



white paper

Capacity and Scaling of Microsoft  
Terminal Server on the Unisys  
ES7000/one Enterprise Server  
Unisys Systems and Technology Modeling and Measurement

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performance

This technical white paper has been written for IT professionals who are responsible for preparing and deploying a Unisys ES7000/one Enterprise Server configured as a Microsoft Terminal Server. The paper reviews the scalability benchmark results of a 4 and 8-processor ES7000/one Enterprise Server running Intel® Xeon® MP processors configured as a Terminal Server and discusses specific results about server resource usage and user response times.

Table of Contents	
Executive Overview	5
Introduction	6
Test Environment	6
Test Components and Tools	6
Hardware	7
Software	8
Remote Desktop Client	9
Microsoft Office	9
Mail and Web Service	9
Print Service	10
Analysis Support Tools	10
Operating System	10
Methodology	10
Test Procedure	10
Terminal Server Capacity	11
x64 versus x86	11
Scaling Terminal Server with Single-Core Intel Xeon® MP Processors	12
CPU Usage and Hyperthreading	13
System Characteristics	14
Resource Requirements	14
Memory Usage	14
Disk Usage	16
Network Usage	17
Terminal Server Scaling with Dual-Core Intel Xeon® MP Processors	18
Settings, Tunings, and Best Practices	19
Office Configuration Settings	19
Registry Settings	20
ConnManagerPoll	20
NoRecentDocsHistory	20

Best Practices	21
Additional Online Resources	22
Conclusion	23
About the Author	23
List of Figures	
Figure 1. Test Configuration	6
List of Tables	
Table 1. Benefits of a Terminal Server	5
Table 2. Unisys ES7000/one Enterprise Server	7
Table 3. Supporting Systems	8
Table 4. Workload Descriptions	9
Table 5. Theoretical Limits for Knowledge Worker Sessions	11
Table 6. Intel Processors	18
Table 7. Office Options	19
List of Charts	
Chart 1. Terminal Server Scaling with Single-Core Processors	12
Chart 2. Response Time	13
Chart 3. User Cycle Time	14
Chart 4. Memory Usage	15
Chart 5. Disk Utilization	16
Chart 6. Network Traffic	17
Chart 7. Dual-Core Performance Gain Relative to Single-Core	18

## Executive Overview

A Terminal Server allows remote client devices to access and use Windows server desktops and applications via a TCP/IP connection. A user's applications are executed on the server, and the virtual desktop is transmitted across the network to the client device.

Windows Server 2003 x64 Edition<sup>1</sup> with Terminal Server enabled breaks the barrier imposed by the predecessor x86<sup>2</sup>, 32-bit architecture, for scaling up the number of terminal server users. Furthermore, the x64 edition effectively runs 32-bit legacy applications without emulation, in addition to newer 64-bit applications.

In this report, we show that a Unisys ES7000/one Enterprise Server with Terminal Server enabled and Windows Server 2003 x64 exceeds previous Windows x86 limits with a 4-processor configuration and further scales up with 8-processors while running the Knowledge Worker workload described later in this paper.

The ES7000/one Enterprise Server can support up to 710 Knowledge Workers, which is more than twice the number that can be supported on an x86 Windows system.

The ES7000/one Server can operate at a higher processor utilization level than commodity servers while still providing the same amount of processing headroom per server. The tests performed in this benchmark pushed the ES7000/one Server's utilization levels to the limit while still delivering acceptable response times. However, in a real-world configuration, a system administrator should reserve processing headroom for varying user workloads.

Scaling up your Terminal Server with the advantages of server-based computing is now a viable business decision. Consider the advantages of building a large server to include more economies of scale and fewer licenses. Also, consider the three important benefits provided by a Terminal Server described in the following table:

Benefit	Description
Rapid, centralized deployment of applications	Terminal Server is great for rapidly deploying Microsoft Windows-based applications to computing devices across an enterprise – especially applications that are frequently updated, infrequently used, or hard to manage. When an application is managed on Terminal Server and not on each device, administrators can be certain that users are running the latest version of the application.
Low-bandwidth access to data	Terminal Server reduces the amount of network bandwidth required to access data remotely. Using Terminal Server to run an application over bandwidth-constrained connections, such as dial-up or shared WAN links, is very effective for remotely accessing and manipulating large amounts of data because only a screen view of the data needs to be transmitted, rather than the data itself.
Windows anywhere	Terminal Server helps users become more productive by enabling access to current applications on any device – including under-powered hardware and non-Windows desktops. Terminal Server allows you to use Windows anywhere, so you can take advantage of extra processing capabilities from newer, lighter-weight devices such as a Pocket PC.

Table 1. Benefits of a Terminal Server.<sup>3</sup>

<sup>1</sup> Windows Server 2003 x64 Editions require x64 processors. x64 allows x86 32-bit applications to run natively. x64 processors have 64-bit extensions. x64 and 64-bit are interchangeable in this paper.

<sup>2</sup> x86 is an architecture and a hardware platform that uses 32-bit addressing. x86 Windows refers to any version of Windows that runs on an x86 platform and thus uses 32-bit addressing. x86 and 32-bit are interchangeable in this paper.

<sup>3</sup> Content in this table was extracted from a *Microsoft Technical Overview of Terminal Services 2003*.

## Introduction

Simulating the potential use of a product has long been known to be a useful guideline for system planners. In this white paper, Unisys provides actual data from a benchmark that simulated a Terminal Services user workload on an ES7000/one Server. The information in this white paper is useful for customers and system planners as they seek to make reasonable decisions regarding Terminal Services solutions.

Processing capacity and memory are two of the most important capabilities of a Terminal Server. The ES7000/one Server provides both of these qualities, making it an ideal platform for Terminal Server solutions. Using the results of the 4 and 8-processor platform tests, we will show that the ES7000/one Server with Terminal Server can scale up to meet the needs of large-scale customers.

The benchmark test environment simulated a user workload that produces a heavy demand on a server's resources. For example, one where users access several applications simultaneously, enter data at a moderate speed, and perform complex operations. It is a recognized industry best practice that a customer's anticipated workload be simulated in a customized test environment prior to installation. This gives a system planner a closer understanding of the necessary server requirements needed to handle the expected workload.

To provide a better understanding of these simulation results, this white paper will first describe the benchmark environment and the methodology. Then it will provide a short discussion about the benchmark's results. It will also describe the impact of those results on a system's resources – processors, memory, disk, and network. Finally, we'll review some useful tips that could help you optimize your Terminal Server environment.

## Test Environment

### Test Components and Tools

The test environment is defined by Microsoft's Terminal Services Scalability Planning Tools (TSScaling). This is a suite of tools to assist with capacity planning for Microsoft Windows Server 2003 Terminal Server. Organizations can manipulate simulated loads on a server to determine whether it is able to handle the load that the organization expects. TSScaling is available online from the Windows Server 2003 Resource Kit Tools <http://www.microsoft.com/downloads/details.aspx?FamilyID=9d467a69-57ff-4ae7-96ee-b18c4790cffd&displaylang=en>.

The measurement environment consisted of hardware and software components. The hardware components – depicted below – communicated through a Local Area Network (LAN). This LAN configuration avoids interference with network traffic not associated with the test environment.

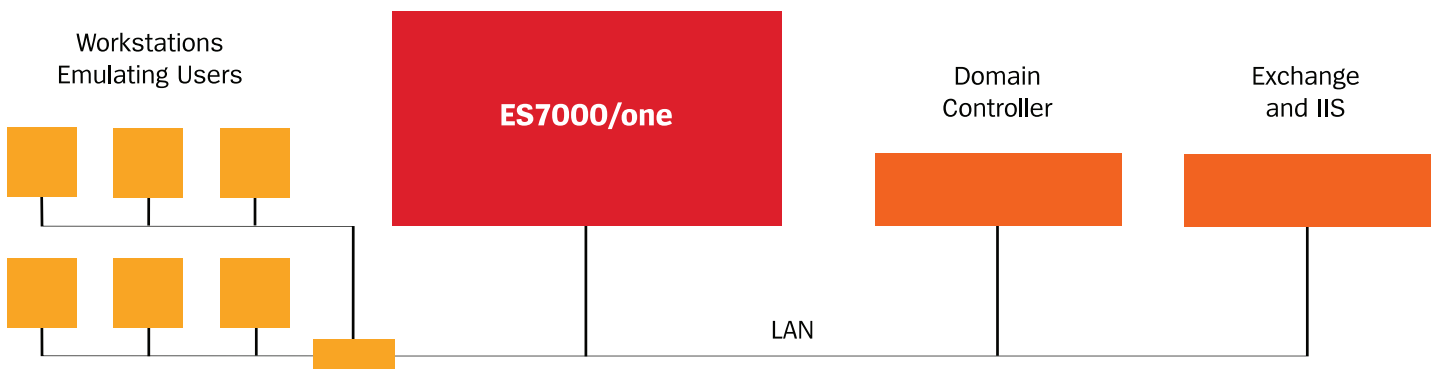


Figure 1. Test Configuration.

## Hardware

The main hardware component is the ES7000/one Server. Detailed product information is available on the Unisys website [http://www.unisys.com/products/enterprise\\_\\_servers/high\\_d\\_end\\_\\_servers/index.htm](http://www.unisys.com/products/enterprise__servers/high_d_end__servers/index.htm).

Initial testing was done with the ES7000/one Server configured with Intel's Single-Core Xeon® MP processors. These test results are discussed in detail in the first part of this paper. A follow-on set of tests was done with the ES7000 configured with Intel's Dual-Core Xeon® MP processors. The dual-core results are summarized in the latter part of this paper. See Terminal Server Scaling with Dual-Core Intel® Xeon® MP Processors.

Refer to *Table 2* for a summary of the system components.

System Component	Quantity	Description
Operating System		<ul style="list-style-type: none"><li>• Microsoft Windows Server 2003 Datacenter<sup>4</sup> x64 Edition</li></ul>
Processors	4 or 8	<ul style="list-style-type: none"><li>• 64-bit Intel® Xeon® MP</li><li>• 3.3 GHz single-core, or</li><li>• 3.0 GHz dual-core</li></ul>
Memory	32 or 64 GB	<ul style="list-style-type: none"><li>• 32 GB of memory for 4-CPU configuration</li><li>• 64 GB of interleaved memory for 8-CPU configuration</li><li>• Used the /maxmem boot.ini switch for some tests to enable Windows to use only a portion of the physical memory</li></ul>
Disk Subsystem	1	<ul style="list-style-type: none"><li>• EMC/CLARiiON CX 300</li><li>• 40 disks: 73 GB per disk, 15k RPM</li><li>• 4 LUNs RAID 0<sup>5</sup></li></ul>
Logical Disk Volumes <sup>6</sup>	1 internal 4 external	<ul style="list-style-type: none"><li>• One internal disk for the operating system</li><li>• One stripe of 16 disks for TS user profiles</li><li>• One stripe of 8 disks for Microsoft Office</li><li>• Two stripes, each with eight disks, for two page files</li></ul>
HBA for External Disk	1	<ul style="list-style-type: none"><li>• Emulex LightPulse LP10000</li><li>• Storport Miniport driver version 7.1.10.4</li></ul>
Network Interface Card	1	<ul style="list-style-type: none"><li>• Intel® PRO 1000 Server MT Dual Port</li></ul>

**Table 2.** Unisys ES7000/one Enterprise Server.

<sup>4</sup> The results described within this document could also have been obtained with the Enterprise x64 Edition.

<sup>5</sup> RAID 0 was chosen in this performance test to provide the fastest disk access times without regards to redundancy. We did not want the disk to be a bottleneck. It is expected that a customer would consider RAID 10.

<sup>6</sup> The number of volumes and the size of each volume are more than enough for the results achieved. Multiple drives were used so we could observe the disk usage based on what function/software the disk was used by. See the disk discussion later in this document.

There were three other major hardware components in the test environment.

- **Domain Controller and Test Controller system:** This is the Domain Name Server for the domain, and it runs the Dynamic Host Configuration Protocol (DHCP) service and Active Directory. This is where the tests are managed and run, including managing the client workstations.
- **Exchange and IIS system:** This houses Microsoft Exchange 2003 Service Pack 1 and Microsoft Internet Information Services (IIS) 6.0. These are the mail and Web services used by the simulated Terminal Server users.
- **Workstations (40):** Multiple terminal services sessions were running on each client workstation. The actual applications run on the server in server-based computing. Therefore, the performance capability of the client workstation is only needed for operation of the network and for image processing.

System	Processors	Memory	Windows
Domain Controller	2 Intel® Xeon® 3.2 GHz	3 GB	Microsoft Windows Server 2003 Enterprise Edition
Exchange and IIS	2 Intel® Xeon® 3.2 GHz	3 GB	Microsoft Windows Server 2003 Enterprise Edition
Client Workstations	1 Intel® Pentium™ 4 2.8 GHz	512 MB	Microsoft Windows XP Professional SP1

Table 3. Supporting Systems.

### Software

The Robosrv, Robocli, and Tbscript executables drive the server-client simulation. Microsoft’s Terminal Services Scalability Planning Tools (TSScaling) includes the following automation tools.

- **Robosrv.exe:** Controls the rate that terminal server sessions logon to the Terminal Server and commands the clients to run scripts that load the Terminal Server. This is run on the Test Controller, which was also the Domain Controller in our test environment.
- **Robocli.exe:** Controls the client side of the load simulation where the scripts are initiated as commanded by Robosrv.exe. Robocli was run on each client workstation system.
- **Tbscript.exe:** The script interpreter that executes Visual Basic Scripting Edition scripts and supports specific extensions for controlling the client.
- **Qidle.exe:** Periodically checks to see if any of the sessions to the Terminal Server have been idle more than a specific period of time. If there are any idle sessions, Qidle will notify the administrator with a beeping sound. For our tests, we ran Qidle on the Terminal Server and logged the results to a file.

### Remote Desktop Client

Windows Remote Desktop Connection Client (mstsc.exe) version 5.1.2600.1106 runs on the client workstations. This software allows the client workstation to attach to and run sessions on the Terminal Server via the Remote Desktop (RDP) protocol.

### Simulated User Scripts

Two scripts were developed by Microsoft-based on Gartner Group specifications for the Knowledge Worker and Data Entry Worker as defined in *Table 4*.

The tests performed for this report used the Knowledge Worker script provided by Microsoft. This script switches between applications (Outlook, Excel, Word, and Internet Explorer) to send and receive mail, manipulate Office documents, and access web pages. The script also records the response time for each of the simulated user actions. This represents a heavy user environment and benefits from both adequate memory and processor resources.

A flow chart of the script is available online in the Windows Server 2003 Terminal Server Capacity and Scaling (TSScaling) document <http://www.microsoft.com/windowsserver2003/techinfo/overview/tsscaling.mspx>.

### Microsoft Office

Microsoft Office 2003 with SP1 was installed on the Terminal Server. There are some tunings recommended by Microsoft that can improve the system's performance if the Office applications are used in a Terminal Server environment. Unisys engineers ran tests with the recommended Office settings found in the TSScaling document. Additionally, they modified a few other settings. See "Settings, Tunings, and Best Practices," on page 19 of this document for details.

The test requires a "hotfix" to Office 2003 SP1. This eliminated errors under heavy load on a multiprocessor system. A post-SP2 version of the hotfix is documented in Knowledge Base article 898778. This fix was not in the initial SP2 release. Contact Microsoft or Unisys Support if you would like more information on this hotfix.

### Mail and Web Service

These services reside on the Exchange and IIS hardware component noted in *Table 3*. Unisys engineers used Internet Information Services 6.0, which is a standard part of the operating system, and installed Exchange 2003 with SP1, and followed the tunings recommended by Microsoft to improve performance in a Terminal Server environment. For more information, see the "Settings, Tunings, and Best Practices" section on page 19 of this white paper.

Name	Load	Characteristics
Knowledge Worker	Heavy	Workers who gather, add value to, and communicate information in a decision support process. They enter data at a moderate speed. Example job tasks include marketing, project management, sales, desktop publishing, decision support, data mining, financial analysis, executive and supervisory management, design, and authoring.
Data Entry Worker	Light	Workers that input data into computer systems, for example: transcription, typing, order entry, clerical work, and manufacturing.

Table 4. Workload Descriptions.

## Print Service

HP LaserJet 6P printers were installed on the NULL port on the Domain Controller and Exchange and IIS hardware components. The script prints twice during a work cycle. The first print job is a large, 24-page, 272 KB Microsoft Excel spreadsheet. The second is a 2-page, 23 KB Microsoft Word document. This is the default print frequency for the script.

## Analysis Support Tools

Unisys engineers used the Windows Performance Monitoring tool to gather system information. TSScaling also includes tools to help determine the point at which the test server's responsiveness degrades beyond the acceptable limit.

## Operating System

Engineers installed Windows Server 2003 Datacenter x64 Edition on the ES7000/one Server, and the Terminal Server role was added. The results described within this document could also have been obtained with the Enterprise x64 Edition, which supports up to eight processors and 1 terabyte (TB) of memory.

Microsoft provided Unisys with a hotfix to the Windows kernel that reduces the overhead of processing timers. In particular, Deferred Procedure Call (DPC) time on processor zero was reduced. Terminal Services and Microsoft Office use many timers. The kernel change is documented in Knowledge Base article 908675.

## Methodology

Our goal was to identify the maximum number of users the ES7000/one Server with Terminal Server could manage before server responsiveness degraded beyond an acceptable limit. The ES7000/one Server was intentionally configured to avoid network, disk, and memory bottlenecks.

Each user script records the response time for a multitude of granular user actions, such as open, close, save, and print commands. The response times for the actions were graphed and user login progression overtime was evaluated.

Typically, the response time curves have two distinct regions: a flat region where little degradation in response time is noticeable and a high slope region where response time degrades fast as the number of active users increases. The following criteria were used to interpret the test's results.

- For actions that have an initial response time of less than 200 ms, the degradation point is considered to be where the average response time is more than 200 ms and roughly 110 percent of the initial value.
- For actions that have an initial response time of more than 200 ms, the degradation point is considered to be the point where the average response increases by roughly 10 percent of the initial value.
- Total cycle time is another measure of how well the Terminal Server is performing the user actions. Tests performing with different cycle times are effectively performing a different amount of work in the same unit of time thus consuming more resources in the time unit.

More detail can be found online in the Windows Server 2003 Terminal Server Capacity and Scaling document <http://www.microsoft.com/windowsserver2003/techinfo/overview/tsscaling.mspx>.

## Test Procedure

To insure a common starting state, all systems were rebooted prior to running each test iteration – starting with the Domain Controller and including the Terminal Server, Application Server, and the client workstations. The user profiles were reset and the Exchange database was remounted. Robosrv was started and the workstations were automatically connected. Most of this was supported with command files.

The users were logged on quickly at the beginning of a test and then changed to a slower log-on rate before the Terminal Server became too busy. This was done to shorten the test time and still represents a reasonable environment to study.

## Terminal Server Capacity

### x64 versus x86

The limiting factor to Terminal Server scalability on the 32-bit server is the Microsoft Windows kernel virtual address space. The 32-bit x86 Windows platform is named after its 32-bit address space, meaning that up to  $2^{32}$  bytes (4 GB) can be addressed by an application, regardless of physical RAM. By default, 2 GB of this address space is allocated to user-mode code and data, and 2 GB is allocated to the kernel. There are three areas in the 2 GB kernel address space that have a significant impact on Terminal Server scalability. These are: paged pool, system page table entries, and system file cache. Although these different allocations share the same area, the partition between them is fixed at system startup in current versions of Windows. If the system runs out of space in one of those areas, the other areas cannot donate space to it and applications may begin to encounter unexpected errors.

While Microsoft improved memory management in Windows Server 2003, it could not overcome the inherent limits of the 32-bit architecture. The extended address space, up to 16 TBs, is one of the biggest advantages of a 64-bit system. Now an application can access up to a theoretical limit of 8 TB, where Windows can be assigned the remaining 8 TB. See Microsoft Knowledge Base article 294418 <http://support.microsoft.com/default.aspx?scid=kb;en-us;294418> for more detailed information. The 8 TB of memory for Windows is available even to 32-bit applications. It opens up a huge opportunity for application environments, which are limited by the 2 GB of operating system memory available on the 32-bit architecture. Terminal Services is one such application environment.

The table below shows the theoretical maximum number of Terminal Server sessions that can be managed on different Windows versions running the Knowledge Worker workload.

In the next section, we will see that the number of users that can be managed on an ES7000/one Server with Windows Server 2003 x64 Datacenter Edition surpasses the x86 architectural limit with 4-processor and 8-processor configurations.

Windows Version	Theoretical Maximum Number of Sessions <sup>7</sup>
Windows Server 2000 (32-bit)	160
Windows Server 2003 (32-bit)	300
Windows Server 2003 x64 Edition	On the order of 10000

Table 5. Theoretical Limits for Knowledge Worker Sessions.

<sup>7</sup> The Windows 2000 maximum is taken from the *Windows Server 2003 Terminal Server Capacity and Scaling* document. The Windows 2003 maximums are taken from a Microsoft Terminal Server WinHEC April 2005 presentation.

## Scaling Terminal Server with Single-Core Intel Xeon MP Processors

Previously, we discussed the potential of Terminal Services to scale up on a 64-bit architecture with Windows Server 2003 x64 Edition. Now we will discuss the actual performance achieved in this benchmark. This section of the report details the results when single-core processors were used. Another section in this paper, Terminal Server Scaling with Dual-Core Processors, summarizes the results when dual-core processors were used.

### Terminal Server Scaling

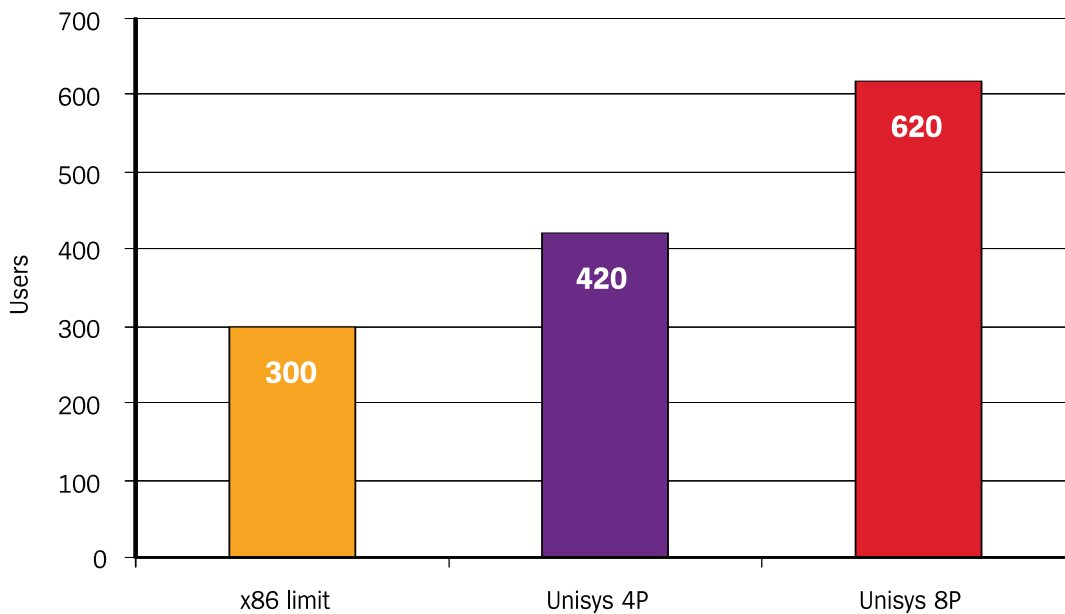


Chart 1. Terminal Server Scaling with Single-Core Processors.

We broke through the x86-limit with the ES7000/one Server x64 4-processor configuration and continued to scale up to eight processors. Comparing with the x86-limit of 300 users, there is a 40 percent gain in the number of users that can be managed with the Knowledge Worker workload on a 4-processor ES7000/one Server. There is a further 48 percent gain moving up to an 8-processor configuration. The net result is that the x64 8-processor single-core configuration can manage more than double the number of users compared to an x86 system (a gain of 107 percent).

## CPU Usage and Hyperthreading

The user workload Unisys simulated has a large demand for processor cycles and therefore benefited from hyperthreading. Enabling hyperthreading in this environment is the recommended method of using the 64-bit Single-Core Intel® Xeon® MP processors found in the ES7000/one Server.

The Terminal Server workload took advantage of all the processor capacity. With hyperthreading disabled, there was a 23 percent and 16 percent loss in the number of users managed by the Terminal Server for the 4 and 8-processor configurations respectively.

As the workload hit maximum levels on the test server, the processors were not only busy, but the processors were inundated with work and the system began to form a queue for backlogged threads. This was observed by the Performance Monitor counter, System: ProcessorQueueLength.

## Response Time

The maximum number of users was determined to be the point where response time to user actions and server responsiveness degraded beyond an acceptable limit, as described in the “Methodology” section on page 10. *Chart 2* below shows the response time for two example user actions. *Chart 3* plots the time it takes for the script to complete a cycle of actions. There are two distinct regions in the charts, separated by a vertical orange line at 620 users. The first region shows the response time for the actions when there are 1 through 619 active users. This is a relatively flat region where little degradation in response time is noticeable. In the later region, response time degrades fast as the number of active users increase.

### Example Response Time: 8-Processors

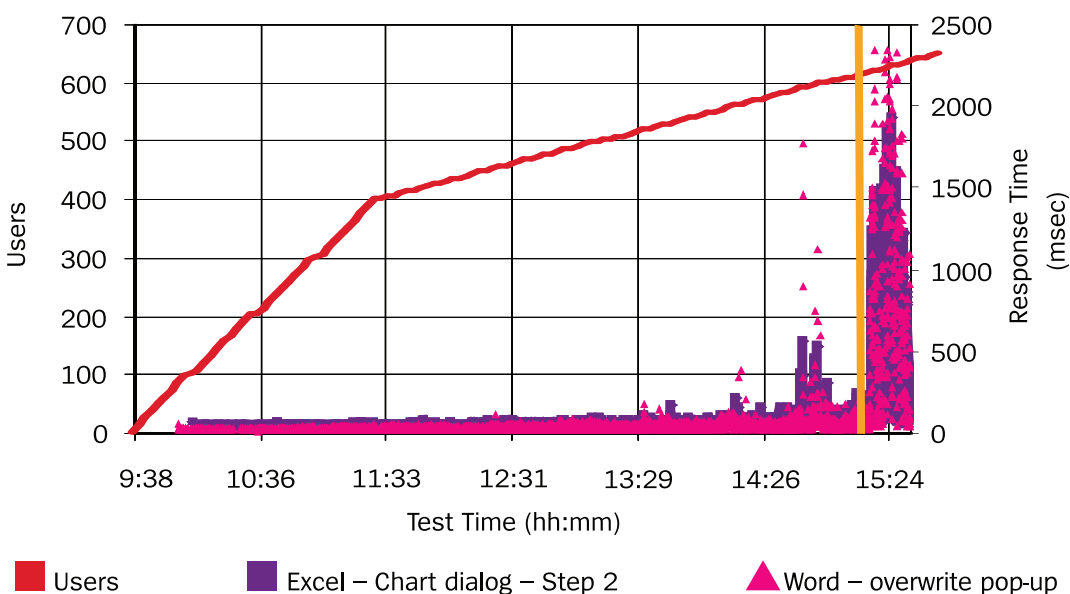


Chart 2. Response Time.

### Cycle Time: 8-Processors

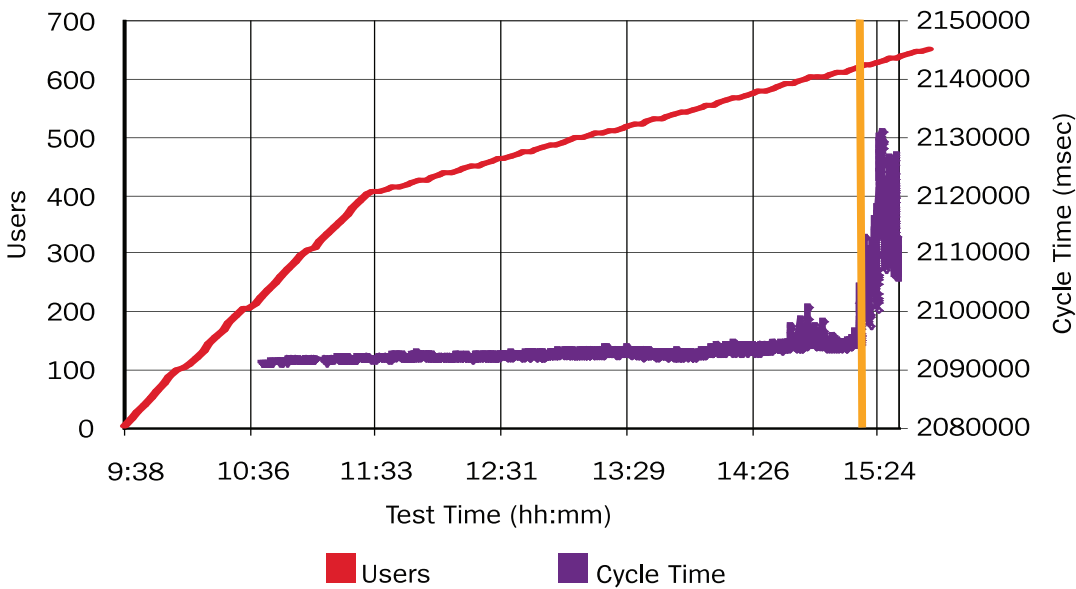


Chart 3. User Cycle Time.

## System Characteristics

### Resource Requirements

Overall computing performance depends on the performance of the critical system components. In this section, we address those components from the view of their usage by Terminal Services. The system characteristics described apply to both single-core and dual-core processor systems. However, the specific data examples discussed are from tests using single-core processors.

### Memory Usage

When using the 64-bit version of Terminal Server, overall memory consumption in the extreme case can be nearly two times higher than the same workload running on a 32-bit version of Microsoft Windows. Data structures are larger mainly because pointers are two times larger, and the System File Cache consumes more memory.

Memory affects the performance of other hardware components because not having enough can add an extra burden on the processor and disk due to heavier page file use. For our tests, enough memory was provided to avoid swapping.

Memory usage in Terminal Server environments is complex. The amount of memory required per user depends on what applications are used and the number of and size of any open documents. Another consideration is that Windows treats multiple instances of the same application in a special way. For example, Windows loads the application once and “points” the other sessions to that first instance. If one session modifies the copy of the executable in memory, Windows makes another copy of the executable for that session.

The best way to determine memory requirements for a particular customer environment is to observe the system with the Performance Monitor tool. The important counters to watch include:

- Process: (Total) Working Set
- Terminal Services: Active Sessions
- Memory: Available Bytes
- Memory: Pages Input/Sec
- Memory: Pages Output/Sec

The 4-processor configuration was tested with 32 GB, 24 GB, and 16 GB of RAM. There was no measurable difference in the number of managed users between the 32 GB and 24 GB results. The 16 GB test started reading from the page file earlier in the test causing more processor cycles to be used and user response time to increase to an unacceptable level sooner. This resulted in a loss of about five percent in the number of managed users compared to the tests with more memory.

The 8-processor configuration was tested with 64 GB, 32 GB, and 24 GB of RAM. There was little difference between the 32 GB and the 24 GB tests. The system read from the page file near the end of both of these tests. There was about a three percent loss in the number of managed users compared to the 64 GB test. On the other hand, 64 GB was more than enough memory to manage 620 users. See *Chart 4* for further details about memory usage on the 8-processor configuration.

#### Memory Usage: 8-Processors

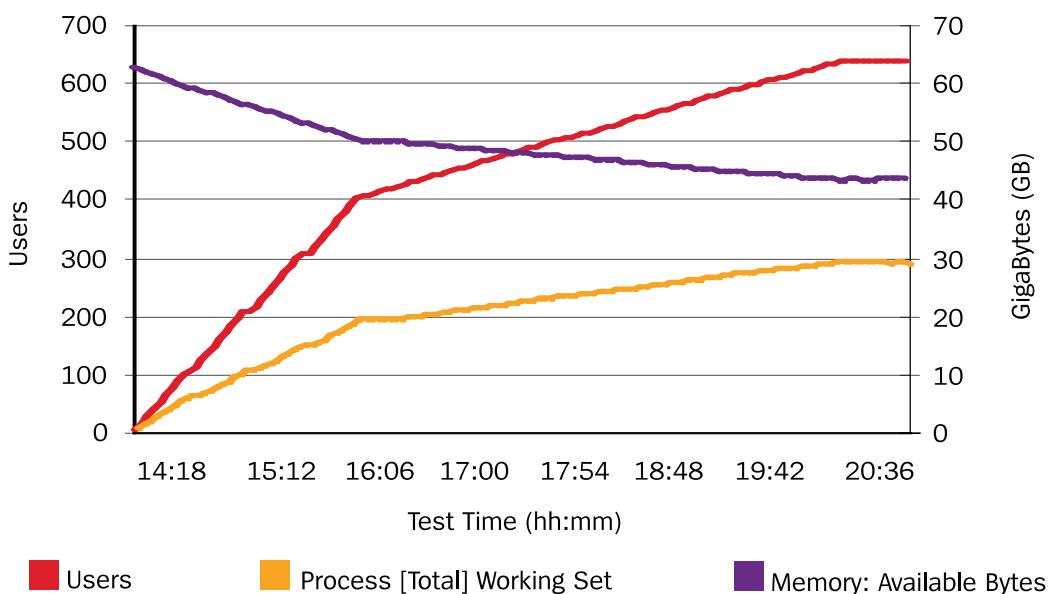


Chart 4. Memory Usage.

The Total Process Working Set is the set of memory pages in physical memory belonging to the processes. If free memory in the server is above a threshold, pages are left in the Working Set of a process even if they are not in use. When free memory falls below a threshold, pages are trimmed from Working Sets. The trimmed pages may still be in memory when they are needed again, or they may need to be read from the page file. This depends on a few things, including the amount of Available Bytes. Available Bytes is the amount of physical memory available to processes running on the computer.

### Disk Usage

Terminal Services does not have great disk demands. However, user applications and services may present disk demands, as well as paging by the Operating System if there is insufficient memory installed.

The operating system and the applications are loaded into memory once – the first time they are needed. Profiles and user data files are also brought into memory. The user data along with the user profiles are altered and may be written to disk. Also, portions of shared EXEs and DLLs are written to the page file.

There was very little disk access with the tested workload. The “Avg Disk Queue Length,” which is a significant indicator of the load on the disk subsystem, remained well below 0.5. *Chart 5* illustrates the disk usage from the 8-processor, 64 GB test where more than enough memory was provided to accommodate the user working sets and avoided reading from the page file.

Disk Utilization: 8-Processors

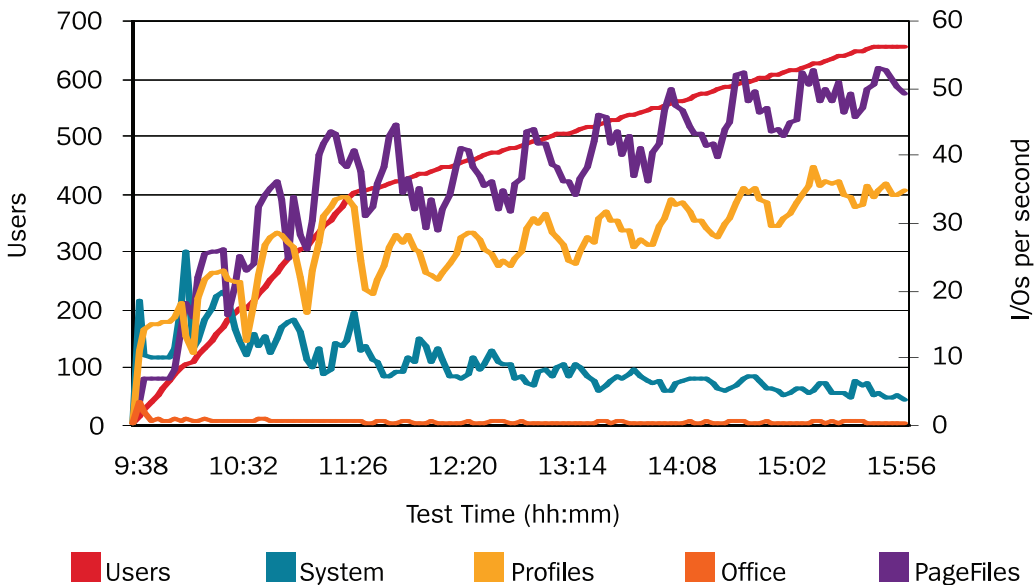


Chart 5. Disk Utilization.

## Network Usage

Network usage for this benchmark is very low. This is due to the nature of the test and because of the efficiency of the RDP protocol.

The bulk of our network traffic is between the Terminal Server and the terminal server clients via the RDP protocol. There is a small amount of network traffic with the Domain Controller, IIS, Exchange, and the test manager. In this test, all the user data and the profiles were stored on drives attached to the Terminal Server.

Chart 6 shows that the average bytes-per-second/per-user converge as the number of users increase. The bytes-per-user is measured from the Terminal Server and includes both bytes sent and received, the bulk of which is sent to the user.

Depending on the specifics of a customer's environment, more network usage may be apparent. For example, network traffic increases if network home directories, printer redirection, and roaming profiles with Active Directory are used. Also a customer environment may have other database and application servers adding to network traffic.

### Network Traffic: 8-Processors

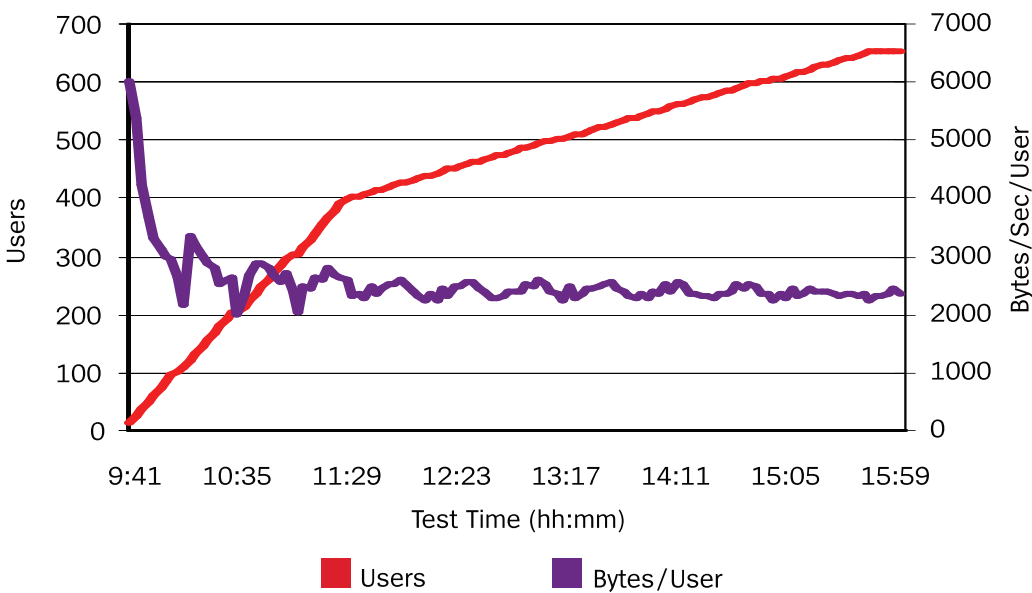


Chart 6. Network Traffic.

## Terminal Server Scaling with Dual-Core Intel Xeon MP Processors

The data presented up to now is based on the ES7000/one Server using Single-Core Intel® Xeon® MP processors. The ES7000/one Server also supports the next generation of Dual-Core Intel® Xeon® MP processors. This section summarizes benchmark results using Intel's Dual-Core Xeon® MP processors.

Table 6 highlights differences between the Intel® Single and Dual-Core processors used in this study.

64-bit Intel Xeon MP Processor	CPU Speed (GHz)	Cache Size (Kilobytes)			System Bus (MHz)	Core(s) per Socket
		L1	L2 <sup>8</sup>	L3		
Dual-Core	3.0	16	2048	n/a	800	2
Single-Core	3.3	16	1024	8192	667	1

Table 6. Intel® Processors.

In all configurations, the Dual-Core system supported more terminal server users than the equivalent Single-Core system. *Chart 7* illustrates: 1) The number of terminal server users supported by each system and 2) the percentage gain comparing the Single-Core and Dual-Core systems with the same configuration. There was a sizable gain from 10 to 49 percent for the configurations tested.

### Terminal Server Capacity — Single-Core vs. Dual-Core

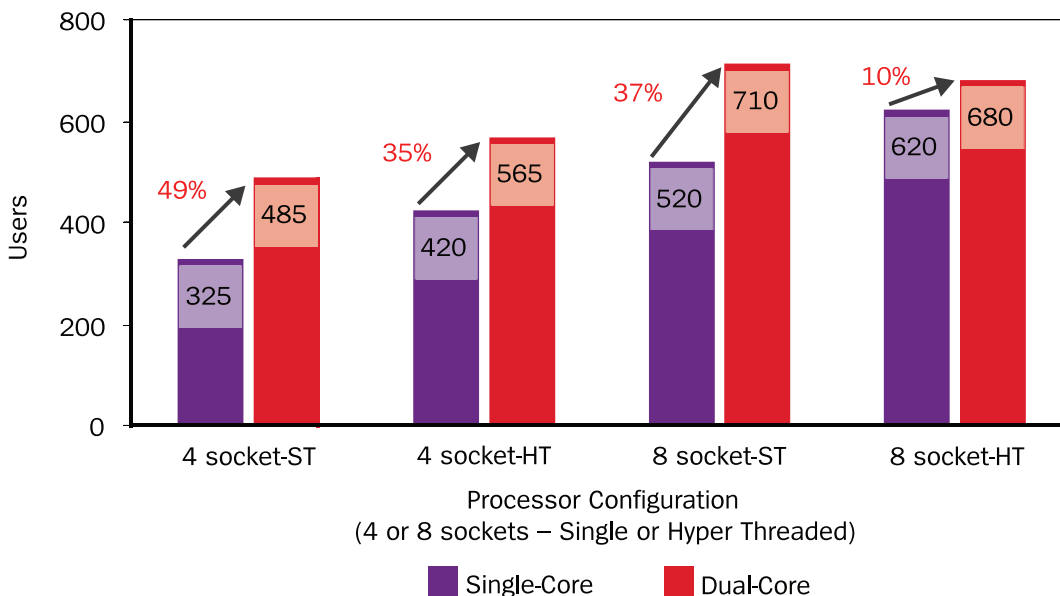


Chart 7. Dual-Core Performance Gain Relative to Single-Core.

<sup>8</sup> Each core has its own L2 cache.

## Settings, Tunings, and Best Practices

Microsoft provides tuning recommendations that can improve performance of Microsoft Office applications when they are used in a terminal server environment. This section provides a summary of the settings applied to the Office environment during this benchmark. Some general tuning recommendations are also available.

### Office Configuration Settings

The settings in *Table 7* are included in the “Procedure for Installing and Configuring Office 2003,” which is described in the documentation provided with the Terminal Services Scalability Planning Tools (TSScaling).

In this benchmark, “Status bar” for Word and Excel was unchecked. The Status bar is the horizontal area at the bottom of the program window. It provides information about the current state of what you are viewing in the window and any other contextual information. Not using the Status bar yielded an eight percent increase in the number of users managed in the 8-processor test.

Office Application	Options
Word	<b>Uncheck the following:</b> “Startup task pane” “Smart tags” “Save AutoRecover info every” “Allow background saves” <b>Disable:</b> “Check grammar as you type”
Excel	<b>Uncheck the following:</b> “Startup task pane” “Save AutoRecover info every”
Outlook	<b>Uncheck the following:</b> “Automatically save unsent messages” “AutoSave unsent every” “Automatic name checking” “Display a new Mail Desktop Alert (default Inbox only)” “Suggest names while completing To, Cc, and Bcc fields” “Run AutoArchive every” “Enable the Person Names Smart Tag” “Use Microsoft Office Word 2003 to edit email messages”

Table 7. Office Options.

## Registry Settings

### ConnManagerPoll

By default, Outlook 2003 polls the network connection every 15 seconds. This network connectivity detection method is processor intensive, and more frequent polling reduces the number of Outlook users that a single Terminal Server can support. To increase the number of supported Outlook 2003 users, you can configure the ConnManagerPoll registry entry so that Outlook polls the network connection less frequently. For more information, see Knowledge Base article 891536 <http://support.microsoft.com/default.aspx?scid=kb;en-us;891536>.

In this benchmark, this value was set to 1,536 seconds (or 600 hexadecimal based) by the TSScaling configuration script. Decreasing the polling rate, from the default 15 seconds to 1,536 seconds, produced a 35 percent gain in the number of terminal server users managed.

### NoRecentDocsHistory

By default, Windows saves a shortcut to each of the non-program files the user opened most recently, and it displays the shortcuts on the Start menu under Documents. These shortcuts let users easily review and restart recently used documents. The NoRecentDocsHistory registry setting allows or prevents Windows from saving these shortcuts. In this benchmark, Windows was prevented from saving shortcuts to documents which resulted in a low, single-digit percentage gain in the 8-processor test.

For more information, go to <http://www.microsoft.com/technet/prodtechnol/windows2000serv/reskit/regentry/93170.msp?mfr=true>

## Best Practices

The previous section described specific settings we applied as standard for running TSScaling as a benchmark comparison. However, there are other settings that affect the performance or scaling of the Terminal Server.

Achieving maximum scalability requires that you examine the tradeoff between the utility and cost (in system resources) of some application features. Applications typically have “innovative” features that potentially consume significant system resources, while other settings only make sense to use in certain environments. Examine the applications running on the Terminal Server and take the approach that makes the most sense for your environment.

The following recommendations have been collected from various sources that should be referenced when running applications in a Terminal Server environment. This is not a complete list; however, it should get you started:

- Resolution and color depth (lower is better). Affects RAM and network bandwidth usage.
- Printer redirection. Impacts server CPU usage especially during the login sequence when the new printer is detected and installed by the spooler service.
- Minimize opening and closing applications. Users who open and close applications, rather than switching between applications, will place a heavier load on a system. This also includes users who move quickly between tasks.
- Background grammar checking – also mentioned above.
- Disabling Internet Explorer’s personalization settings will increase loading speed.
- Check the features of your Terminal Server Client software. Some of the default features could be degrading the performance of your system and may not be necessary. Other features may allow you to optimize session performance, such as the RDC Bitmap caching feature.

## Additional Online Resources

### Terminal Server Best Practices

<http://www.microsoft.com/technet/prodtechnol/windowsserver2003/library/ServerHelp/7c5ff862-ec28-4d62-b1d5-79c4bd544b36.mspx>

### Resources on Terminal Server

[http://msdn.microsoft.com/library/default.asp?url=/library/en-us/termserv/termserv/resources\\_on\\_a\\_terminal\\_server.asp](http://msdn.microsoft.com/library/default.asp?url=/library/en-us/termserv/termserv/resources_on_a_terminal_server.asp)

### Programming Guidelines

[http://msdn.microsoft.com/library/en-us/termserv/termserv/terminal\\_services\\_programming\\_guidelines.asp](http://msdn.microsoft.com/library/en-us/termserv/termserv/terminal_services_programming_guidelines.asp)

### Deploying Microsoft Office in a Terminal Services Environment

<http://www.microsoft.com/technet/prodtechnol/office/office2003/deploy/o2k3dpts.mspx>

## Conclusion

The Unisys ES7000/one Enterprise Server with Terminal Server and Windows Server 2003 x64 Edition scales up from previous Windows x86 limits with a 4-processor configuration and further scales up with eight processors while running the Knowledge Worker workload.

With a 4-processor configuration and 24 GB of memory, it is possible to achieve as much as an 88 percent increase from the x86-limit, resulting in as many as 565 users. By scaling up to eight processors with 64 GB of memory, our test results showed an additional 26 percent gain, resulting in as many as 710 users. The net result is more than double the number of users compared to an x86 system. This represents an impressive 137 percent gain in the number of users that can be managed.

These results were achieved with little disk and network utilization. At peak user capacity, the processors were busy handling the workload and the users experienced acceptable response times. Memory was also an important ingredient in supporting the maximum number of users. Test results showed performance varied little with less memory as long as there was enough to avoid significant page file read activity. The 64 GB used for the 8-processor test was more than enough to accommodate the 710 users without reading from the page file.

The results in this paper were from a simulation of a workload characterized by the Knowledge Worker<sup>9</sup> type of users. The simulation script is from Microsoft. Both Microsoft and Unisys describe this as a heavy workload. Since a typical customer environment will include custom applications, virus scanners, and other packaged software, Unisys recommends that a simulation of a particular installation be done prior to deployment.

## About the Author

Linda Krasinski has been with Unisys for 28 years. Most recently, she has been working with Unisys ES7000 servers and Windows Server operating systems in the areas of benchmarking, measurement, system analysis, system performance, and networking. She has also recently worked with SPECweb, Terminal Server, and various virtualization technologies.

<sup>9</sup> A Knowledge Worker is classified by Gartner Group in: *"TCO: A Critical Tool for Managing IT"* Gardner Group, 12.10.1998.

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