IBM

IBM® System x3650 and xSeries® 346: A Comparison of Capacity and Power Utilization When Running Microsoft® Windows® Terminal Services

By Quang Le
IBM Systems and Technology Group

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Introduction

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]

Businesses are seeing an increase in the number of remote workers every year, and the advantages of a remote workforce—reduced facility costs, centralized software and systems management, troubleshooting and support, and increased business agility—clearly outweigh the disadvantages and added complexities introduced by a remote workforce to an organization.

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 64-Bit Advantage

The new 64-bit processors provide superior performance to 32-bit processors. Because of this, 64-bit processors are presently the best foundation for servers aimed at creating, sustaining, and growing a large remote workforce.

Some key benefits of 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.

- Multi-core Intel® Xeon® processors equipped with a large amount of memory can support more Terminal Server users on a single system.

- The 64-bit systems provide I/O throughput and processor power that are superior to that of 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; therefore, a robust storage system is required to handle the increased disk and I/O traffic from both the operating system and from applications.

The IBM Solution

The IBM System x3650, running Microsoft Windows Server 2003 Enterprise x64 Edition, and Microsoft Windows Server 2003 Terminal Server, allows remote workers to access Microsoft Windows OS-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 x3650 and Microsoft Windows Server 2003 Enterprise x64 Edition take full advantage of the Microsoft Terminal Server enhancements for the 64-bit environment. Running a simulated Terminal Server benchmark on an IBM System x3650 with two Dual-Core Intel Xeon 5160 processors allowed us to support up to 300 simultaneously connected, working users—a 50% increase over the number of users supported on the older IBM eServer™ xSeries® 346.

In addition to the its superior performance compared to that of the x346, the x3650 consumes approximately 16% *less* power than does the x346. In a typical 24/7 server environment, this reduced power consumption can save thousands of kilowatt-hours per year, per server.

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

This white paper presents the results of benchmark tests conducted to measure both the performance and power consumption of the x3650 and the x346 servers. In addition, system recommendations for running Windows Terminal Services on x64-based versions of Windows Server 2003 on the IBM System x3650 platform are also included.

The following two sections present the key features standard on the x3650 and x346 servers. The systems as configured for the tests are also described.

IBM System x3650: Key Features

Description	Standard	As Tested
Form Factor/height	Rack/2U	
Processor	Dual-Core Intel Xeon Processor 5160, up to 3.0 GHz and 1333 MHz front-side bus	3.0 GHz, 1333 MHz front-side bus
Number of processors	1 standard, 2 maximum	2
L2 cache	2x4MB	2x4MB
Memory	1GB standard, Up to 48GB Fully Buffered DIMM 667 MHz via 12 DIMM slots	12GB PC2-4200 DDR2
Expansion slots	4xPCI-E **or** 2xPCI-X and 2xPCI-Express	
Disk Bays	8 total, 8 hot-swappable	
Maximum internal storage	1.8 Terabyte hot-swap SAS	136GB RAID-1E 8 HDDs
Network interface	Integrated dual Gigabit Ethernet	
Power supply (std/max)	Up to 2x835W	2x835w
Hot-swap components	Power supply, fans and hard disk drives	
RAID support	Integrated RAID-0, -1, -10, Optional RAID–5, –6	
Operating System	**Supported:** Microsoft Windows® Server 2003, Windows 2000/Advanced Server, Red Hat Linux®, SUSE Linux, Novell NetWare, VMware ESX Server 2.5	Windows Server 2003 x64 Enterprise Edition

Table 1: x3650 with Standard Features and As Tested

IBM eServer xSeries 346: Key Features

Description	Standard	As Tested
Form Factor/height	Rack/2U	
Processor	Single-core Intel Xeon Processor up to 3.8 GHz and 800 MHz front-side bus	3.6GHz, 800 MHz front-side bus
Number of processors	1 standard, 2 maximum	2
L2 cache	Up to 2MB L2 per processor core	1MB
Memory	512MB, 1GB, or 2GB/16GB PC2-3200 DDR2 via 8 DIMM	8GB PC2-3200 DDR2
Expansion slots	4xPCI-E **or** 2xPCI-X and 2xPCI-Express	
Disk Bays	6 total, 6 hot-swappable	
Maximum internal storage	1.8 Terabyte Ultra320 SCSI	36.4GB RAID-1 2 HDDs for Terminal Server, 5 HDDs for power analysis
Network interface	Integrated dual Gigabit Ethernet	
Power supply (std/max)	Up to 2x625W	2x625w
Hot-swap components	Power supply, fans and hard disk drives	
RAID support	Integrated RAID-0, -1, Optional RAID-5	
Operating System	**Supported:** Microsoft Windows Server 2003, Windows 2000/Advanced Server, Red Hat Linux, SUSE Linux, Novell NetWare, VMware ESX Server 2.5	Windows Server 2003 x64 Enterprise Edition

Table 2: xSeries 346 with Standard Features and As Tested

Test Objective

The objective of these tests was to compare how many remote workers can be supported on the IBM System x3650 and the IBM eServer x346 running Terminal Services on Microsoft Windows Server 2003 x64 Enterprise Edition. The maximum number of users is the number of users that can log in to the terminal server and run through the tests before performance degrades to an unacceptable level.

The x3650 was equipped with two Dual-Core Intel Xeon Processor 5160 (3.0GHz, 4MB L2 cache, 1333 MHz FSB). The x346 was equipped with two single-core Intel Xeon Processors 3.6GHz processors.

Two test scripts—the Knowledge Worker script and the Data Entry Worker script—were used for the tests. Appendix A describes the two scripts in detail.

Server capacity was defined as the maximum number of users that can be logged in to the terminal server with acceptable server response times. Server response time (in milliseconds) was measured for a variety of simulated user actions—for example, opening a file in Microsoft Excel, or inserting a file attachment into an e-mail in Microsoft Outlook®. Exceeding the maximum number of users caused server response times to increase, and the server ultimately became unresponsive. For our tests, an "unacceptable" server response time was defined as any response exceeding 1000 milliseconds (one second) for a particular user action.

In addition to the remote worker load tests, power consumption data was collected when the servers were idle, and when they were carrying the maximum number of users that they could service before becoming unresponsive. During the maximum user load test, data was collected from the beginning of the test until 30 minutes after the maximum number of users was reached.

Note: Appendix A describes the test setup and configuration; Appendix B describes the systems settings; Appendix C describes test parameters; and Appendix D describes power measurement tools and collection methods used to obtain power consumption data.

For more information about the Terminal Server kit used for these tests, see:

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

Test Results and Observations

The following table illustrates the number of users that each system was able to support for the type of test script used. Microsoft engineers also examined the data and confirmed the results.

System	Knowledge Worker	Data Entry Worker
x346	200 users	450 users
x3650	300 users	750 users

Table 3: Users Supported on the Knowledge Worker and Data Entry Worker Scripts

Processor Usage

Processor usage was monitored during the tests to determine the maximum number of users the server could support before the CPU became unresponsive.

Figure 1 illustrates the increase in processor usage for the x3650 system as the number of users logged in to the system increases.
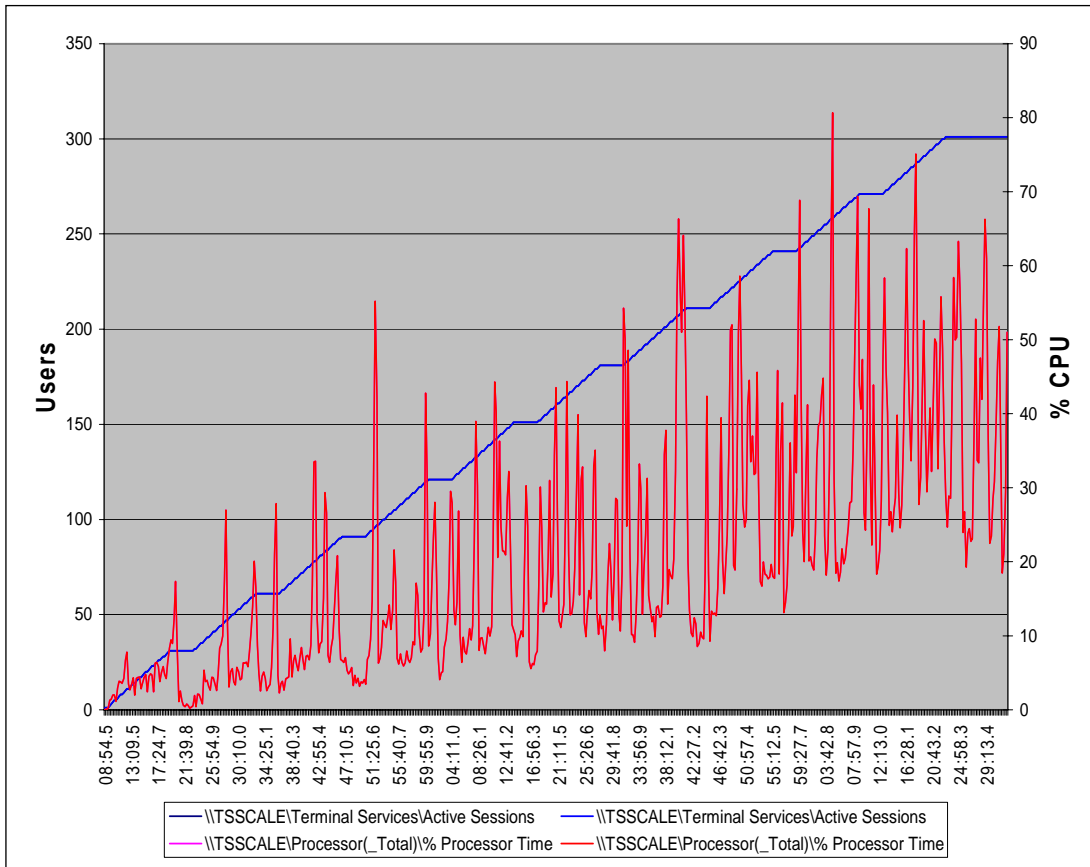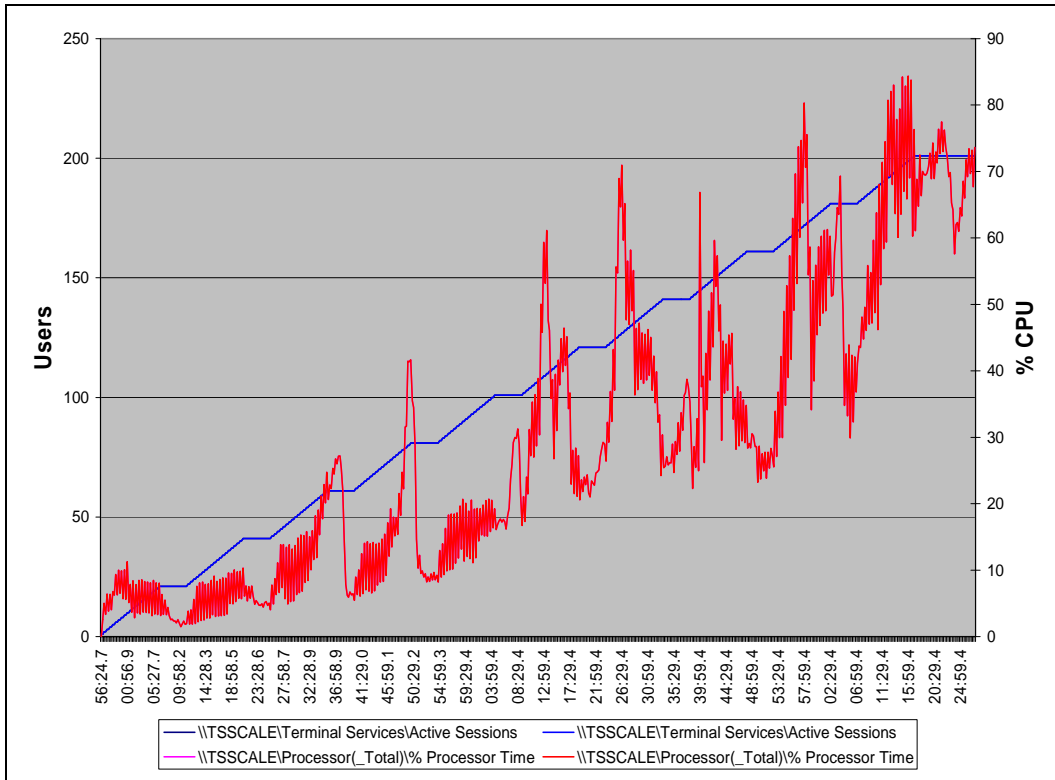

Figure 1: x3650 – Active Sessions vs. Total CPU Usage – 300 Users

Figure 2 shows the behavior of the x346 processor as the number of users logged in to the system increases.

Figure 2: x346 – Active Sessions vs. Total CPU Usage – 200 Users

Figures 1 and 2 show that, even at maximum user loads, ample CPU cycles are still available.

Response Time

The amount of time (in milliseconds) required for a terminal server to respond to user actions was also measured to identify the point at which a server reached its maximum user load. Figures 3, 4, 5 and 6 on the following pages illustrate the relationship between server response times and the number of users logged in to the system.

The point immediately preceding an unacceptable increase in response times was considered the maximum number of users that the system can support. Additional tests were also conducted with the maximum number of users loaded to confirm that the response times fell within the acceptable range.
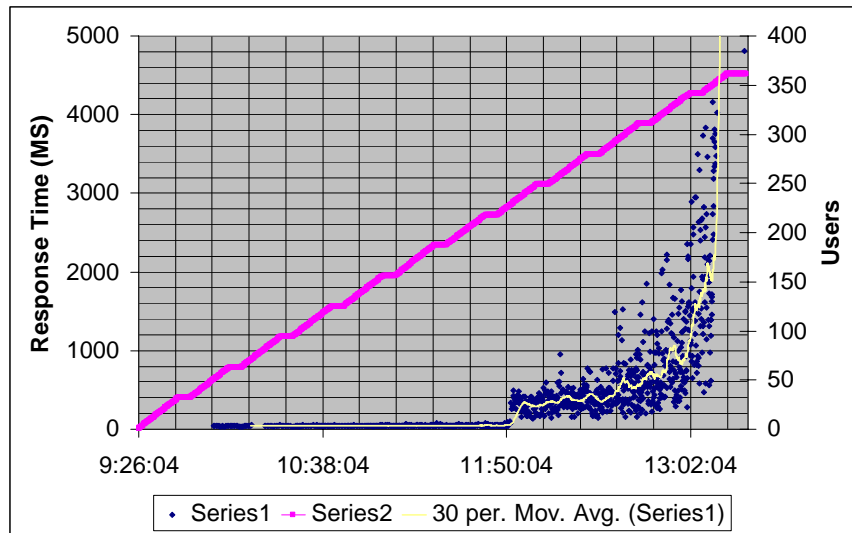
Figure 3: x3650 – Response Time – 350 Users (Excel Save as Dialog)
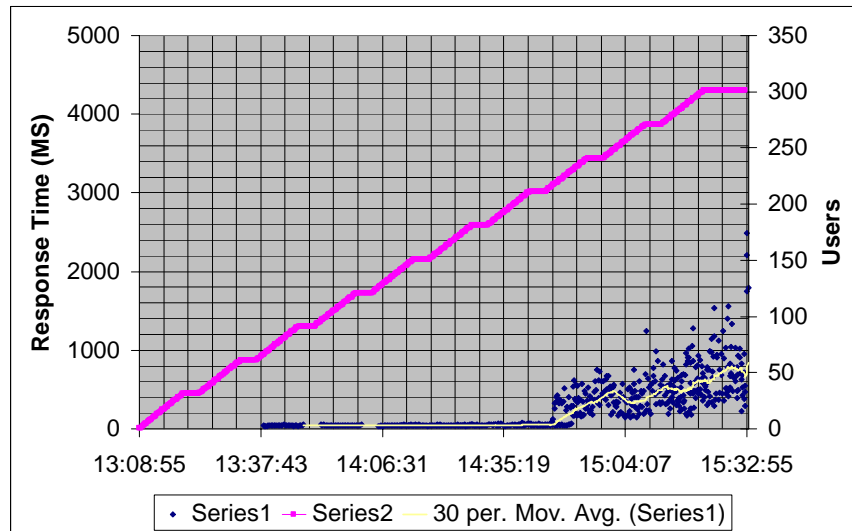
Figure 4: x3650 – Response Time – 300 Users (Excel Save as Dialog)

Figures 3 and 4 show that response times for the x3650 rose to an unacceptable level after 300 users were logged in to the system. Compare those results with the results illustrated in Figures 5 and 6, which show the x346 becoming unresponsive after 200 users are logged in to the system.

Comparing the results of Figures 3, 4, 5, and 6, we clearly see the x3650 providing a 50% improvement over the x346 with regards to the number of users the server can support**.**
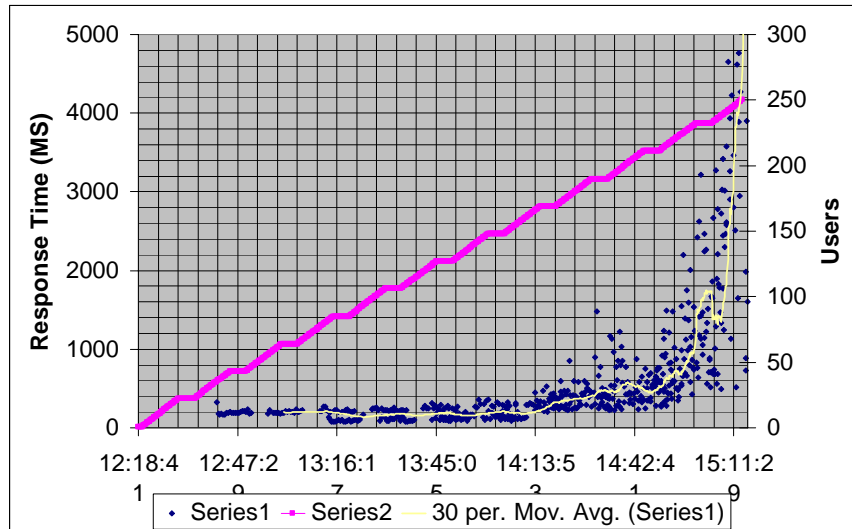

Figure 5: x346 – Response Time – 250 Users (Word Print Dialog)
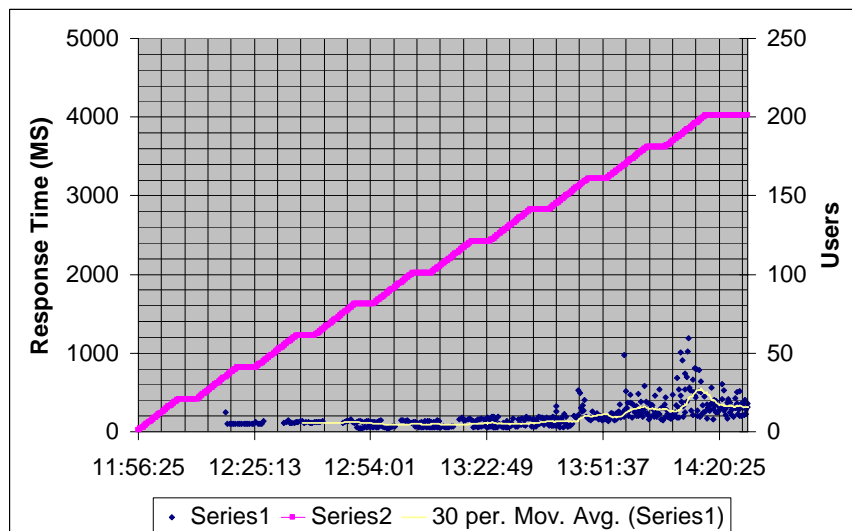
Figure 6: x346 – Response Time – 200 Users (Word Print Dialog)

Memory Usage

Memory usage was measured during the tests. Figures 7 and 8 show that ample physical memory was still available at the end of the tests.

Pages Input/sec is a measurement of the number of memory "pages" read from the hard disk when the requested data is no longer stored in the server's physical (RAM) memory. This counter also includes pages read from disk when the server's cache memory accesses data for applications.

Because reading data from the hard disk is slower than reading data from physical memory, an increase in the number of Pages Input/sec indicates that the server is becoming less responsive to the users logged in to the server.

The x346 system experienced severe spikes in the Pages Input/sec metric when 230 users logged in to the server. The x3650 system experienced similar spikes when 340 users were logged in to the server.

In addition, the x346 system's total CPU usage rose to 100% when 230 users were logged in to the system. The x3650 system's total CPU usage rose to 90+% when 340 users were logged in to the system.

The spikes in the Pages Input/sec metric and the greatly increased processor usage caused a significant increase in response times—and, therefore, significantly reduced performance—for both servers.
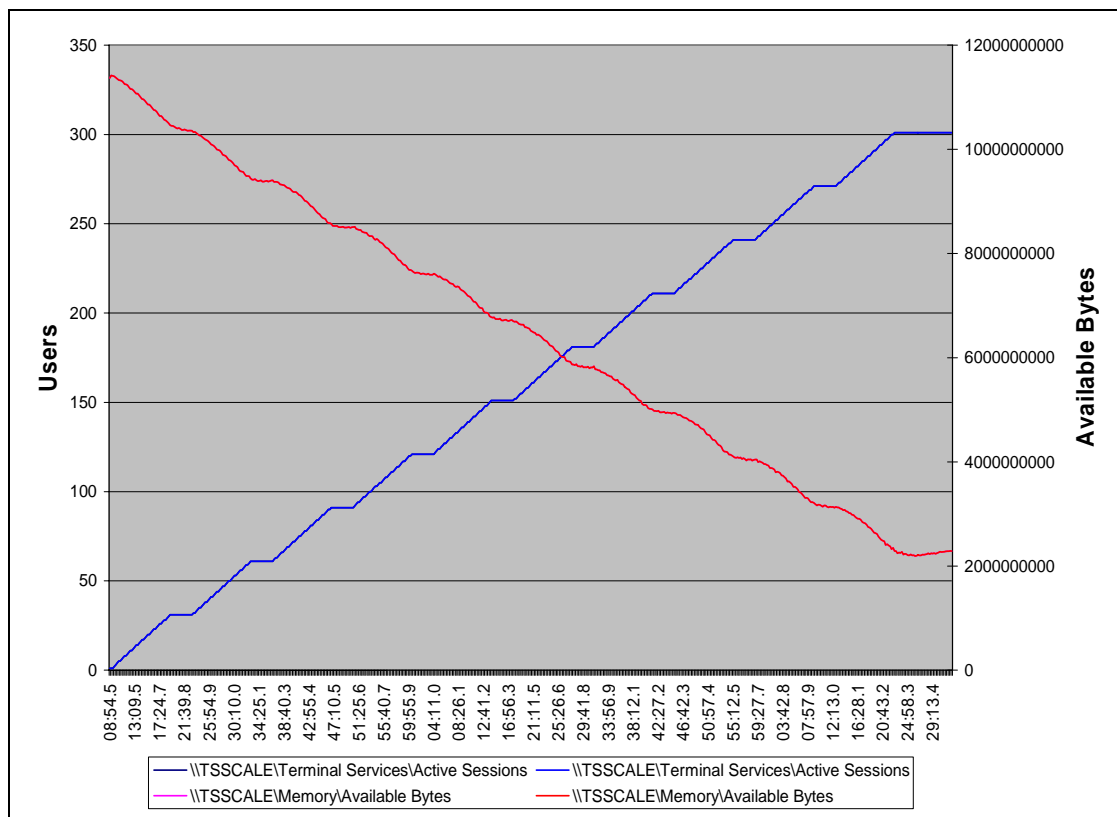

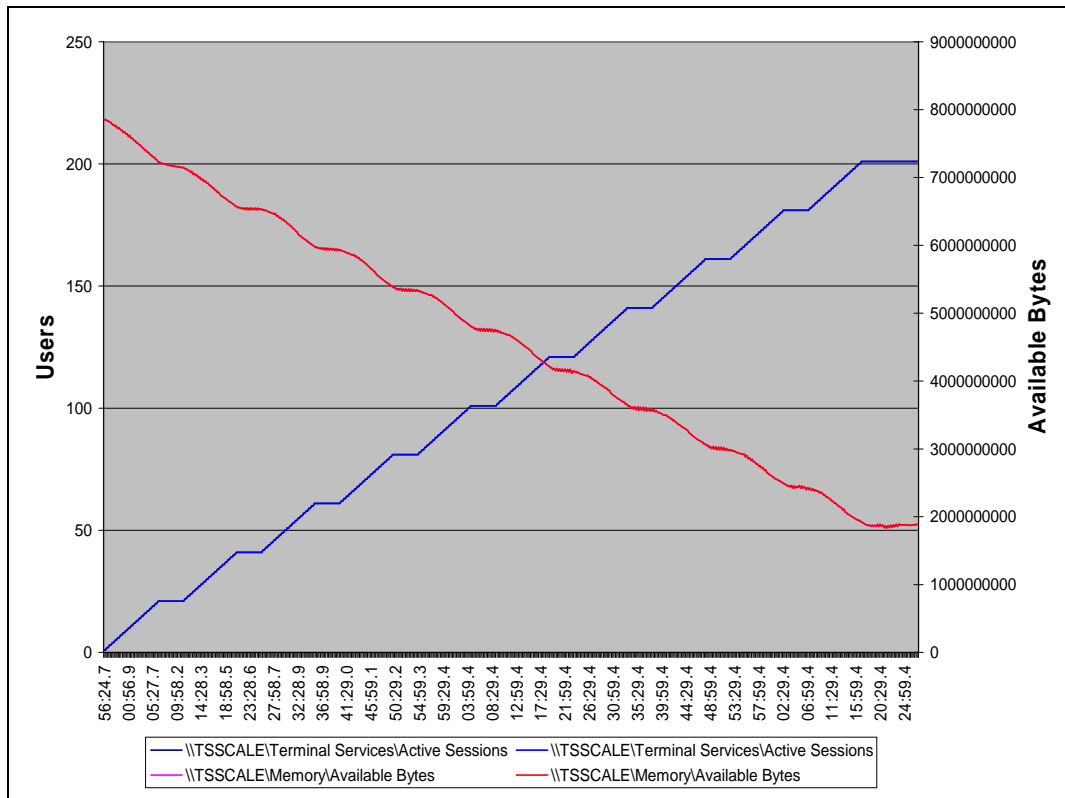**Figure 7: x3650 – Active Sessions vs. Available Memory**

Figure 8: x346 – Active Sessions vs. Available Memory

Power Consumption Test

The following table illustrates the maximum amount of power in watts used by each system when it was idle and when it was running with the maximum number of users connected to it with the Knowledge Worker script.

System	Idle	At Maximum Load
x346	353 Watts	481 Watts
x3650	338 Watts	415 Watts

Table 4: Maximum Power Consumption with Maximum Users Logged In

For more information about how power consumption data was collected, see Appendix D: Power Consumption Test—Technical Details.

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 Services can reduce overhead costs, and increase the speed, flexibility and efficiency at which a business can operate.

A single IBM System x3650 server, equipped with two Dual-Core Intel Xeon Processor 5160 and 12GB memory, is ideally suited to support a medium-sized business with up to 300 remote users.

In addition, the IBM System x3650 server uses less power than many similarly equipped servers. It is the ideal replacement for the IBM eServer x346. The x3650 fits into the same 2U rack space used by the x346 and boasts a 50% capacity and performance improvement over the x346. In addition, the x3650 uses 16 % *less* power than the x346. In a typical 24/7 server environment, this can mean saving thousands of kilowatt-hours per year, per server.

Additional 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

This paper used materials from the IBM White Paper, "IBM System x3950 and Microsoft Windows Terminal Server Performance Analysis," by Vinay Kulkarni, et al.

http://www-03.ibm.com/servers/eserver/xseries/benchmarks/index.html

Appendix A: Test Environment—Technical Specifications

Figure 9 illustrates the test environment used to run the Terminal Server benchmark and is described below:

- Twelve client machines were used to simulate multiple users. Each client was an IBM eServer x336 with up to 6GB of memory.

- The Domain Controller was an IBM eServer x306 with 2.5GB of memory.

- The Exchange server was an IBM eServer x365 with 8GB of memory.

- The two Terminal Server test machines were an IBM System x3650 with 12GB of memory and an IBM eServer x346 with 8GB of memory.
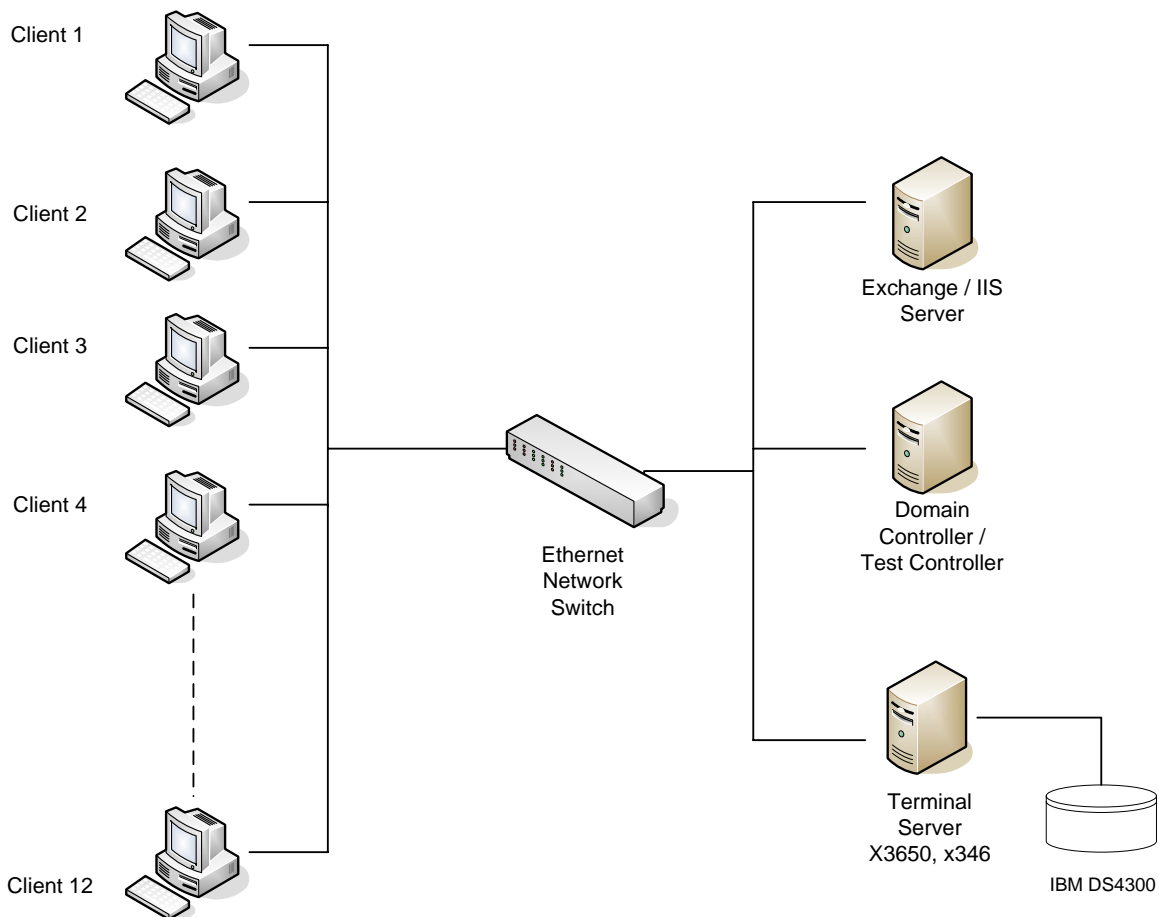
Figure 9: Test Environment

Domain Controller
The domain controller was an IBM eServer x306 running Microsoft Windows Server 2003
Enterprise Edition with Service Pack 1. DHCP, WINS and DNS services were enabled on this
server. It was also the test controller that managed the client systems used in the test.

Exchange Server
The Exchange server was an IBM eServer x365 running Microsoft Windows Server 2003
Enterprise Edition with Service Pack 1 and Microsoft Exchange Server 2003 with Service Pack 1.
This system also functioned as the Web server.

Client Systems
Each client system was an IBM eServer x336 machine running Microsoft Windows Server 2003
Enterprise Edition. For the client machines with less than 3GB of RAM, up to 50 user sessions
were run. For the client machines with 6GB, up to 100 user sessions were run.

Storage System
The IBM TotalStorage® DS4300 storage expansion unit contained fourteen 18.2GB, 15K RPM
SCSI disk drives. The DS4300 was connected to the Terminal Server with a QLogic QLA2350
HBA. Four 16GB LUNs were created and used as swap files. A single 164GB LUN was created
to store the user profiles.

Test Tools and Software
Microsoft Terminal Services Scalability Planning Tools were used to run the tests. These tools
are part of the Windows Server 2003 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 in 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 during the test
  and keeps a log of any Terminal Server sessions that have been idle for more than a specified
  amount of time.

- **Tbscript.exe:** A script interpreter that drives the client-side load simulation. It executes Visual
  Basic scripts and supports specific extensions for controlling the Terminal Server client.

Appendix B: Test Parameters

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

Test Script Description
The Knowledge Worker script used for this test was developed by Microsoft and is 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.

The Data Entry Worker script used for this test was written by Microsoft. It simulates data entry workers who input data (e.g., transcription, typing, order entry) into a computer system. The Data Entry Worker script was tested in a dedicated mode, in this case, running Microsoft Excel exclusively.

More information about Microsoft Terminal Services Scalability Planning Tools is available at:

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

Terminal Server Configuration

- Microsoft Windows Server 2003 x64 Enterprise Edition (build 3790) and Microsoft Office 2003 with Service Pack 1 were both installed on the Terminal Server.

- An IBM DS4300 storage expansion unit with fourteen 18.2GB SCSI disk drives was connected to the Terminal Server through a QLogic QLA2350 HBA.

- Four 16GB LUNs were created and used as swap files. A single 164GB LUN was created to store the user profiles.

- The x3650 system was configured to use four network printers. (See the Exchange Server Configuration section for additional information.)

- The x346 system was configured to use an HP LaserJet 6P printer installed on the system's NULL port as a local printer.

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

Exchange Server Configuration

- Microsoft Exchange Server 2003 with Service Pack 1 was installed on an IBM eServer x365 system.

- Internet Information Services 6.0 was installed on the 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 x3650 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 machine was running Microsoft Windows Server 2003 Enterprise Edition with Service Pack 1

- The robocli.exe tool was copied from the test control server (domain controller) for communication with the Roboserv.exe program.

Appendix C: System Settings for the x3650 and x346

Following are the BIOS system settings for the IBM System x3650 and x346:

x3650 BIOS Settings

- Hyper-Threading Enabled

- System Cache Type Write Back

- Prefetch Queue Enabled

- Flat Memory Configuration

x346 BIOS Settings

- Hyper-Threading Enabled

- System Cache Type Write Back

- Prefetch Queue Enabled

- Execute Disable Bit Disabled

Drivers Used

The latest driver for the QLogic HBA QLA2350 was downloaded from www.qlogic.com.

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 four 16GB Logical Volumes that were created on the DS4300 external storage arrays.

Memory usage was optimized for system cache by modifying the registry entry LargeSystemCache at HKLM\SYSTEM\CurrentControlSet\Control\Session Manager\Memory Management and setting it to 1.

Appendix D: Power Consumption Test—Technical Details

Measurement Tools
A Watts Up? Pro power analyzer manufactured by EED, Inc., was used to collect data for both the x3650 and the x346 systems. Each server was connected to a power strip and tested separately for power consumption. Both power supplies for the system being tested were plugged into the power strip. The power strip was plugged into the Watts Up? Pro for the duration of the tests.

The Watts up? Pro power analyzer includes memory storage and the ability to download the data to a PC for analysis. Starting with a sampling rate resolution of one second, 1023 data points stored in memory. The sample rate resolution increases over time (sample rate equals total time divided by 1023) so data are accurately recorded independence of the test duration. A serial cable and software program allows the data to be quickly downloaded to a PC for creating usage charts. Included in the software is a Data Table, Charting, and Payback Analysis. The data can also be exported in a comma-delimited format to popular spreadsheet programs for further analysis.

Data Collection
Power consumption data was collected for each system, from the beginning of the test until 30 minutes after the maximum number of users logged in. Users are simulated by the Knowledge Worker script. Power data was also collected for both systems when they were idle. Power data was collected for thirty minutes.

- For the x3650 system, the maximum number of users logged in to the server was 300. The total time of data collection was approximately 4 hours.

- For the x346 system, the maximum number of users logged in to the system was 200. The total time of data collection was approximately 3 hours.