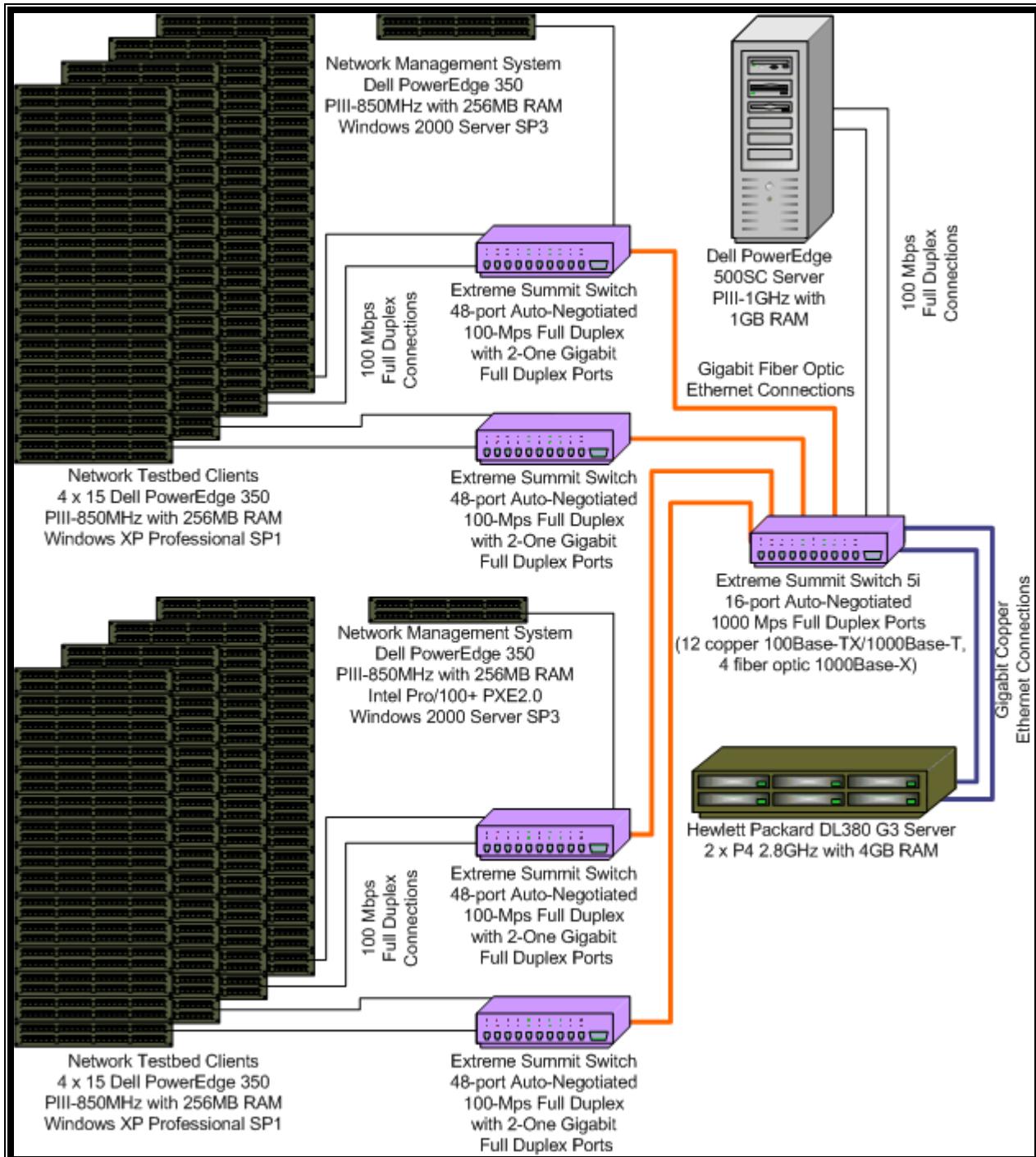


Figure 30. Test Network Configurations

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