

# **IBM® Lotus® Notes® 8.0.2 on Citrix XenApp 4.5: A scalability analysis**

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**Abstract:** This white paper provides an overview of, and recommendations, for how to get the most from your IBM® Lotus® Notes® client on the Citrix XenApp server. In particular, we show that, by tuning your environment so that you get the most from your applications, you can realize significant improvements in running the Lotus Notes client on XenApp. This is true for both the standard and the basic configurations of Lotus Notes.

Moreover, with the addition of 64-bit Citrix XenApp server support for the Lotus Notes client in 8.0.2, you can scale to even higher numbers—well over 100 users—at a much reduced cost. Also presented are the testing environment, tuning parameters, and the workflows that were executed to gather the scalability data.

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# 1 Introduction

IBM® Lotus® Notes® 8 software delivers a compelling new user experience with enhancements to existing core functions, complemented by new functionality that can help you increase effectiveness, improve efficiency, and speed your decision making processes. Much more than feature enhancements to mail and calendar, Lotus Notes and Domino® 8 is the next step in a rich evolution of the software that demonstrates IBM's commitment to business users across the spectrum.

With an open, collaborative work environment, Lotus Notes and Domino 8 takes business communication and collaboration to new heights, while continuing to build on the value of current investments. Familiar yet powerful capabilities—in a comfortable, clean new look—are designed to give you the tools and information to conduct business, all from the same page.

IBM and Citrix have worked together for many years, and IBM is committed to improving the scalability and performance of the Lotus Notes client on XenApp. With the overall memory improvements that have been incorporated into the Lotus Notes 8.0.2 client, the Citrix XenApp hardware and software you likely have in place today can be a cost-effective means of deploying Lotus Notes 8.0.2.

## 2 Overview of the analysis

This scalability analysis for Lotus Notes running on IBM [System x](#) hardware provides Citrix XenApp architects, system integrators, and project managers with the data they need to help design and capacity plan a XenApp server environment to meet the needs of their organization.

To expand the options available—improving scalability and potentially lowering your overall costs—we tested four different configurations, including new support of the Citrix XenApp 64-bit server.

Our study showed that the configuration of the Citrix server can have a significant impact on scalability. The way your XenApp server is currently set up and tuned may not be optimal to running the Lotus Notes client; however, by using Citrix's tuning guidelines and some specific Lotus Notes tuning we were able to dramatically improve scalability. (Refer to Appendixes B, C and E for tuning parameter details.)

By leveraging the methodology and workflows used in this analysis, we can perform similar testing scenarios to benchmark future or alternative hardware platforms. Additionally, many of the tuning guidelines presented, though not formally tested as part of the analysis for this paper, can be similarly applied to earlier versions of Lotus Notes to gain significant scalability improvements.

### 2.1 Configuration

Lotus Notes 8.0.2 is available in two alternative configurations: the “standard configuration” and the “basic configuration”. The standard configuration is based on Eclipse and IBM Lotus Expeditor technology and brings a new look and increased openness to Lotus Notes.

The basic configuration provides a more limited set of new functionality and is based on the same general architecture as earlier versions of Lotus Notes. The basic configuration is intended for installations lacking the additional hardware requirements needed for the standard configuration.

The Lotus Notes standard configuration is usually referred to in literature as simply “Lotus Notes.” For the sake of clarity, in this paper we try to be explicit when we are referring to just the “standard configuration” or just the “basic configuration.”

For analysis, IBM and Citrix leveraged a proven methodology to assess the server scalability of a XenApp Server running on four separate hardware configurations hosting IBM’s Lotus Notes 8.0.2 Standard client. The hardware configurations that were evaluated included:

- Microsoft® Windows® 2003 32-bit 2 Dual Core Processors 4GB RAM
- Windows 2003 32-bit 2 Dual Core Processors 8GB RAM with PAE enabled
- Windows 2003 64-bit 2 Dual Core Processors 16GB RAM
- Windows 2003 64-bit 2 Quad Core Processors 32GB RAM

where “PAE” is Physical Address Extension (refer to Appendix D for more information on this).

## 2.2 Summary of the results

Table 1 summarizes the results of the scalability tests of the Lotus Notes client (Standard Configuration). Refer to Appendix A for details of the scalability test results for the Lotus Notes client (Basic Configuration).

**Table 1. Scalability test results**

Test Platform	Lotus Notes Standard Client ( 8.0.2 )			Lotus Notes Standard Client ( 8.0.1 )	
	Acceptable Active Sessions Range	Max Sessions	Limiting Factor	Max Sessions	Limiting Factor
Windows 2003 32-bit 2 Dual Core Processors 4GB RAM	23 – 25	25	Memory	14	Memory
Windows 2003 32-bit 2 Dual Core Processors 8GB RAM /PAE enabled	40 – 50	55	Memory	Not measured	N/A
Windows 2003 64-bit 2 Dual Core Processors 16GB RAM	65 – 72	75	CPU Memory	N/A	N/A
Windows 2003 64-bit 2 Quad Core Processors 32GB RAM	120 – 145	155	CPU Memory	N/A	N/A

After a baseline was established on each of the servers, groups of users were incrementally added to each server as system resources were monitored for potential bottlenecks. Throughout the duration of the test, a real user logged on to the systems and validated the performance of the environments before new users were added.

During the scalability analysis, automated user sessions were launched on a single XenApp Server that executed mail and calendar workflows. The limiting factor that determined the maximum number of users for each scalability test was not consistent across all hardware configurations; physical memory, CPU, and/or disk utilization were all identified as limiting factors for the tests.

During the 32-bit environment testing, performance began to degrade after the physical RAM was 100% utilized and virtual memory (pagefile) was leveraged more frequently. This behavior was expected since performance typically degrades as memory-intensive applications cause frequent swapping of pages between RAM and physical disk.

For these reasons, the memory threshold was 75%–85%, which provides a buffer for unexpected spikes in memory consumption. After the memory bottleneck was eliminated by use of the x64 platform, the performance on four dual-core processors began to degrade when CPU utilization reached 75%–85%.

Performance was deemed unacceptable when CPU utilization surpassed the 80% threshold and the processor queue length spiked up consistently to unacceptable levels. This performance degradation correlated with 80% CPU utilization, which was the limiting factor in our test. In addition, disk queue length also spiked up consistently, which could potentially be a disk bottleneck with future tests. For these reasons, the CPU threshold was 70%–80% for the x64 platform.

## 2.3 Recommendations

Citrix recommends that XenApp administrators evaluate their environment and test data to determine an acceptable threshold for average resource utilization. The threshold accounts for the periodic CPU spike experienced during normal system usage as well as providing a buffer for unexpected or scheduled server operations. In some instances, organizations may choose to increase or decrease the acceptable threshold based on application characteristics and redundancy requirements.

IBM recommends using the Lotus Notes client optimization settings if you want to achieve the best scalability results. Also note that, the more applications you deploy to the same physical XenApp server, the less each application has to utilize the available memory and CPU; therefore, it is best to plan your installations and configurations beforehand.

Overall, with the enhancements made to the 8.0.2 client in terms of performance and memory footprint, we are now seeing our scalability figures on XenApp double what there were in 8.0.1 on the same hardware. This in turn results in a decrease in the number of XenApp servers you need to deploy when moving to Lotus Notes client 8.0.2 and beyond.

## 3 Test methods

There are four primary types of scalability testing methods appropriate for the Citrix XenApp 4.5 environment. The testing methods are summarized as follows:

- **Scripted Test.** Automated execution of scripts that mimic a user's actions without any user intervention.
- **Real Users Test.** Actual users enter the system and run through their daily tasks without any specified order.
- **Real Users with Tasks List.** Actual users enter the system and run through a set of pre-defined tasks.
- **Combination.** A combination of two or more of the aforementioned testing methods.

This section discusses each method in more detail and compares the advantages and disadvantages of using each method.

### **3.1 Scripted Test**

For this method, a standard set of scripts are leveraged to control the actions of test users who are similar to typical Lotus Notes client users. These scripts are developed to simulate a desired set of predefined actions (workflows) that are based on the user's role and applications used during a typical user session.

Each workflow may contain sub-workflows that dictate the multiple paths users take to complete their daily tasks. These sub-workflows are the basis for scripts that are generated. Initiation of script execution is at set intervals to ensure that steps taken while working in an application are not repeated simultaneously for all virtual users during the test. These intervals ensure more accurate results because the application is able to respond in a more realistic manner.

### **3.2 Real User Test**

The second method for scalability testing is to have users log in to the system and perform tasks similar to those of a typical workday. The results obtained from this method are geared toward real-life scenarios. More variables exist in the test, such as the number of users, activities, and interruptions. This makes it difficult to reproduce the same exact test while increasing user load, making system configuration changes, or repeating the test.

When running a real user test, most client environments benefit from monitoring their systems and capturing the performance data in a database format for an extended period of time. Resource Manager for Citrix XenApp is designed to accomplish this objective and can provide significant value and accuracy, assuming that a large enough population sample of data is captured.

### **3.3 Real User Test with Task List**

This next method for scalability testing is a combination of scripted tests and real user testing. Real user testing with task lists includes having real users access the system while executing a written set of tasks in a random order. These tasks are analogous to the workflows defined in this document.

Developing customer-specific tasks for scalability testing represents the different types of users who access the system on a daily basis. Each user accesses the system at different speeds, reflecting a realistic production environment. However, these users follow a common set of tasks that help with standardizing the scalability tests when they need to be re-run with additional users.

This type of test is resource intensive and can be difficult to coordinate. Most corporate environments cannot provide multiple resources for this type of application testing and evaluation.

### **3.4 Combination**

The final method for scalability testing is a combination of a custom script and real users accessing the test environment. For example, five client computers emulating six users each could be used in conjunction with several real users performing searches and more complex customer transactions. This would allow the administrators to load the system to a specific level and then evaluate the subjective and objective results of the users' interaction with the Citrix XenApp servers.

### 3.5 Scalability test methods summary

Table 2 summarizes the advantages and disadvantages of each scalability test method described above.

**Table 2. Scalability test methods summary**

Testing Method	Advantages	Disadvantages
<b>Scripted Test</b>	<ul style="list-style-type: none"> <li>• Completely controlled with no variables</li> <li>• Identical tests can be repeated as many times as needed</li> <li>• User time not required to do test</li> <li>• Tests can be re-run as environment grows</li> </ul>	<ul style="list-style-type: none"> <li>• Takes significant time/tools to create test scripts</li> <li>• User skill levels not incorporated in test</li> </ul>
<b>Real Users Test</b>	<ul style="list-style-type: none"> <li>• Real life test</li> <li>• Allows for different user types and skill levels</li> </ul>	<ul style="list-style-type: none"> <li>• Impossible to have two identical tests</li> <li>• User's time is needed to perform test</li> <li>• Need users from ISV's customer base</li> </ul>
<b>Real Users with Task List Test</b>	<ul style="list-style-type: none"> <li>• Can be as controlled as necessary</li> <li>• Tests can be repeated with high degree of similarity between previous tests</li> <li>• Allows for different user types and skill levels</li> </ul>	<ul style="list-style-type: none"> <li>• User's time is needed to perform test</li> <li>• The project team must create task list for users customized to their role (very complex and time consuming).</li> </ul>
<b>Combination</b>	<ul style="list-style-type: none"> <li>• Can emulate most user activities with custom scripts while real users can test actions that are not scripted</li> </ul>	<ul style="list-style-type: none"> <li>• Multiple users' time is needed to perform tests</li> </ul>

## 4 Test plan

This section provides details of the test plan for the scalability testing on the XenApp and Lotus Notes 8.0.2 environment. As with all testing strategies, a clearly defined testing process helps to ensure accurate and repeatable results.

### 4.1 Scalability testing process

Successful testing requires development of a detailed test plan. A clearly defined test plan ensures that the scripted workflow scenarios that are developed will accomplish the testing objectives.

#### 4.1.1 Planning

Capacity planning involves the following:

- Analyzing the application to determine hardware and software components, the system configuration, and typical usage patterns

- Defining testing objectives (for example, maximum user load, application upgrade compatibilities, and identifying bottlenecks)
- Defining the launch sequence of the test users
- Monitoring the server with no activity before test execution, to allow for proper benchmarking

After the benchmark information has been gathered in a log file, we start adding groups of users by spawning test sessions from the automation controller.

Additional users should be added to the test until it is complete. Throughout the duration of the scripted test, a user should manually log on to the system to measure user experience, to validate the performance of the system.

For the initial scalability and performance tests, performance graphs should be monitored. Also, user load increases should be stopped when the system is reaching critical thresholds or the scripts fail to respond.

#### **4.1.2 Creating vUser scripts**

The vUsers emulate production users interacting with the system under test conditions. The vUser scripts contain the actions that each virtual user will perform during a scenario execution. These scripts should emulate how real users typically interact with the system in a production environment. To emulate real users, you need to do the following:

- Create a detailed functional flow of user activities
- Break down the flow into manageable transactions
- Create the actual test script using a scripting tool

For this test, the scripts were based on real users. These scripts directed vUsers to perform common functional activities when using Lotus Notes. The vUsers launched an ICA session to the XenApp server and opened the Lotus Notes application like a real user would. After launching the application, the vUsers logged into the application and followed the steps provided by selected workflows. (Refer to Appendix E for more details on the workflows.)

#### **4.1.3 Benchmarking**

To get a more accurate scalability result, performance logging should be completed before vUsers start accessing and testing the server. Benchmarking helps to determine the system resources that are necessary to run the operating system, along with other software requirements, all of which yields a much better representation of what resources the application will require.

#### **4.1.4 Creating and running the scenario**

A scenario describes the configurations for a particular testing session. These configurations include defining the client machines that vUsers will use, scripts that vUsers will execute, and a specified number of vUsers or vUser groups that will run the scenario. In addition, we should determine the rate at which users are introduced into the actual test.

User load is emulated by instructing multiple vUsers to perform tasks simultaneously. Configuration and scheduling should be defined before executing a scenario. This setup will determine how the load generators and vUsers will behave when running the scenario.

#### **4.1.5 Monitoring the scenario**

While running the scenario, a monitoring tool such as Microsoft Performance Monitor or Resource Manager for Citrix XenApp Server should be leveraged to monitor all components of the test server. In addition, the monitoring tool should be configured to capture performance data and import the data to log files.

In addition to using a monitoring tool, a real user should log on during testing to measure performance. During our test executions, an administrator remained logged into the Citrix XenApp Server. After every 10-20 users logged on to the XenApp Server, the administrator session was used to obtain qualitative measurements of the server, including application responsiveness of Lotus Notes and screen refresh speed.

To analyze the results, the log files that are generated from the monitoring tool are organized into a readable format for archiving, analysis, and reporting.

## **5 Lotus Notes 8.0.2 and Citrix XenApp 4.5 scalability testing**

The Scripted Test method was leveraged to determine the scalability of Citrix XenApp servers hosting Lotus Notes Standard 8.0.2 client. This method ensured identical controlled tests that could be replicated. The test scripts were based on workflows obtained on a standard Lotus Notes Operational Profile to accurately simulate user activity on the Citrix XenApp servers. AutoIT, IBM Rational Performance Tester for Citrix, and the Citrix ICA client integration functionality were the primary testing tools that were used to develop the scripts.

The purpose of the scalability tests in this project was to determine the maximum number of users that could access the Lotus Notes 8.0.2 Standard application via XenApp 4.5 without overwhelming the server. Four different test scenarios were executed to assess differences in scalability between using 32-bit and 64-bit operating systems on XenApp servers.

The test scripts simulated, as best as possible, how most users would use the Lotus Notes application. The simulated users launched an ICA session to the Citrix XenApp server and opened the Lotus Notes application like a real user would.

The Lotus Notes application was on the desktop of the XenApp server, and the desktop was set as the published application for all the test users that logged in to the system during the test. After launching and logging into Lotus Notes, the simulated users followed the steps provided by selected workflows. (Refer to the Appendix E for more details on the workflows.)

This testing established a baseline, or threshold, regarding the maximum number of concurrent ICA sessions a XenApp server could effectively support on a typical physical XenApp server. Although the focus of testing was to ascertain the highest number of user sessions supported by a single XenApp server, it was also necessary to ensure that product usability was in no way adversely affected. The primary focus of the testing was to evaluate objective factors such as memory and utilization.

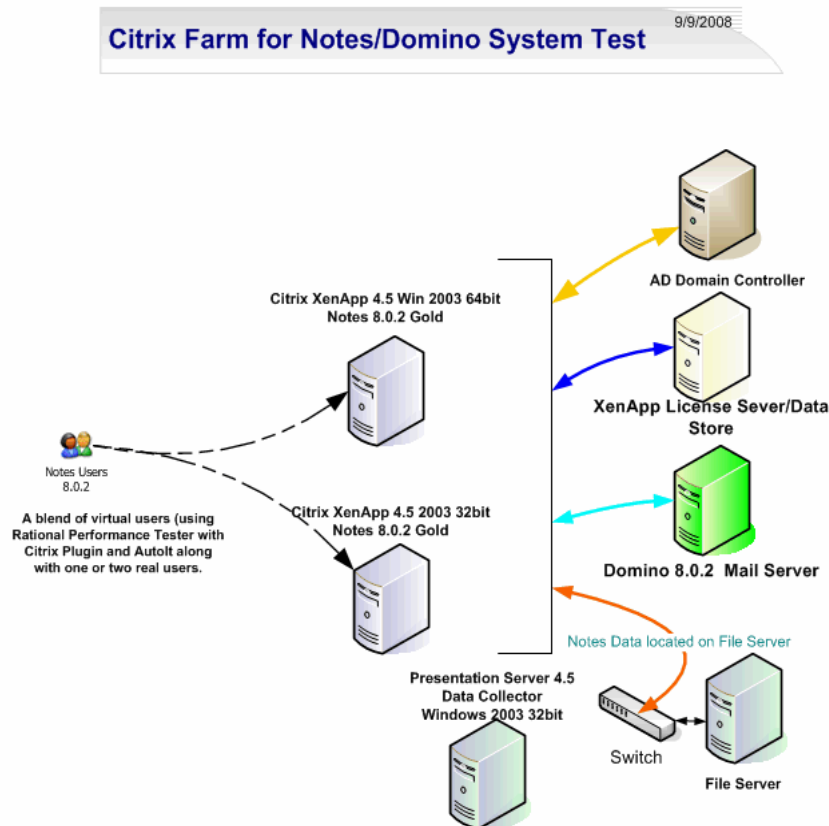
The testing was configured to ensure that a sufficient number of concurrent ICA sessions would be created to reach approximately 90% of the system's maximum threshold; that is, the point at which users could begin to notice a decrease in performance significant enough to potentially affect productivity.

To ensure functional validity in the testing, the test team performed logins and limited manual application execution to evaluate application response and usability. The number of concurrent ICA sessions was recorded by use of Microsoft's Performance Monitor, and the associated data was analyzed.

## 5.1 Test environment

This section describes the elements of the testing environment (see figure 1) used throughout the scalability analysis test cycle.

Figure 1. Test environment



As illustrated in the figure, the test environment between Citrix XenApp 4.5 and Lotus Notes consists of the following components:

**XenApp Server.** These servers run Citrix XenApp 4.5, allowing multi-user access to published resources. For the purpose of this test the desktop was published on the Citrix server, and each simulated user logged in and launched Lotus Notes. Four servers were used to host Citrix XenApp server, each with varying hardware configurations.

**XenApp License Server/Data Store.** This server is responsible for maintaining and providing concurrent user licenses to ICA sessions. It also serves as the data store that stores the static information for all Citrix XenApp servers in the farm.

**XenApp Data collector.** This server is responsible for polling other XenApp servers and gathering statistical data about how they are performing.

**File Server.** Hosts the Lotus Notes client data files for each user.

**AD Domain controller.** Responsible for user registrations and controlling rights.

**Domino 8.0.2 Mail Server.** Stores the user's mail files that were accessed via the Lotus Notes client.

## 5.2 Hardware specifications

Tables 3 and 4 provide detailed information for the hardware involved in this test environment.

**Table 3. Hardware specifications**

Facet	XenApp Server 32-bit	XenApp Server 32-bit	XenApp Server x64	XenApp Server x64
Hardware - System Type	IBM xSeries 346	IBM xSeries 346	IBM System x 3650	IBM System x 3550
Bios Version	1.17	1.17	1.05	1.11
Number of Processors	2 - Dual Core	2 - Dual Core	2 - Quad Core	2 - Quad Core
Processor Type/Speed	Xeon 3.4 GHz	Xeon 3.4 GHz	Xeon 3.0 GHz	Xeon 2.5 GHz
Memory (GB)	4 GB (/PAE enabled)	8 GB (/PAE enabled)	16 GB	32 GB
Disk Capacity	4 @ 73.4 GB	4 @ 73.4 GB	6 @ 146.8 GB	4 @ 73.4 GB
Disk Speed	15000 RPM	15000 RPM	15000 RPM	10000 RPM
RAID	5	5	5	0
Maximum NIC Speed/type	1 Gb/sec	1 Gb/sec	1 Gb/sec	1 Gb/sec
External Storage	N/A	N/A	N/A	N/A
Page file Size	6GB	12GB	24GB	32GB
Operating System	Windows Server 2003 Enterprise Edition SP2	Windows Server 2003 Enterprise Edition SP2	Windows Server 2003 Enterprise x64 Edition SP2	Windows Server 2003 Enterprise x64 Edition SP2

**Table 4. Hardware specifications, continued**

Facet	License Server	Data Store SQL Server	File Server	Domino Mail Server
Hardware - System Type	IBM Intellistation Z Pro	IBM xSeries 225	IBM xSeries 346	IBM xSeries 225
Bios Version	1.51C	1.28	1.17	1.26
Number of Processors	2	2 – Dual Core	2 – Dual Core	2
Processor Type/Speed	Xeon 2.4 GHz	Opteron 2.39 GHz	Xeon 3.4 GHz	Opteron 2.39 GHz
Memory (GB)	4 GB	4 GB	4 GB	4 GB
Disk Capacity	60 GB	2 @ 80 GB	5 @ 73.4 GB	2 @ 80 GB
Disk Speed	7200 RPM	7200 RPM	15000 RPM	7200 RPM
RAID	N/A	N/A	5	N/A
Maximum NIC Speed/type	1 Gb/sec	1 Gb/sec	1 Gb/sec	1 Gb/sec
External Storage	N/A	N/A	N/A	N/A
Page file Size	2 GB	2 GB	4 GB	2 GB
Operating System	Windows Server 2003 Enterprise Edition SP2	Windows Server 2003 Enterprise Edition SP2	Windows Server 2003 Enterprise Edition SP2	Windows Server 2003 Enterprise Edition SP2

### 5.3 Software specifications

Here we describe all the software necessary for the test environment.

#### 5.3.1 Windows Server 2003 environment

The servers in this test environment were built with Windows Server 2003 Enterprise Edition. We updated the servers used for this test using Microsoft Windows Update with the recommended Critical Updates and Service Packs installed. In addition, all Windows Server 2003 settings were configured with default options, with the exception of the Internet Explorer Enhanced Security Configuration option, which was disabled.

#### 5.3.2 Citrix XenApp server configuration

Four servers were installed with Citrix XenApp Server 4.5, two of which were installed with the 32-bit version, while two other servers were installed with the x64 version (see table 5). The four servers were designated to host published applications such as the 32-bit Lotus Notes client.

**Table 5. Software specifications**

Role	Software
Application Delivery Tool	XenApp 4.5 Enterprise Edition (32 bit and 64 bit)
Test Application	IBM Lotus Notes 8.0.2
Test Application Backend	IBM Lotus Domino 8.0.2
XenApp Operating System	Windows Server 2003 SP2, Enterprise Edition (32 bit and 64 bit)

XenApp Server 4.5 (see table 6) was installed with default options, with the exception of the CPU Utilization feature, which was enabled. This feature is designed to allocate CPU time fairly

across all users on the server, thereby normalizing the CPU usage of each user by smoothing out the usual CPU peaks that exist with most applications.

**Table 6. XenApp server settings**

Server Type	Operating System	Settings
XenApp on Physical 64-bit server	32-bit Windows 2003	2 x Dual-core 3.4 GHz, 4 GB RAM, 6-GB page file with Physical Address Extension (PAE) enabled
	32-bit Windows 2003	2 x Dual-core 3.4 GHz, 8 GB RAM, 12-GB page file with PAE enabled
	64-bit Windows 2003	2 x Quad-core 3.0 GHz, 16 GB RAM, 24-GB page file
	64-bit Windows 2003	2 x Quad-core 2.5 GHz, 32 GB RAM, 32-GB page file

It is important to note that one XenApp server was used to host applications during the scalability tests. Since there are four different platforms for this assessment, four different XenApp servers were used to publish applications to accommodate for testing each platform.

Infrastructure servers were designated as the License Server and the data store. The data store was configured by use of Microsoft SQL Server 2005 with direct connections from each XenApp Server.

## 6 Scalability results and analysis

Throughout the testing cycle, server performance activity was monitored and recorded via Microsoft's Performance Monitoring (PerfMon) utility.

### 6.1 Measurements

Table 7 lists the performance counters that were recorded during test execution.

**Table 7. Key counters**

Object	Counter
Logical Disk	% Disk Time, % Free Space
Memory	Available Bytes, Pages Input/Sec, Pages Output/Sec
Paging File	% Usage
Physical Disk	Current Disk Queue Length
Processor	% Interrupt Time, % Processor Time
System	Context Switches, Processor Queue Length
Terminal Services	Active Sessions
Application Responsiveness	User Experience

Collect counter using PerfMon, the log file should be saved as CSV on the local drive of the server under test. An interval of 4 seconds was used for sampling data.

While executing the script, both concurrency and rate control factors were enabled for a period of 3 hours. Over the period for which the load was defined, the rate at which users connected changed, from the start rate to the end rate.

As a result, the load started connecting users every 5 seconds, and over the course of 180 minutes this rate increased to 10 seconds, with the first 120 users loaded every 5 seconds and

then the remaining users loaded every 10 seconds. Depending on the environment (32- or 64-bit), the maximum concurrent users was defined differently.

During test execution, an administrator remained logged into the Citrix XenApp server. After several users logged onto the XenApp server, the session was used to obtain qualitative measurements of the server, including application responsiveness (see table 8) of Lotus Notes and screen refresh speed.

**Table 8. Application responsiveness definitions**

<b>Application Responsiveness</b>	
<b>Excellent to Acceptable</b>	Responsiveness is in the range of equivalent or better than local PC, and performance to screen updates are fluid with minimal effect on user's workflow.
<b>Poor</b>	Screen updates are noticeable and latency is increased; however, the user is still able to function.
<b>Failure</b>	The session becomes frozen or disconnected; therefore, the users cannot continue their tasks.

When analyzing the raw data, it may be beneficial to convert the PerfMon logs into comma-separated values for further processing in Microsoft Excel. (Refer to Appendix J for details on this.)

## **6.2 Scenario #1 Results: XenApp on a 32-bit Win2003 SP2 Enterprise Server with 4GB RAM**

**Qualitative performance analysis.** Qualitative usability thresholds are listed in table 9. For an explanation of the rating system, refer back to Section 3, Test methods.

**Table 9. 32-bit, 4-GB results**

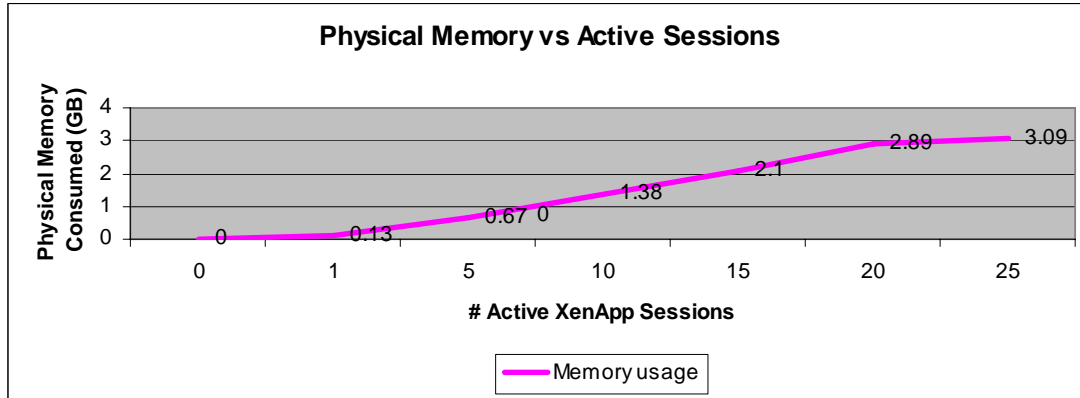
<b>32-bit XenApp Server: Windows 2003 SP3/ Intel Xeon CPU 3.4 GHz 4GB RAM / 2 Dual Core Processors Lotus Notes 8.0.2 Standard</b>							
<b>Total Sessions</b>	<b>Base-line</b>	<b>1 User</b>	<b>5 Users</b>	<b>10 Users</b>	<b>15 Users</b>	<b>20 Users</b>	<b>25 Users</b>
<b>CPU (%)</b>	2.0	2.13	6.36	10.81	14.89	17.49	27.21
<b>AvMemory (GB)</b>	3.33	3.20	2.66	1.95	1.23	0.44	0.24
<b>Page file in use (%)</b>	0.10	1.54	7.92	15.95	23.92	32.00	50.52
<b>User Experience*</b>	<b>G</b>	<b>G</b>	<b>G</b>	<b>G</b>	<b>G</b>	<b>G</b>	<b>G</b>

(\*where G = Good to acceptable; Y = Poor; R = Failure)

In the Lotus Notes client on Citrix XenApp 4.5 test for the above hardware, memory was determined to be the bottleneck when performing this scalability test. The amount of memory consumed on the Citrix XenApp Server was tracked throughout the testing cycle and is presented in figure 2. The memory consumed was just over 3 GB of the 4-GB system, leaving the rest for OS and other processes on the Windows 2003 server.

The graph depicts the amount of consumed memory for active sessions, in gigabytes. The amount of memory consumed by each additional active ICA session was consistent, resulting in a linear trend line.

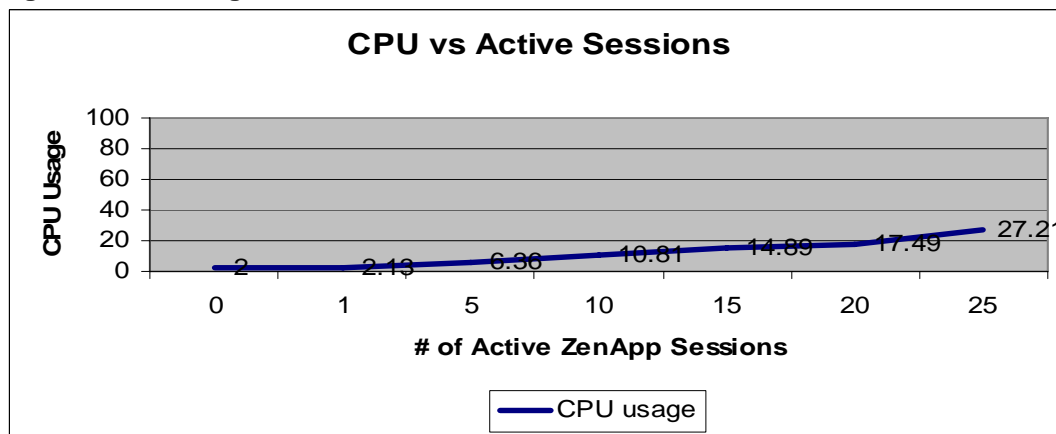
**Figure 2. Physical memory vs. active sessions**



End user performance began to degrade as memory consumption approached 100% and became unacceptable as it started to swap pages between RAM and physical disk more frequently. (The swapping of pages occurs whenever 100% of RAM is consumed and the server is seeking additional memory resources.)

As figure 3 shows, the amount of processor utilization increased steadily as user sessions increased on the Citrix XenApp server.

**Figure 3. CPU usage vs # of active sessions**



End user performance began to degrade as memory surpassed 100%. However, a buffer should be provided for any unexpected behavior that may result in a real-world environment, so the acceptable memory threshold was 80%–90%, which correlates to 23–25 users.

In some instances, bottlenecks in other server resources can cause an artificial increase in processor and memory utilization. In this case, the other performance counters were monitored and did not show signs of approaching a bottleneck.

Thus, memory utilization is the limiting factor here, and you should monitor end user performance as memory approaches 80%–90% utilization when running the Lotus Notes 8.0.2 Standard client on a Citrix XenApp server.

### 6.3 Scenario #2 Results: XenApp on a 32-bit Win2003 SP2 Enterprise Server with 8GB RAM / PAE enabled

**Qualitative performance analysis.** Qualitative usability thresholds are listed in figure 10. (Again, for an explanation of the rating system, refer back to Section 3, Test methods.)

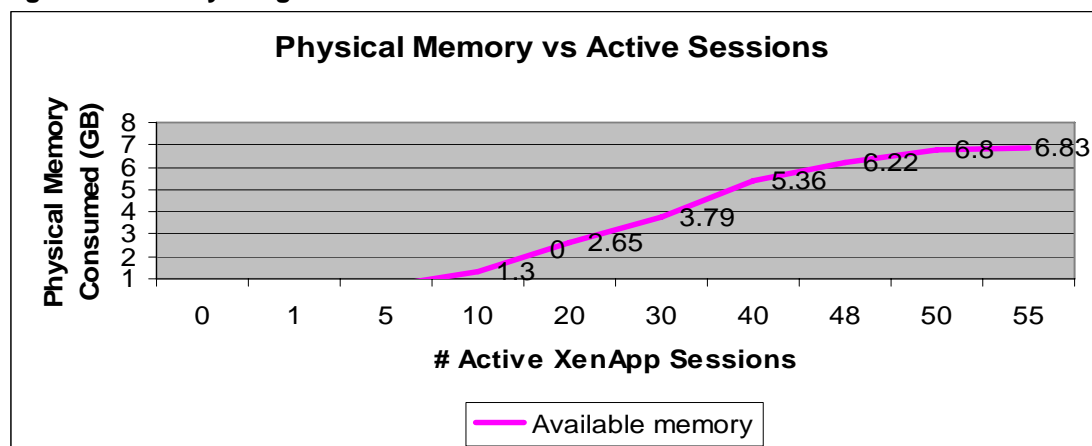
**Table 10. 32-bit, 8-GB results with PAE**

32-bit XenApp Server: Windows 2003 SP3/ Intel Xeon CPU 3.4 GHz 8GB RAM with /PAE 2 Dual Core Processors Lotus Notes 8.0.2 Standard										
Total Sessions	Base-line	1 User	5 Users	10 Users	20 Users	30 Users	40 Users	48 Users	50 Users	55 Users
CPU (%)	0.26	1.21	3.80	9.58	16.90	25.86	36.80	49.68	48.57	67.26
AvMemory (GB)	7.21	7.05	6.55	5.90	4.55	3.24	1.84	0.99	0.41	0.37
Page file in use (%)	0.33	0.99	3.88	7.17	15.27	23.06	30.75	42.35	38.63	47.68
User Experience*	G	G	G	G	G	G	G	G	Y	Y

(\*where G = Good to acceptable; Y = Poor; R = Failure)

In the Lotus Notes client-on-Citrix test for the above hardware, memory was determined to be the bottleneck when performing this scalability test. The amount of memory consumed on the Citrix XenApp server was tracked throughout the testing cycle and is presented in figure 4. In this test almost 7 GB of the 8 GB of available memory was consumed, leaving the rest for OS and other processes.

**Figure 4. Memory usage of 55 active Citrix sessions**

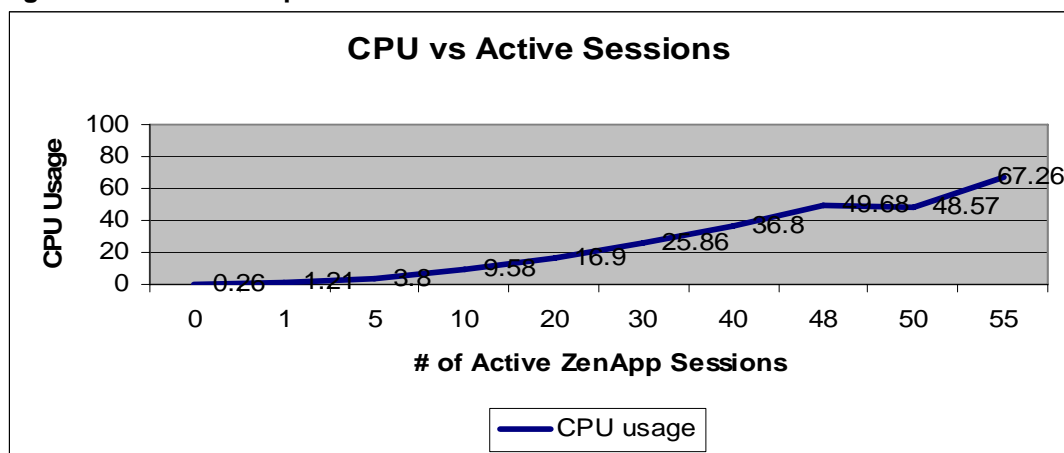


The graph in figure 4 depicts the amount of consumed memory for active sessions, in gigabytes. The amount of memory consumed by each additional active ICA session was consistent, resulting in a linear trend line.

End user performance began to degrade as memory consumption approached 100% and became unacceptable as it started to swap pages between RAM and physical disk more frequently. (The swapping of pages occurs whenever 100% of RAM is consumed and the server is seeking additional memory resources.)

Figure 5 depicts the CPU usage of the Citrix XenApp server when running the Lotus Notes 8.0.2 Standard client on the 2 Dual Core Processors with 8 GB RAM and PAE enabled on the server.

**Figure 5. CPU consumption of 55 active sessions**



As you can see, the amount of processor utilization increased steadily as user sessions increased on the Citrix XenApp server. End user performance began to degrade as memory surpassed 100%. However, a buffer should be provided for any unexpected behavior that may occur in a real-world environment, so the acceptable memory threshold was 80%–90%, which correlates to 49–50 users.

In some instances, bottlenecks in other server resources can cause an artificial increase in processor and memory usage. In this case, the other performance counters were monitored and did not show signs of approaching a bottleneck.

Thus, memory use is again the limiting factor, and you should monitor end user performance as memory approaches 80%–90% utilization when running the Lotus Notes 8.0.2 Standard client on a Citrix XenApp Server.

### **6.4 Scenario #3 Results: XenApp on a 64-bit Win2003 SP2 Enterprise Server with 16GB RAM / 2 dual core processors**

**Qualitative performance analysis.** Qualitative usability thresholds are shown in table 11.

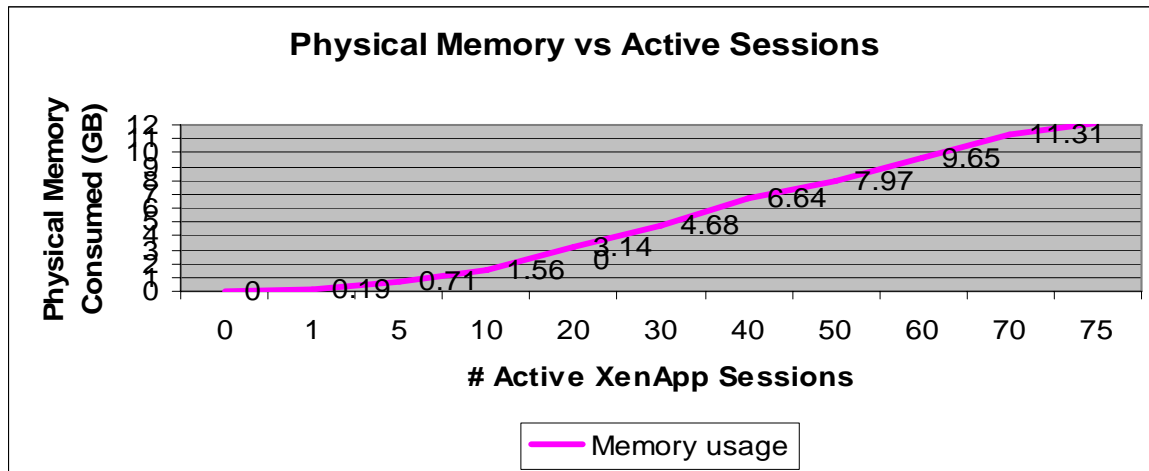
**Table 11. 64-bit, 16-GB results**

64bit XenApp Server: Windows 2003 SP3/ Intel Xeon CPU 3.4 GHz 16GB RAM / 2 Dual Core Processors Lotus Notes 8.0.2 Standard											
Total Sessions	Base-line	1 User	5 Users	10 Users	20 Users	30 Users	40 Users	50 Users	60 Users	70 Users	75 Users
CPU (%)	0.67	1.37	4.57	8.02	15.28	25.10	35.75	47.70	63.71	78.31	89.52
Memory (GB)	14.03	13.83	13.31	12.46	10.89	9.35	7.68	6.06	4.37	2.73	1.87
Page file in use (%)	0.06	0.45	2.30	4.64	9.32	13.98	18.65	23.36	28.02	32.71	35.10
User Experience*	G	G	G	G	G	G	G	G	G	Y	Y

(\*where G = Good to acceptable; Y = Poor; R = Failure)

The graph in figure 6 depicts the amount of consumed memory for active sessions, in gigabytes. The amount of memory consumed by each additional active ICA session was consistent, resulting in a linear trend line.

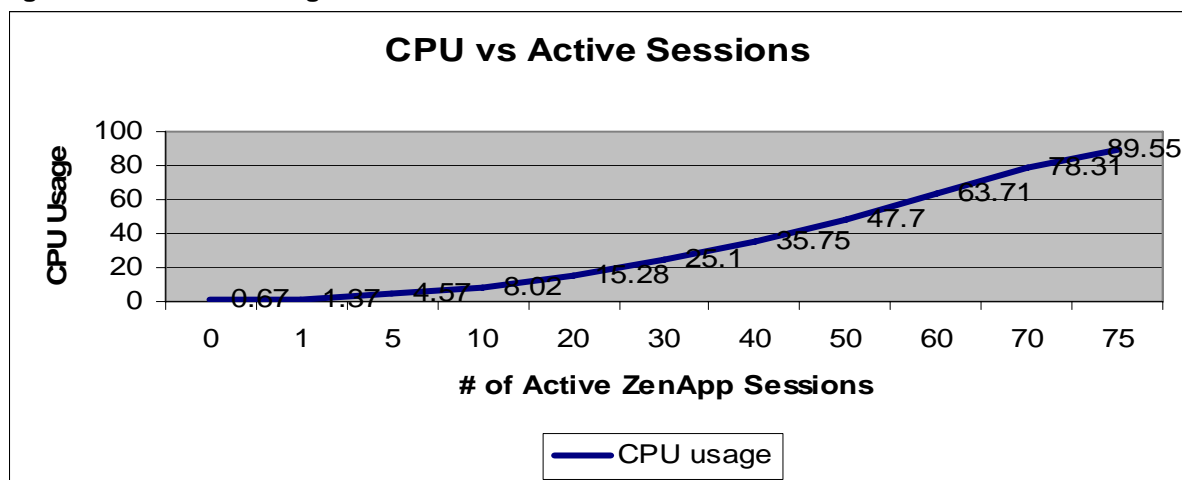
**Figure 6. 64-bit system's memory usage of 75 active sessions**



End user performance began to degrade as CPU consumption approached 100%. Memory on the box in this test was not all consumed before the CPU usage started to degrade users' performance. However, almost 12 GB of the 16 GB available in the system was consumed, leaving the rest for OS and other running processes, so the resulting limitation in this box is CPU.

The amount of processor utilization increased steadily as user sessions increased on the Citrix XenApp Server (see figure 7).

Figure 7. 64-bit CPU usage with 75 active sessions



End user performance began to degrade as memory surpassed 100%. However, a buffer should be provided for any unexpected behavior that may result in a real-world environment. Therefore, the acceptable memory threshold was 80%–90%, which correlates to 70–75 users.

In some instances, bottlenecks in other server resources can cause an artificial increase in processor and memory utilization. In this case, the other performance counters were monitored and did not show signs of approaching a bottleneck.

Therefore, memory utilization is the limiting factor here, and end user performance should be monitored as memory approaches 80%–90% utilization when running the Lotus Notes 8.0.2 Standard client on a Citrix XenApp Server.

### 6.5 Results Scenario #4: XenApp on a 64-bit Win2003 SP2 Enterprise Server with 32GB RAM / two quad core processors

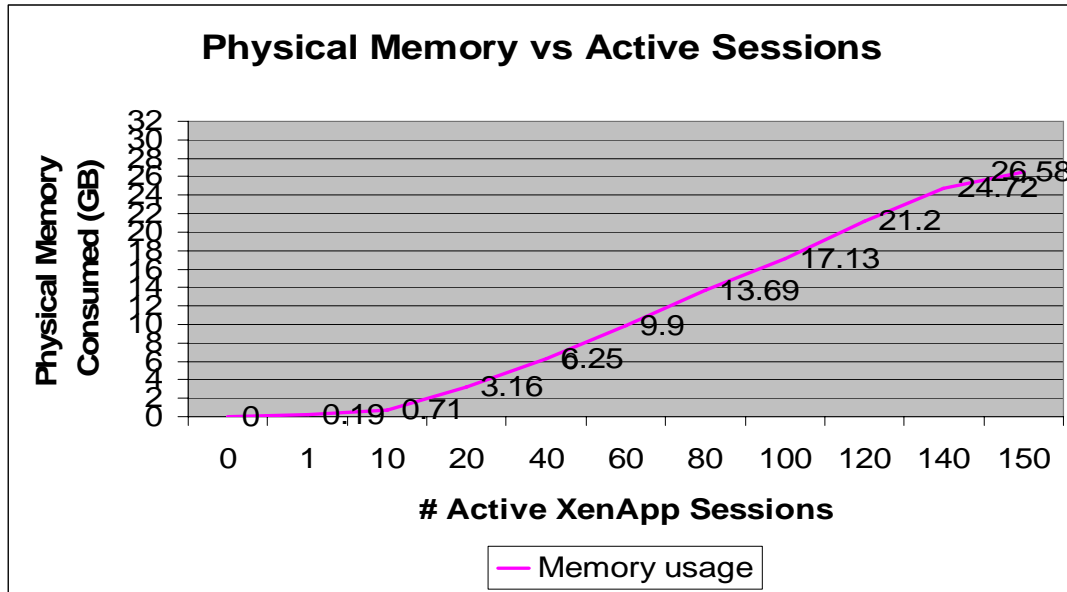
**Qualitative performance analysis.** Table 12 lists the qualitative usability thresholds for this scenario.

Table 12. 64-bit, 16-GB / two quad core processors results

64-bit XenApp Server: Windows 2003 SP3/ Intel Xeon CPU 3.4 GHz 32GB RAM / 2 Quad Core Processors Lotus Notes 8.0.2 Standard											
Total Sessions	Base-line	1 User	20 Users	40 Users	60 Users	80 Users	100 Users	120 Users	140 Users	150 Users	155 Users
CPU (%)	0.34	0.74	11.96	17.03	31.17	43.53	54.87	70.14	76.04	88.56	92.60
Memory (GB)	29.83	29.64	26.67	23.58	19.93	16.14	12.70	8.63	5.11	3.25	2.16
Page file in use (%)	0.05	0.39	6.90	13.20	23.35	30.21	37.06	44.07	51.0	54.53	57.21
User Experience	G	G	G	G	G	G	G	G	G	Y	Y

Figure 8 depicts the amount of consumed memory for active sessions, in gigabytes.

Figure 8. 64-bit, 32-GB system's memory usage with 150 active sessions

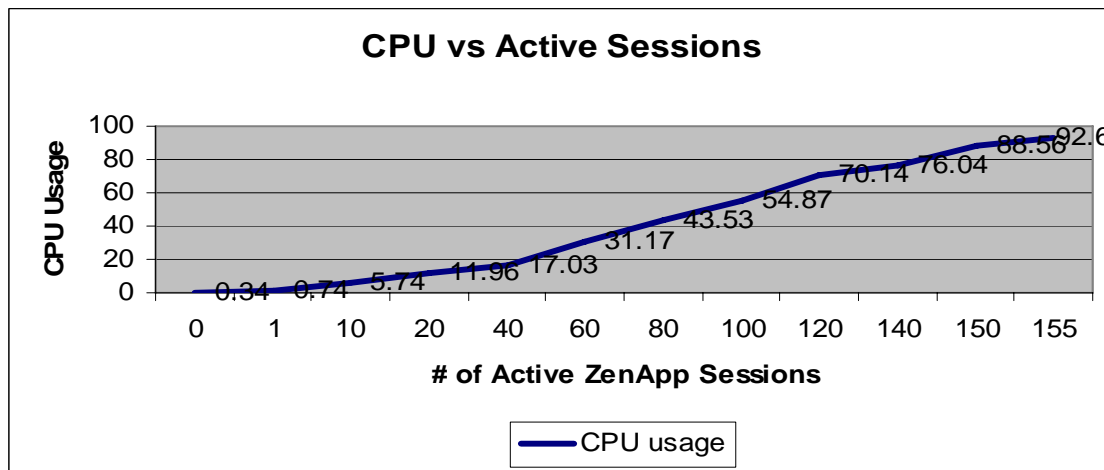


The amount of memory consumed by each additional active ICA session was consistent, resulting in a linear trend line. End user performance began to degrade as CPU consumption approached 100%. In this test, memory on the box was not all consumed before the CPU usage started to degrade users' performance, although almost 27 GB of the 32 GB was consumed.

The resulting limitation in this box was CPU, as the many users all fought for CPU time.

The amount of processor utilization increased steadily as user sessions increased on the Citrix XenApp Server (see figure 9).

Figure 9. 64-bit quad core system's CPU usage under 155 active sessions



End user performance began to degrade as memory surpassed 100%. However, a buffer should be provided for any unexpected behavior that may result in a real-world environment. Therefore, the acceptable memory threshold was 80%–90%, which correlates to 140–145 users.

In some instances, bottlenecks in other server resources can cause an artificial increase in processor and memory utilization. In this case, the other performance counters were monitored and did not show signs of approaching a bottleneck.

Therefore, memory utilization is the limiting factor, and end user performance should be monitored as memory approaches 80%–90% utilization when running the Lotus Notes 8.0.2 Standard client on a Citrix XenApp Server.

## 7 Conclusions

The analyses presented in this white paper yield the following key conclusions:

- Lotus Notes runs on the 32-bit version of XenApp with reasonable scalability levels with 4 GB of RAM, and by enabling /PAE and adding more RAM, you could scale your 32-bit systems even higher. Moreover, by enabling optimizations on both your XenApp servers and within your Lotus Notes client and the OS environment you can achieve even higher scalability numbers.
- Historically Lotus Notes client-on-Citrix customers have relied primarily on two-CPU, 4-GB RAM servers like we used in our first test. However, with the additional performance available from today's CPUs, this still leaves CPUs underutilized with Lotus Notes. As expected in a 32-bit OS environment, memory was determined to be the bottleneck with regard to both the Lotus Notes Standard and Lotus Notes Basic clients.

To increase scalability, one option is to leverage the Windows Server 2003 Physical Address Extension (PAE) configuration. This allows x32 servers to partially overcome the 4-GB RAM limitation at the cost of some CPU overhead. In our second test, approximately \$500 worth of additional RAM coupled with the /PAE configuration nearly doubled scalability, with 55 concurrent users reached.

Memory remained the bottleneck, but XenApp Server was still able to cater to more users than before. Given the power of today's multi-core CPUs, the overhead generated by the PAE switch is inconsequential when compared to the performance gains for the Lotus Notes client.

- During our testing, as more processor and memory capacity was added, we saw near-linear scalability for the Lotus Notes client in terms of capacity. We therefore anticipate that, for large implementations, there is potential value in using the System x 3550 hardware and growing it to even more CPUs and memory.
- Given that Lotus Notes' use of a 64-bit OS combined with XenApp 64-bit achieves higher scalability compared to 32-bit implementations, it was no surprise that CPU becomes the main bottleneck in 64-bit environments.

Running the Lotus Notes client in Windows 2003 x64 with XenApp x64 is a supported configuration in Lotus Notes versions 8.0.2 and later, and a well tuned x64 XenApp server is capable of hosting 140 users with good response times—a significant improvement over what we've seen with the 4-GB x32 XenApp server.

- Note that XenApp Server x64 can be deployed in the same server farm with existing 32-bit versions of XenApp Server, creating a smooth migration path and helping your IT group consolidate servers to reduce costs.

In summary, the Lotus Notes versions 8.0.2 and later Standard client provide the ability to scale better than before, and the introduction of x64 support in Citrix XenApp means that for a few extra dollars you can avoid buying new hardware when upgrading to versions 8.0.2 and later.

## Appendix A: Summary of Lotus Notes *Basic* 8.0.2 Client scalability results

**Table 1. XenApp Server settings**

Server Type	Operating System	Settings
XenApp on Physical 64-bit server	32-bit Windows 2003	2 x Dual-core 3.4 GHz, 4 GB RAM, 6GB page file with Physical Address Extension (PAE) enabled
	32-bit Windows 2003	2 x Dual-core 3.4 GHz, 8 GB RAM, 12GB page file with Physical Address Extension (PAE) enabled
	64-bit Windows 2003	2 x Dual-core 3.0 GHz, 16 GB RAM, 24GB page file
	64-bit Windows 2003	2 x Quad-core 2.5 GHz, 32 GB RAM, 32GB page file

Table 2 summarizes the results of the scalability tests based on the defined threshold for each hardware configuration that was tested during this assessment.

**Table 2. Scalability results**

Test Platform	Lotus Notes Basic Client ( 8.0.2 )			Lotus Notes Basic Client ( 8.0.1 )	
	Acceptable Active Sessions Range	Max Sessions	Limiting Factor	Max Sessions	Limiting Factor
Windows 2003 32-bit 2 Dual Core Processors 4GB RAM	35 – 40	45	Memory	45	Memory
Windows 2003 32-bit 2 Dual Core Processors 8GB RAM PAE enabled	70 – 80	85	Memory/ CPU	Not measured	N/A
Windows 2003 64-bit 2 Dual Core Processors 16GB RAM	90 – 100	105	CPU Memory	N/A	N/A
Windows 2003 64-bit 2 Quad Core Processors 32GB RAM	190 – 200	225	CPU	N/A	N/A

# Scenario #1 Results: XenApp running on a 32-bit Win2003 SP2 Enterprise Server with 4GB RAM

**Qualitative performance analysis.** Qualitative usability thresholds are listed in table 3 below. (For an explanation of the rating system, refer to Section 3, Test Methods.)

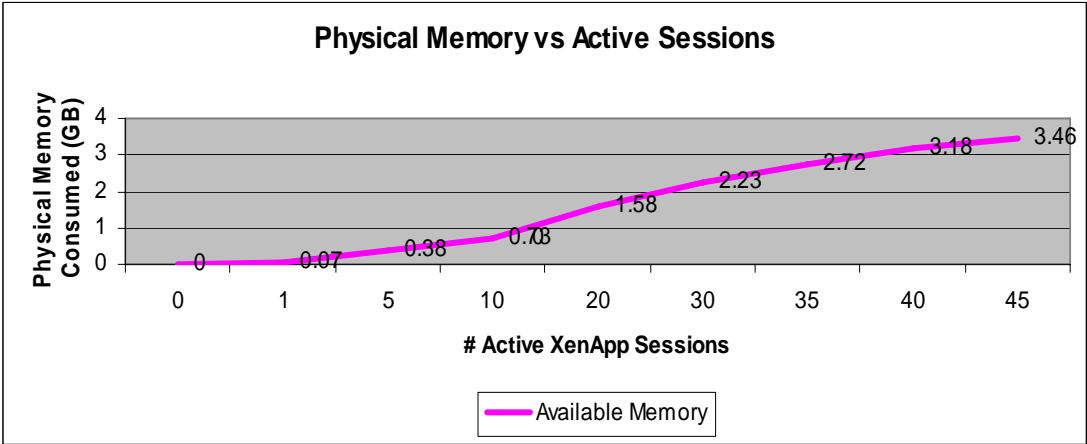
**Table 3. 32-bit, 4-GB Basic Client results**

Total Sessions	Baseline	1 user	5 users	10 users	15 users	20 users	25 users	35 users	45 users
CPU (%)	2.0	2.43	4.41	7.36	14.89	15.89	27.21	35.34	44.56
Available Memory (GB)	3.31	3.24	2.93	2.58	1.23	1.73	0.24	0.59	0.14
Page file in use (%)	0.16	0.58	2.29	4.47	6.24	8.78	11.52	17.41	19.95
User Experience*	G	G	G	G	G	G	G	G	R

(\*where G = Good to acceptable; Y = Poor; R = Failure)

In the Lotus Notes client-on-Citrix XenApp 4.5 test for the above hardware, memory was determined to be the bottleneck when performing this scalability test. The amount of memory consumed on the Citrix XenApp Server was tracked throughout the testing cycle and is presented in figure 1. The memory consumed was just over 3 GB of the 4-GB system, leaving the rest for OS and other processes on the Windows 2003 server.

**Figure 1. Available memory with 45 Active users**



**Scenario #2 Results: XenApp running on a 32-bit Win2003 SP2 Enterprise Server with 8 GB RAM /PAE enabled**

**Qualitative performance analysis.** Qualitative usability thresholds are listed in table 4. (For an explanation of the rating system, refer to Section 3, Test methods.)

**Table 4. 32-bit, 8-GB Results with PAE**

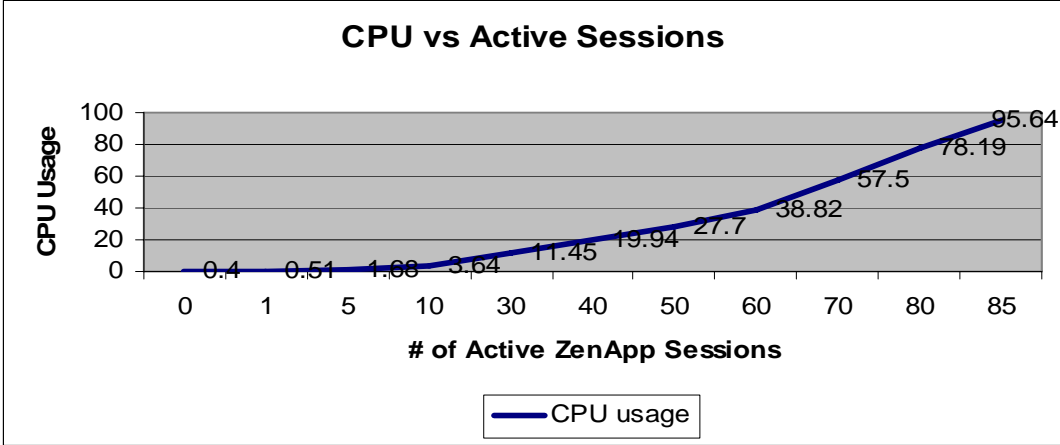
<b>32bit XenApp Server: Windows 2003 SP3/ Intel Xeon CPU 3.4 GHz 8GB RAM / PAE enabled Lotus Notes 8.0.2 Basic</b>											
<b>Total Sessions (Users)</b>	<b>Base-line</b>	<b>1</b>	<b>5</b>	<b>10</b>	<b>30</b>	<b>40</b>	<b>50</b>	<b>60</b>	<b>70</b>	<b>80</b>	<b>85</b>
<b>CPU (%)</b>	0.40	0.51	1.68	3.64	11.45	19.94	27.70	38.82	57.50	78.19	95.64
<b>AvMemory (GB)</b>	7.31	7.23	6.99	6.69	5.51	4.90	4.26	3.60	2.90	2.21	1.85
<b>Page file in use (%)</b>	0.11	0.27	1.22	2.26	6.63	10.00	12.14	15.29	17.71	19.39	21.30
<b>User Experience*</b>	G	G	G	G	G	G	G	G	G	G	Y

(\*where G = Good to acceptable; Y = Poor; R = Failure)

In the Lotus Notes client-on-Citrix test for the above hardware, CPU was determined to be the bottleneck when performing this scalability test. The amount of memory consumed on the Citrix XenApp Server was tracked throughout the testing cycle, and in this test almost 7 GB of the 8 GB available memory was consumed, leaving the rest for OS and other processes.

However, it was CPU that degraded users' performance before memory (see figure 2).

**Figure 2. CPU usage with 85 Active sessions**



### Scenario #3 Results: XenApp running on a 64-bit Win2k3 SP2 Enterprise Server with 16GB RAM / 2 Dual Core Processors

Qualitative performance analysis. Qualitative usability thresholds are listed in table 5.

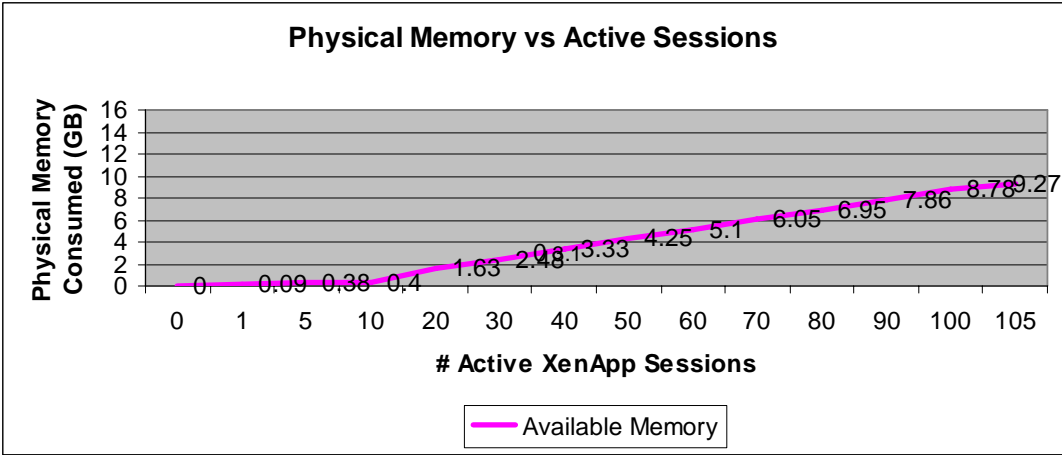
Table 5. 64-bit, 16-GB Results

64bit XenApp Server: Windows 2003 SP3/ Intel Xeon CPU 3.4 GHz 16GB RAM / 2 Dual Core Processors Notes 8.0.2 Basic											
Total Sessions	Base-line	1 User	5 Users	10 Users	20 Users	40 Users	60 Users	80 Users	90 Users	100 Users	105 Users
CPU (%)	0.70	1.04	2.49	3.96	7.13	13.77	23.50	48.45	70.82	87.40	90.75
Memory (GB)	14.03	13.93	13.63	13.23	12.39	10.69	8.92	7.03	6.16	5.25	4.76
Page file in use (%)	0.18	0.32	1.11	2.10	3.84	7.36	10.92	16.31	18.01	19.65	20.54
User Experience*	G	G	G	G	G	G	G	G	G	Y	Y

(\*where G = Good to acceptable; Y = Poor; R = Failure)

The graph in figure 3 below depicts the amount of consumed memory for active sessions, in gigabytes. The amount of memory consumed by each additional active ICA session was consistent, resulting in a linear trend line.

Figure 3. 64-bit system’s memory usage of 105 active sessions



End user performance began to degrade as CPU consumption approached 100%. Memory on the box in this test was not all consumed before the CPU usage started to degrade users’ performance; however, almost 10 GB of the 16 GB available in the system was consumed, leaving the rest for OS and other running processes.

Thus the resulting limitation in this box was CPU.

# Scenario #4 Results: XenApp running on a 64-bit Win2003 SP2 Enterprise Server with 32GB RAM / 2 Quad Core Processors

**Qualitative performance analysis.** Qualitative usability thresholds are listed in table 6. (For an explanation of the rating system, refer to Section 3, Test methods.)

**Table 6. 64-bit, 16-GB / 2 Quad Core Processors Results**

64bit XenApp Server: Windows 2003 SP3/ Intel Xeon CPU 3.4 GHz 32GB RAM / 2 Quad Core Processors Lotus Notes 8.0.2 Basic											
Total Sessions	Base-line	1 User	30 Users	60 Users	90 Users	120 Users	150 Users	180 Users	210 Users	220 Users	225 Users
CPU (%)	0.18	0.38	5.53	10.82	18.54	26.21	35.25	60.20	81.13	88.70	89.75
Memory (GB)	29.96	29.82	27.16	24.25	21.13	18.22	15.28	12.21	9.24	8.17	7.63
Page file in use (%)	0.04	0.17	3.83	7.55	11.36	15.12	20.08	27.62	31.07	32.21	32.75
User Experience*	G	G	G	G	G	G	G	G	G	Y	Y

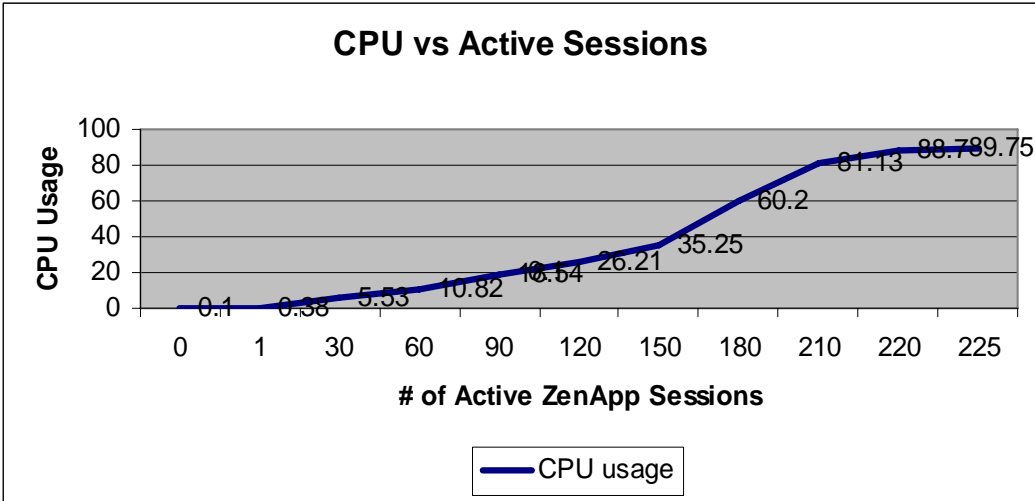
(\*where G = Good to acceptable; Y = Poor; R = Failure)

**Results and analysis.** End user performance began to degrade as CPU surpassed 100%. However, a buffer should be provided for any unexpected behavior that may result in a real-world environment. Therefore, the acceptable CPU threshold was 80%–90%, which correlates to 210–225 users.

In some instances, bottlenecks in other server resources can cause an artificial increase in processor and memory utilization. In this case, the other performance counters were monitored and did not show signs of approaching a bottleneck.

Therefore, memory CPU utilization is the limiting factor here when running the Notes 8.0.2 Basic client on a XenApp Server.

**Figure 4. 64-bit, 32-GB system’s CPU usage with 225 active sessions**



## Appendix B: Windows Server 2003 and XenApp Server optimizations

In preparation for our analysis, Citrix Consulting Solutions applied a standard set of server tuning to improve performance for Citrix XenApp operating in a terminal services environment on Windows Server 2003. These adjustments can help avoid commonly seen issues, such as frequent session disconnects or sluggish servers, and can increase user load. Modifications to the operating system focused on optimizing the following:

- kernel memory
- hard disk and file system
- file sharing
- network
- operating system

For 32-bit operating systems, kernel memory depletion is one of the top limiting factors that affect server load. Kernel memory improvements made to both the physical and virtual XenApp servers include ensuring sufficient resources are allocated to the following four areas, which are interdependent:

- paged pool
- non-paged pool
- system page table entry (PTE)
- the system cache

The optimum values for these kernel memory areas were verified on the 64-bit servers as well. Additional details can be seen in table 1 below.

Tuning for the hard disk was performed both within the operating system and on the RAID controller on the hardware. Within Windows Server 2003 device manager, write caching was enabled where applicable, and advanced performance was also selected. Registry changes were made to avoid known terminal services issues. These and other details are outlined in table 1.

In Windows Server 2003, file sharing in a terminal services environment, to access resources such as user profiles, is dependent on legacy protocols and can also be tuned to operate much more reliably for users and between servers and file shares. Improvements that were made to the environment included those that allow for additional file sharing requests per session, reduced network traffic and improved network utilization. These adjustments to the registry on the XenApp servers are also detailed in table 1.

You can further improve the XenApp user experience by tuning various built-in operating system services and components in Windows Server 2003. Adjustments such as the following were made to graphics and user inputs:

- cursor and menu item displays
- Windows visual effects adjustments
- automatic warning messages
- auto-end-task or other notifications

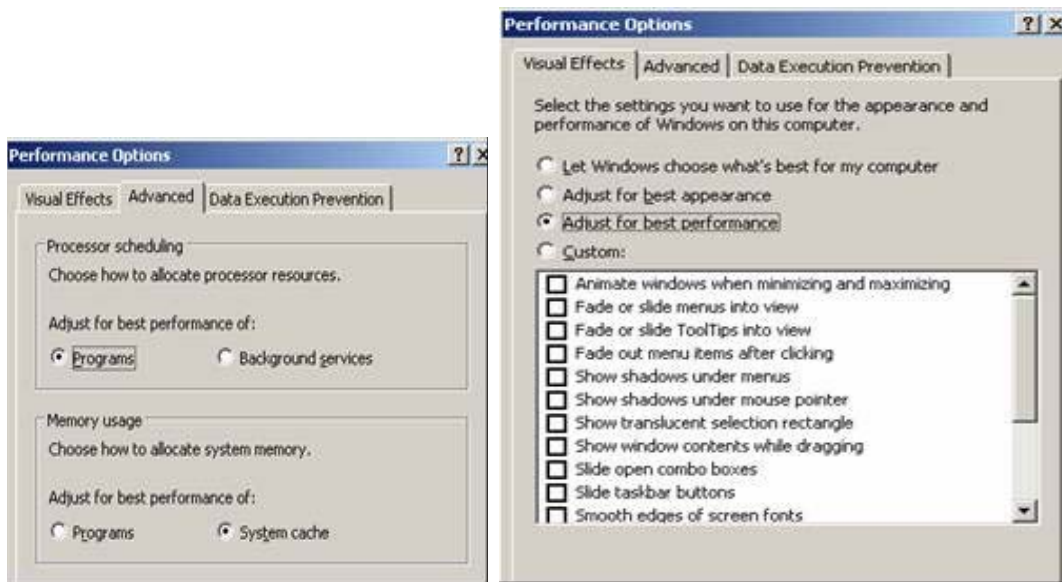
In addition, lower-level operating system services were modified to improve operating system performance with a high user load, such as disk paging and file system notify events (see table 1).

**Table 1. XenApp Server optimizations**

Optimization Name	Category	Applicable Servers	Description
<b>System Cache</b>	Kernel Memory	All	Verified system cache is enabled in performance options
<b>Non-paged Pool</b>	Kernel Memory	All	Verified that the paged pool allocation is allocated automatically
<b>Page Pool allocation</b>	Kernel Memory	x32	Increased to maximum for 32-bit systems
<b>System PTE</b>	Kernel Memory	x32	Increased Page Table Entries
<b>Page File</b>	Kernel Memory	All	Page file size increased to size of RAM, which is 8 GB for x32 servers and 16 GB for x64 servers
<b>Write Cache</b>	Hard Disk & File System	All	Write caching improves hard disk read/write times
<b>Lazy Flush Interval</b>	Hard Disk & File System	All	Improves reliability for terminal services sessions
<b>SMB Requests</b>	File Sharing & Network	All	Max open files and file requests are optimized for this file sharing protocol
<b>Packet Resubmit</b>	Network	All	Optimizes the number of times that lost packets are resubmitted
<b>System Messages</b>	Operating System	All	System error messages are reduced and not reliant on user input
<b>NTFS Updates</b>	Operating System, File System	All	Disables file system updates to the operating system to improve performance
<b>Visual Effects</b>	Operating System	All	Changes Windows graphics settings to best performance
<b>Executing Paging</b>	Operating System	All	Decreases amount of paging to disk for drivers and other system components
<b>Auto End Tasks</b>	Operating System	All	Automatically ends non-responsive applications
<b>Menu Delays</b>	Operating System	All	Increases response time for mouse-overs and menu items
<b>Cursor Blink Rate</b>	Operating System	All	Cursor blink rate reduced in half to decrease devoted resources

**Performance settings.** We configured advanced Performance Options such as “Programs for Processor scheduling” and “System cache for Memory usage”, along with configuring Visual Affects to “Adjust for best performance” (see figure 1).

Figure 1. Performance Options configurations



## Appendix C: Environment optimizations

By implementing the settings in table 1 we were able to scale higher during scalability testing.

**Table 1. Citrix XenApp and Lotus Notes Anti-virus optimized settings**

Optimization Name	Category	Applicable Servers	Setting
AV setting	AV	All	Scan on write events only
AV setting	AV	All	Scan on local drives only
AV setting	AV	All	Exclude the system page file from being scanned
AV setting	AV	All	Exclude Print spooler from being scanned
AV setting	AV	All	Exclude the \Program Files\Citrix folder from being scanned (the heavily accessed local host cache and Resource Manager local database are contained inside this folder)
AV setting	AV	All	If ICA pass-through connections are used, exclude the user's XenApp Server Client bitmap cache and the XenApp Server Client folders
AV setting	AV	All	If users are connecting to a published desktop, Citrix recommends removing the antivirus-related calls from the HKEY_LOCAL_MACHINE\Software\Microsoft\Windows\Current Version\Run registry key to improve performance
AV setting	AV	All	Exclude files with extension from scanning: <ol style="list-style-type: none"> <li>1. *.ndk</li> <li>2. *.ini</li> <li>3. *.nsf</li> <li>4. *.ntf</li> </ol>
AV setting	AV	All	The service which polls for AV definition file should be tuned. It should not start polling for updates, instead it should be scheduled
System Setting	SY	All	Page file was set to 1.5 times installed RAM
System Setting	SY	All	PAE for Citrox/32 enabled in the boot.ini for 32bit systems
System Setting	SY	All	Disable the WindowsSearch process from running
System Setting	SY	All	Uninstall SearchIndexer from the XenApp Server

## Appendix D: Physical Address Extension (/PAE)

The /PAE switch in the Boot.ini file can be enabled to allow the 32-bit operating system to address more physical memory (RAM) on the server. This switch lets Windows Server 2003 take advantage of the PAE of x86 processors.

PAE is an Intel-provided memory address extension that enables processors to expand the number of bits that can be used to address RAM from 32 bits to 36 bits, through support in the host operating system for applications using the Address Windowing Extensions (AWE) API. PAE maps up to 64 GB of physical memory into a 32-bit (4 GB) virtual address space for applications running on most 32-bit (IA-32) Intel Pentium Pro and later platforms.

Using the /PAE switch can be beneficial in situations where servers are not kernel memory-bound and the published applications use large amounts of memory. The additional memory enabled with the /PAE switch is allocated to the user space while the kernel memory is still limited to 2 GB. However, there is also a small kernel memory cost because the operating system needs to track this additional memory in the form of Page Table Entries (PTEs).

For additional information on /PAE refer to:

<http://www.microsoft.com/whdc/system/platform/server/PAE/PAEdrv.msp>

## Appendix E: Lotus Notes optimization

When running your Lotus Notes Standard client in a XenApp environment, it is recommended to enable the following optimization:

- The Lotus Notes Sharedclass cache for Citrix XenApp running Lotus Notes 8.0.2.

The Lotus Notes Sharedclass cache for Citrix allows the multiple Lotus Notes users on a Citrix server to share some of the Java™ classes, ensuring that each Lotus Notes instance does not load its own copy of the class files. This in turn allows you to reduce memory usage for each Lotus Notes user.

To enable this setting, complete the following steps:

1. Find the *jvm.properties* file in the following directory:

In Windows:

```
<install_dir>\framework\rcp\eclipse\plugins\com.ibm.rcp.j2se.win32.x86_1.6.0.20080416-200806200100
```

2. Find the following string and remove the singleJVM item:

```
vmarg.Dshare=  
-Xshareclasses:name=xpdplat,controlDir=${prop.jvm.shareclasses.loc},groupAccess,keep,  
<singleJVM>,nonfatal
```

3. Find and change the following line from:

```
jvm.shareclasses.loc=${env.TEMP}/xpdplat
```

to:

```
jvm.shareclasses.loc=c:/temp/xpdplat
```

4. Add the following to the file:

```
vmarg.Xnolinenumbers=-Xnolinenumbers
```

5. Save the file.

## Appendix F: Workflows

The following actions were coded in AutoIT, and all virtual users performed these same actions

### Begin Script

Launch Lotus Notes  
Log in to Lotus Notes

Open Mail  
Change view to Inbox  
Create a new email:  
- Enter 2 random names in To field  
- Enter subject text  
- Enter message text  
- add an attachment  
- Send

Refresh view  
Change view to Sent  
Forward the first email in the view:  
- Enter 2 random names in To field  
- Enter subject text  
- Enter message text  
- add an attachment of variant sizes  
- Send

Change view to All Documents  
Refresh  
Delete the first email in the view  
Change view to Trash  
Empty Trash  
Close Mail

Open Calendar  
Create a new Calendar Entry:  
- Disable Alarm notifications  
- Enter subject text  
- Change time to 15mins  
- Open Select Addresses dialog  
- Enter Random name  
- Enter location name  
- add an attachment of variant sizes  
- Send

Change view to One Day  
Change view to Two Days  
Change view to One Week  
Change view to One Work Week  
Change view to Two Weeks  
Change view to Two Work Weeks  
Change view to One Month  
Change view to One Work Month  
Close Calendar

Loop for variable time x

### End Script

## Appendix G: Test Environment preparations

Test user provisioning involved the following:

- Microsoft Active Directory 5.2 was installed on a Windows 2003 Server in the same domain as the Citrix servers and populated with virtual users from a batch file via the “dsadd user” command.
- Each added user corresponded to a Lotus Domino virtual user with a mail file already registered on the Domino server.
- A group was created on the Active Directory containing all users, and this was added to the Remote Desktop Users group locally on each Citrix server.
- The published application on each Citrix server was then set to contain the Remote Desktop Users group local to that machine.
- Another Windows 2003 Server with 4 GB RAM was set up as a File Server, and PAE was enabled on this machine. Because this machine was to act as the repository for the Lotus Notes Data directory for all users, a large amount of disk space was essential.
- We initialized all users by creating a script that logged in via an ICA client, launched the Lotus Notes client, and walked through the steps to configure that user, such as pointing the user to the Domino server on which the user’s mail file resides and setting a common Home Page for all users.
- Once all users were set to launch their Lotus Notes clients in a common state, the test was ready to begin.

## Appendix H: Lotus Notes install

Here are the general steps for installing a Lotus Notes 8 Standard or Basic client on a Citrix XenApp server (from Technote #1265898, "Steps for installing Lotus Notes 8 on a Citrix Presentation server"):

1. Install the Lotus Notes client:
  - a. Log on to the Citrix server (directly, not remotely) as Administrator.
  - b. From the Microsoft Windows Control Panel, select "Add/Remove Programs." Click Add New Programs, and select the Lotus Notes client CD-ROM.
  - c. During the installation, select the Single User Install. Set the Lotus Notes Directory to C:\Program Files\IBM\Lotus\Notes and the data directory to c:\r8clienttemplate, where "c:" represents a directory on the local Citrix machine.
  - d. If you are prompted to set Lotus Notes as your default Mail Program, select Yes.

NOTE: To store templates in only one location, and not in each user's data directory, refer to the "Additional steps to configure a Shared template directory" section at the end of this appendix.

2. Move and modify the Notes.ini file:
  - a. The Notes.ini file is located in the default Windows directory (for example, c:\WINDOWS). Manually move this file from the Windows directory to the c:\r8clienttemplate directory. (Once you complete the initial installation process, each user that logs on to the Citrix server receives a copy of this notes.ini file.)
  - b. After moving the file, modify it with Notepad to include the following lines:

```
[Notes]
KitType=1
InstallType=2
InstallMode=1
Directory=w:\notes\data
SPELL_DIR=w:\notes\data
SUDIALOG_ON=0
DEBUG_GLOBAL_NAMESPACE_DISABLE=1
```

where "w:\" represents the standard user's home drive assignment. (***Additional steps to configure a Shared template directory***) will require a different Directory= path)

NOTE: **DEBUG\_GLOBAL\_NAMESPACE\_DISABLE=1** resolves the issue reported in IBM Support Technote #1295156, "Two users cannot launch Lotus Notes 8.0 on a Citrix server." The issue is fixed in the Lotus Notes 8.0.3/8.5 codestreams.

Also, add to this file any additional Notes.ini parameters that you want to distribute to all users.

3. Set security permissions on the c:\r8clienttemplate directory to allow all users Read access to this directory. This permission allows users to copy the files and folders from this directory to their individual home directory:
  - a. Right-click the folder and select Security.

b. Add or change the "Everyone" group to have Reader access.

4. Configure Log-on Scripts for the users:

**NOTE:** The changes made in this step will apply to all users because these log-on scripts are run for each user that logs on to the Citrix server. The virtual drive letter that maps to the user's home profile directory (C:\Documents and Settings\

Any Lotus Notes client issues that arise from mapping the virtual drive letter to a directory on a remote file server, instead of to a directory on the local Citrix server, are not supported by IBM Lotus Technical Support. Refer to Technote #1086958, "Is running Client Notes.ini and/or Notes Data directory on a File Server a supported configuration?," for more information on using remote data directories.

**Script A**

- a. Using Notepad, edit or create the file %systemroot%\Application Compatibility Scripts\RootDrv2.cmd
- b. Add the following line, where W is the standard user's home drive assignment:

Set RootDrive=W:

- c. Save and close the file.

**Script B**

- a. Using Notepad, edit or create the file %systemroot%\system32\usrlogn2.cmd
- b. Add the following lines, where w is the standard user's home drive assignment:

if not exist w:\notes md w:\notes  
if not exist w:\notes\data md w:\notes\data  
if not exist w:\notes\data\notes.ini xcopy /s c:\r8clienttemplate\\*. \* w:\notes\data

5. Next, modify the Lotus Notes Desktop icon to point to the user's home directory:

- a. Right-click the icon and select Properties.
- b. Edit the target field to include the following line, where w is the user's home drive assignment:

If using Lotus Notes 8.0.x (Eclipse based build):

"C:\Program Files\IBM\Lotus\notes\notes.exe" =w:\notes\data\notes.ini

If using Basic Client Configuration:

"C:\Program Files\IBM\Lotus\notes\notes.exe" -sa =w:\notes\data\notes.ini

Note that the -sa switch launches the Lotus Notes 8 (Basic Configuration) client.

6. Finally, at this point you should log off as the Administrator, log on to the Citrix server with a user account, and then launch the Lotus Notes client using the Desktop icon.

**Additional steps to configure a Shared template directory:** [<A NAME="steps"/>]

Create a directory called "sharedNotesData" in which you would like the common shared data to reside:

1. In addition to adding the Directory line to the Notes.ini as described above in Step 2(b), add the following entry:

```
SharedDataDirectory=C:\sharedNotesData
```

The above path is given as an example; you may instead choose to place the sharedNotesData directory in another location. If you do so, you will need adjust the path accordingly.

2. From the Data directory that was created in the \r8clienttemplate directory, cut and paste the following directories and files into the new "sharedNotesData" directory:

```
Help Directory
Modems Directory
W32 Directory
alog4.ntf
archlg50.ntf
autosave.ntf
bookmark.ntf
busytime.ntf
cache.ntf
canadien.dic
dblib4.ntf
doclbm7.ntf
doclbs7.ntf
doclbw7.ntf
headline.ntf
imapcl5.ntf
journal6.ntf
log.ntf
mail8.ntf
mailbox.ntf
nntpcl6.ntf
pernames.ntf
perweb50.ntf
phonebook7.ntf
uk.dic
us.dic
us.med
```

Continue with the remaining steps of the technote, starting with Step 2, "Move and modify the Notes.ini file."

## Appendix I: Performance objects and counters

Table 1 details the counters used to monitor Citrix XenApp Servers during the scalability testing effort.

**Table 1. Counters and their descriptions**

Counter	Description
<b>LogicalDisk:</b> % Disk Time	The average number of read and write requests that were queued for all logical disks. Sustained value of 2--3 or greater indicates disk speed may become a bottleneck, and typically increases processor activity. If hard disk performance becomes a bottleneck, a hardware disk controller that includes both read and write cache can improve disk performance.
<b>LogicalDisk:</b> % Free Space (%)	Free Space is the percentage of total usable space on the selected logical disk drive that was free
<b>Memory:</b> Available Bytes	Amount of physical memory available to processes, measured in megabytes. Paging should be monitored if less than 25% of physical memory is available, as excessive paging may occur.
<b>Memory:</b> Pages Input/sec	The rate at which pages are read from disk to resolve hard page faults. Hard page faults occur when a process refers to a page in virtual memory that is not in its working set, or elsewhere in physical memory, and must be retrieved from disk. When a page is faulted, the system tries to read multiple contiguous pages into memory to maximize the benefit of the read operation. Compare the value of Memory\\Pages Input/sec to the value of Memory\\Page Reads/sec to determine the average number of pages read into memory during each read operation.
<b>Memory:</b> Pages Output/sec	The rate at which pages are written to disk to free up space in physical memory. Pages are written back to disk only if they are changed in physical memory, so they are likely to hold data, not code. A high rate of pages output might indicate a memory shortage. Windows writes more pages back to disk to free up space when physical memory is in short supply. This counter shows the number of pages and can be compared to other counts of pages, without conversion.
<b>Memory:</b> Pages/sec	The number of memory pages read from or written to disk to resolve memory references that was not in memory at the time of reference. A value greater than 100 is not a problem, unless it is accompanied by low Available Bytes or high Disk Transfers/sec.
<b>Paging File:</b> % Usage	The percentage of page file in use. If greater than 75% of the page file is in use, physical memory (RAM) should be increased.
<b>PhysicalDisk(_Total):</b> Current Disk Queue Length	Current Disk Queue Length is the number of requests outstanding on the disk at the time the performance data are collected. It also includes requests in service at the time of the collection. This is an instantaneous snapshot, not an average over the time interval. Multi-spindle disk devices can have multiple requests that are active at one time, but other concurrent requests are awaiting service. This counter might reflect a transitory high or low queue length, but if there is a sustained load on the disk drive, it is likely that this will be consistently high.

	Requests experience delays proportional to the length of this queue minus the number of spindles on the disks. For good performance, this difference should average less than two.
<b>Processor:</b> % Interrupt Time	Percentage of total usable space on the selected logical disk drive that was Free.
<b>Processor:</b> % Processor Time	Percentage of elapsed time a CPU is busy executing a non-idle thread. A high value is a concern, only if accompanied by a Processor Queue Length sum greater than <2 x # of CPU's> or growing with % Processor Time greater than 80-90%.
<b>System:</b> Context Switches/sec	Combined rate at which all CPU's are switched from one thread to the other. This occurs when a running thread voluntarily relinquishes the CPU, is preempted by a higher-priority thread, or switches between user mode and privileged mode to use an executive or subsystem service. A baseline should be established to determine if excessive context switching is occurring. For example, some systems have been observed to behave just fine with context switches between 50,000 – 60,000, but on other systems, values this high negatively impact performance.
<b>System:</b> Processor Queue Length	Number of threads in the processor queue-- for ready threads only, not threads that are running. Greater than <2 x # of CPU's> for 5-10 minutes or with %Total Processor Time of 80%-90%.
<b>Terminal Services:</b> Active Sessions	Number of active Terminal Server sessions.

## Appendix J: Converting Windows Performance Monitor (PerfMon) logs

Data collected in PerfMon logs may need to be converted to be opened in a spreadsheet application.

### **How to create a comma-separated values (CSV) file:**

Windows 2003 and XP provide a number of command-line tools to monitor performance. These are the logman utility (logman.exe), the relog utility (relog.exe), and the typeperf utility (typeperf.exe).

The relog.exe utility can create new performance logs from existing performance logs. Use the Relog.exe tool to:

- Convert a log from one type to another, such as a Microsoft Windows 2003 binary log file (.blg) to a comma-separated values (.csv) file.
- To convert a binary PerfMon log to a CSV file, use the command: `>>relog logfile.blg -f csv -o logfile.csv`

For details on how to use relog, in a Windows XP box, run "relog -?" or review <http://support.microsoft.com/?kbid=303133>

## 8 Resources

- IBM Support Technote #1314215, [What install methods are supported when installing the Notes client in a Citrix environment?](#)
- IBM Support Technote #1265898, [Steps for installing Lotus Notes 8 on a Citrix Presentation server](#)
- IBM Support Technote #1314211, [Lotus Notes scalability in a Citrix Presentation Server \(XenApp\) 4.5 environment](#)
- Technote # 1314212, [Does the Notes embedded Sametime client work with Citrix Presentation Server \(XenApp\) 4.5?](#)
- Technote #1295156, [Two users cannot launch Lotus Notes 8.0 on a Citrix server](#)
- developerWorks® article, [“Using IBM Rational Performance Tester V7.0.1 to load test IBM Lotus Notes standard client in a Citrix environment”](#)

## 9 About the authors

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