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IBM® System x3950 and Microsoft® Windows® Terminal Server Performance Analysis

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Executive Summary

Nemertes Research (www.nemertes.com) recently reported an 800% increase in remote workers—workers residing in separate locations from their managers—over the past five years.¹

Despite the added complexities introduced by a remote workforce, it's clear that the advantages of working remotely—reduced facility costs, centralized software and systems management, troubleshooting and support, and increased business agility, to name a few—outweigh the disadvantages—and businesses are seeing an increase in the number of remote workers every year.

To meet the increasing demands of the growing remote workforce, businesses need a centralized, robust server-based solution to provide reliable, responsive, and sustainable connectivity.

The IBM System x3950, running the Microsoft® Windows® Server 2003 Enterprise x64 Edition, and Microsoft Windows Server 2003 Terminal Server, allows remote workers to access Microsoft Windows-based applications remotely from any computer using a member of the Microsoft Windows XP or Windows Server 2003 family of operating systems.

The IBM System x3950 and Microsoft Windows Server 2003 Enterprise x64 Edition take full advantage of the Microsoft Terminal Server enhancements for the 64-bit environment. Running an artificial Terminal Server benchmark on an IBM System x3950 with four Dual-Core Intel® Xeon® 7040 processors allowed us to support 630 simultaneously connected, working users—more than double the number of users practically possible on a typical 32-bit system.

This white paper demonstrates the capabilities of the IBM System x3950 and presents the benchmark test results and system recommendations for running Windows Terminal Services on x64-based versions of Windows Server 2003 on the IBM System x3950 platform.

Key Benefits of a 64-bit Environment

Some key benefits and considerations for running Microsoft Windows Server™ 2003 Terminal Server in a 64-bit environment include:

- The theoretical user limit is much higher on a 64-bit system than it is on a 32-bit system because 64-bit architecture removes the kernel virtual address space limitations of 32-bit systems.
- New systems from IBM, using powerful multi-core Intel processors and a large amount of memory (64GB per 4-processor chassis), take advantage of 64-bit architecture to support a large number of Terminal Server users on a single system.
- 64-bit systems provide superior I/O throughput and processor power compared to 32-bit systems. A large number of users on a single system cause a significant amount of disk, processor, and I/O (input/output) activity on the system, and a robust storage system is required to handle the increased disk and I/O traffic from both the operating system and from applications.

¹ "The Virtual Workplace: Leveraging Real-Time Communications in the Enterprise," Nemertes Research, (www.nemertes.com).

The Power of X3 Architecture™

The IBM System x3950 is built on the power of IBM eServer™ X3 Architecture™, the third generation of IBM Enterprise X-Architecture™ technology. X3 Architecture drives the x3950 to deliver the performance, reliability, expandability, and manageability required for the next generation of industry-standard servers.

X3 Architecture delivers a formidable combination of 64-bit performance, availability, and investment protection that is currently unavailable in industry-standard x86 servers.

X3 Architecture is the culmination of many years of research and development aimed at bringing mainframe-inspired capabilities, and sophisticated high-end technology to the company's next-generation 64-bit Intel Xeon processor-based System x™ servers. With support for up to 32 Intel Xeon MP Processors and 512GB of RAM with over 20Gbps of memory bandwidth per 64GB, System x servers based on X3 Architecture offer cutting-edge performance and scalability.

IBM System x3950: Key Features

- 3U chassis that supports up to four single- or dual-core Intel Xeon MP Processors.
- Support for up to 64GB of PC2-3200 ECC DDR2 dual inline memory modules (DIMMs).
- 64-bit memory addressing with the Intel Extended Memory 64 Technology (EM64T) architecture.
- Six hot-swappable drive bays.
- Active Memory™ with Memory ProteXion, memory mirroring, memory hot-swap/hot-add, and Chipkill™.
- Six full-length 64-bit 266 MHz PCI-X 2.0 Active peripheral component interconnect (PCI) slots.
- Integrated Adaptec AIC-9410 serial-attached SCSI (SAS) controller.
- Support for internal RAID using an optional ServeRAID™-8i adapter; ServeRAID-6M is also supported for external SCSI storage with the EXP400 Expansion Enclosure.
- Integrated dual-port Broadcom 5704 PCI-X Gigabit Ethernet.
- Integrated Baseboard Management Controller. Supports the IBM Integrated xSeries® Adapter for iSeries™ (IXA) for a fast, direct link to an iSeries server.
- Hot-swappable fans and power supply.
- Light Path diagnostics to identify failed components.
- Three-year warranty on site, nine hours per day, five days per week, with a next business day response.

Test Objective

The objective of the test was to determine how many remote users can be supported on an IBM System x3950 equipped with four 3.0GHz Dual-Core Intel Xeon 7040 processors and Microsoft Windows Terminal Server.

The maximum number of users was determined to be the number of users that could log in to the terminal server and run through the tests before performance degraded to an unacceptable level.

Performance was measured on the server as the response time for a particular action such as opening a file in Microsoft Excel or inserting a file in a Microsoft Outlook e-mail message. The

maximum number of users was reached when response times increased to an unacceptable level.

Note: Appendix A describes the test setup and configuration. Appendix B describes the performance tuning applied to the system under test.

For more information on the Terminal Server kit used, see:

<http://www.microsoft.com/windowsserver2003/techinfo/overview/tsscaling.mspx>

Test Results

During the course of testing the x3950, the maximum number of Terminal Server users was verified on two different processor configurations. Both configurations had four processors and 32GB of memory.

The first configuration was an x3950 equipped with four single-core 3.33GHz Intel Xeon MP Processors with 1MB L2 cache and 8MB L3 cache (code name Potomac).

The second configuration was an x3950 equipped with four Dual-Core 3.0GHz Intel Xeon 7040 processors with 2MB of L2 cache per core (code name Paxville).

An additional test was run on the Dual-Core Intel Xeon 7040 processor-based system with 64GB of memory to learn if doubling system memory would significantly increase the number of users. All three sets of results are shown in Figure 1.

Potomac vs. Paxville Processor Test Results

Figure 1 shows that:

- Moving from a single-core processor to a dual-core processor increased the maximum number of users that could be handled by the server by 24%.
- Doubling system memory from 32GB to 64GB increased the maximum number of users by an additional 12.5%.

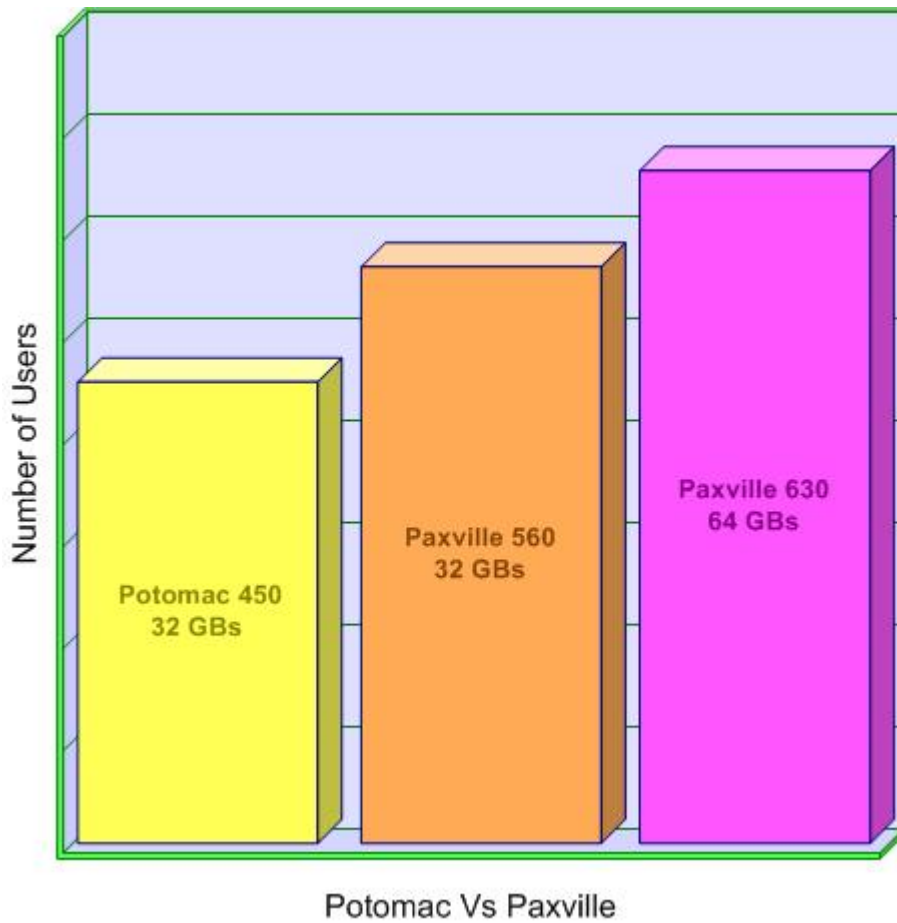


Figure 1: Maximum number of Terminal Server users supported on Intel Potomac and Paxville Processors.

Test Observations

Processor Usage

Processor usage was monitored throughout the test. Figure 2 shows the behavior of the processor as the number of users logged in to the system increases.

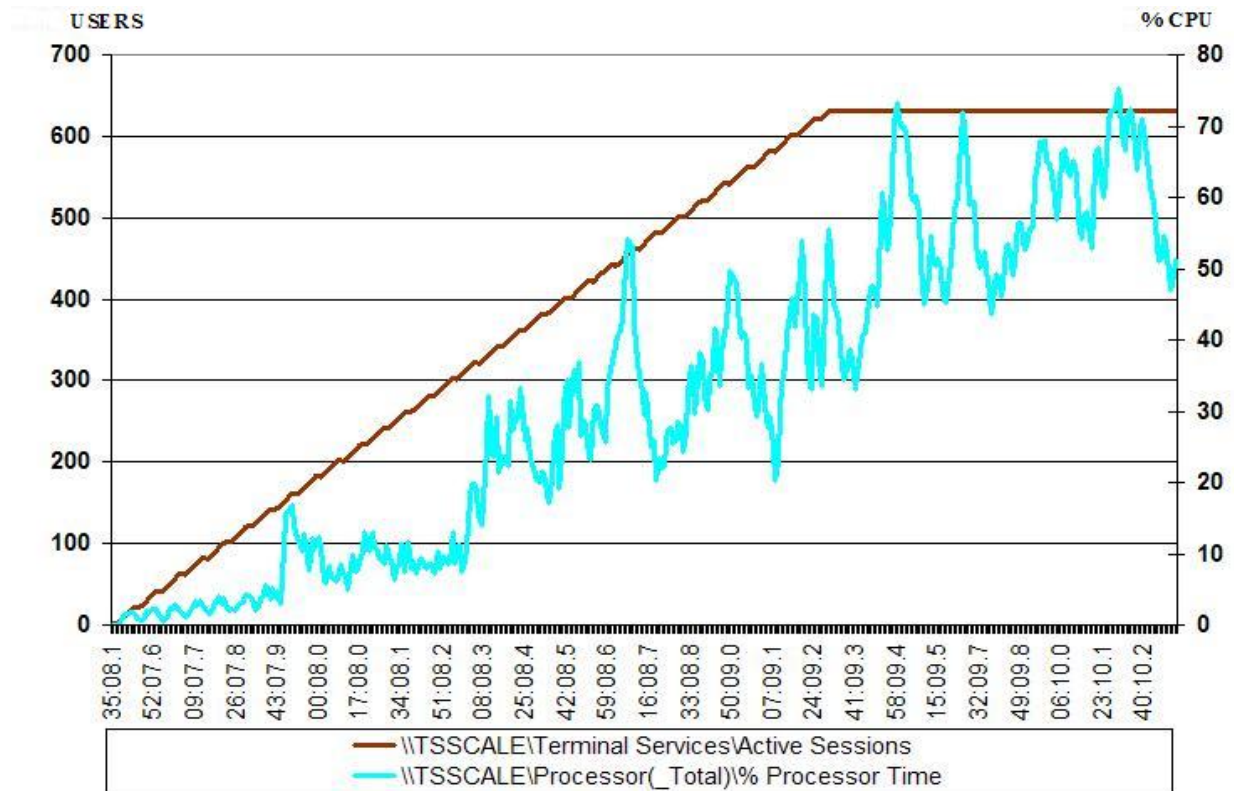


Figure 2: Active Sessions vs. Total CPU Usage.

Memory Recommendations

When the Terminal Services Server was configured with 32GB, physical memory became a performance bottleneck, as illustrated in Figure 4.

Increasing physical memory from 32GB to 36GB moved the bottleneck from a 560 user limit to a 600 user limit. Increasing memory to 64GB memory allowed us to have 630 users logged in and running with good responses times.

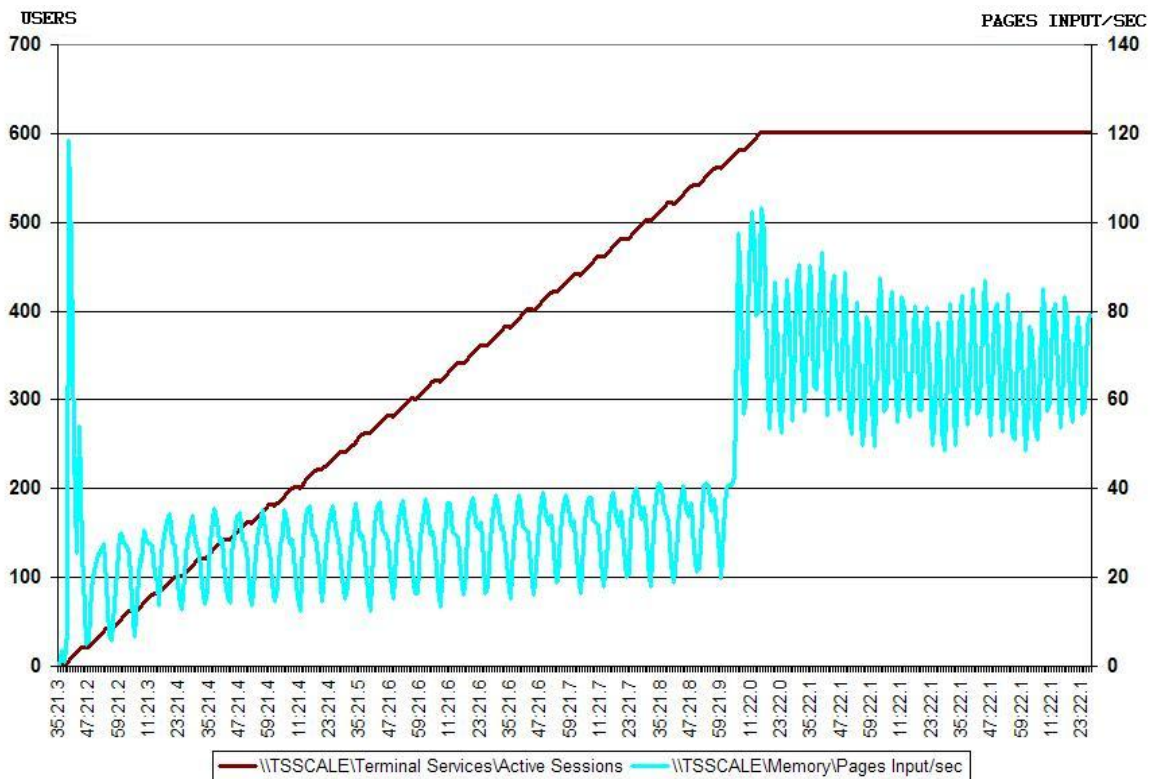


Figure 4: Active Sessions vs. Memory Usage.

Memory Usage

Memory usage was measured during the tests. As Figure 5 shows, there was ample physical memory still available at the end of the run.

Pages Input/sec is defined as the number of pages read from the disk to resolve memory references to pages that were not in memory at the time the reference was made. This counter also includes paging activity incurred by the system cache accessing file data for applications.

When more than 560 users were logged in to the system, the number of pages Input/sec more than doubled. Because accessing a hard disk is much slower than accessing physical memory, performance is degraded. As a result, response times increased and prevented the addition of more users.

Further increasing the number of users from 630 to 700 caused the CPU usage to rise from 70% to 100%, causing a significant increase in responses times.

Note: Microsoft engineers examined the data and confirmed the results.



Figure 5. Active Sessions vs. Memory Pages Input/sec.

Conclusion

The manageability, serviceability and flexibility of an enterprise network and its systems are critical to the success of individual employees and the corporate enterprise. Centralizing software and systems management with Microsoft's Terminal Server can reduce overhead costs and increase the speed and flexibility with which a business can operate.

The IBM System x3950 server, equipped with four Dual-Core Intel Xeon 7040 processors and 64GB memory, is a high-performance system powerful enough to support a medium-sized business organization with a need to host up to 630 remote users.

References

- Terminal Services Scaling and Performance on x64-Based Versions of Windows Server 2003 – <http://www.microsoft.com/downloads/details.aspx?familyid=9B1A8518-D693-4BBB-9AF8-B91BBC0D2D55&displaylang=en>

Appendix A: Test Environment—Technical Specifications

The test environment (illustrated in Figure 6) used to run the Terminal Server benchmark is described below:

- Thirteen client machines were used to simulate multiple users. Each client was an IBM eServer 326 with 2GB of memory.
- Both the Domain Controller and Exchange server were IBM eServer 326s with 2GB of memory.
- The Terminal Server test machine was an IBM System x3950 with 32GB or 64GB of memory depending on the test being run.

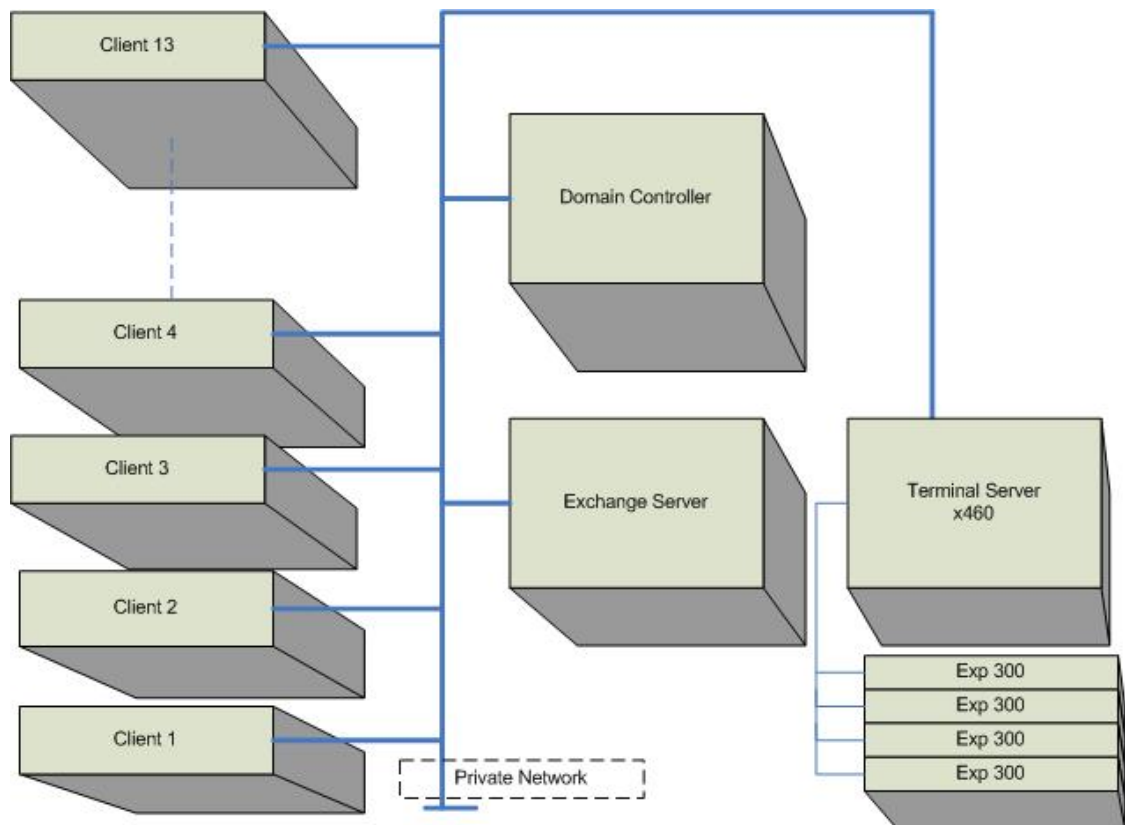


Figure 6: Terminal Services Test Configuration.

Domain Controller

The domain controller running Microsoft Windows Server 2003 Enterprise Edition was also the DHCP and DNS server for the domain. It was also the test controller that managed the client systems used in the test.

Exchange Server

The Exchange server was an IBM eServer 326 running Microsoft Windows Server 2003 Enterprise Edition with Service Pack 1 and Microsoft Exchange Server 2003. This system was also used as the Web server during the remote user tests.

Clients

Each client workstations was an IBM eServer 326 machine running Microsoft Windows Server 2003 Enterprise Edition. Because multiple Terminal Services Client sessions can be running on a single client, we ran up to 50 user sessions on each of the 12 clients, and 30 sessions on client 13.

Storage System

The IBM EXP400 storage expansion unit contained 14 SCSI disks per enclosure. Each of the four enclosures was connected to an IBM ServeRAID-6M adapter via a SCSI connector. Two 2-channel ServeRAID-6M adapters were installed in the IBM System x3950. The drives used were 15K rpm drives.

Test Tools and Software

Microsoft's Terminal Services Scalability Planning Tools were used to run the tests. These tools are part of the Windows resource kit and consist of the following executable files:

- **Robosrv.exe:** Runs on the test controller (the domain controller) and controls the rate at which Terminal Server sessions log on to the Terminal Server. It also runs a script to load the Terminal Server on each client.
- **Robocli.exe:** Runs on each client system and connects to the test controller to run the scripts ordered by Robosrv.exe.
- **Qidle.exe:** Runs on the Terminal Server machine. It monitors the connections throughout the test and keeps a log of any Terminal Server sessions that have been idle for more than a specific period of time.

Test Parameters

Each client connects to the Terminal Server using the Windows Remote Desktop client (mstsc.exe). These sessions on the Terminal Server are run via the Remote Desktop (RDP) protocol.

The "Knowledge Worker" script used for this test was developed by Microsoft and based on Gartner Group specifications. This script switches between Microsoft Word, Microsoft Excel, Microsoft Outlook, and Internet Explorer to send and receive e-mail, edit office documents and access Web pages. The script also records the response time for each of the simulated user actions.

More information about Microsoft's Terminal Services Scalability Planning Tools is available at: <http://www.microsoft.com/windowsserver2003/techinfo/overview/tsscscaling.mspx>

Terminal Server Configuration

- The Terminal Server ran Microsoft Windows Server 2003 x64 Enterprise Edition with Service Pack 1.
- Microsoft Office 2003 with Service Pack 1 was installed on the Terminal Server.

- Two IBM ServeRAID-6M adapters and four IBM EXP400 enclosures were used for storage. Each IBM EXP400 enclosure was populated with fourteen 15K rpm 18GB hard drives.
- Four logical volumes were configured: one on each EXP400. One volume stored the Terminal Server user profiles. Paging files were created on the other three volumes to support the disk paging requirements of this workload.

Adjustments recommended by Microsoft's Terminal Services Scalability Planning Tools document were applied to the Terminal Server environment.

Exchange Server Configuration

- Microsoft Exchange Server 2003 was installed on an IBM eServer 326 system.
- IIS Services 6.0 and printing services were also installed on the Microsoft Exchange Server.
- Four HP LaserJet 6P printers were installed on the NULL port of the Exchange Server machine, and shared as HPLaserJ1, HPLaserJ2, HPLaserJ3 and HPLaserJ4. Each printer was configured as a network printer on the Terminal Server. User connections were added in a round-robin manner to the Terminal Server to distribute print jobs evenly among the four printers.

Client Configuration

- Each client was running Microsoft Windows Server 2003 Enterprise Edition.
- The only other software installed on the client was the robocli.exe tool.

Appendix B: System Settings for the x3950

The following settings were made to the IBM System x3950 systems for both processor (Potomac and Paxville) types to further optimize the systems. These adjustments were made in addition to the settings recommended by Microsoft.

BIOS Settings

- HyperThreading Enabled.
- Adjacent Sector Prefetch Disabled (default *enabled*).
- Hardware Prefetch Disabled.
- Memory – High Performance Memory Architecture (default is *RBS or Redundant Bit Steering*).

With the default settings we see 10% higher CPU utilization and the system can run only 580 users before response times increase.

Registry Settings

- **ConnManagerPoll** was set to 1,536 seconds to increase the number of supported Outlook 2003 users.
- **NoRecentDocsHistory** was enabled to prevent users from saving shortcuts to documents.

Drivers

The latest drivers for the IBM ServeRAID-6M and Intel PRO/1000M NIC were downloaded from www.ibm.com and www.intel.com for this test.

Operating System Performance Settings

The following adjustments were made under the System Properties for each system:

- Adjust for Best Performance was selected for Visual Effects.
- Processor Scheduling was optimized for Programs.
- Memory Usage was optimized for System Cache.
- Virtual Memory was changed to add paging files on three of the Logical Volumes that were created on three external storage RAID arrays.

In this test, a large number of users were simultaneously logged on to the Terminal Server. Each user simultaneously opens several, large files, which are temporarily stored in the file system cache on the client machine. Optimizing Memory Usage for System Cache improves performance significantly, and increases the number of users that can be logged in to the system by 15%. Memory usage can be optimized for system cache by modifying the registry entry LargeSystemCache at HKLM\SYSTEM\CurrentControlSet\Control\Session Manager\Memory Management and setting it to '1'.



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