

# IBM Lotus Notes and Lotus iNotes 8.5.2 on Citrix XenApp 4.5/5.0: A scalability analysis

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**Summary:** This white paper provides an overview and recommendations for how to get the most from the IBM® Lotus® Notes® 8.5.2 client on the Citrix® XenApp™ 5.0 server. Specifically, it shows that by tuning the environment, you can realize significant improvements when running the Notes client on XenApp. This is true for both the standard and the basic configurations of Lotus Notes.

Moreover, the new support for Microsoft® Windows® 2008 SP2 by Notes 8.5.2, together with memory improvements, means increased scalability to even higher numbers than before at a much reduced cost. We also present the testing environment, tuning parameters, and the workflows that were executed to gather the scalability data on Notes 8.5.2.

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# 1 Overview of the software

Let's begin with a description of the software we used.

## 1.1 Lotus Notes 8.5.2

IBM Lotus Notes 8 software delivers a new user experience with enhancements to existing core functions, complemented by new functionality that can help increase effectiveness, improve efficiency, and speed 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 the tools and information to conduct business, all from the same page.

## 1.2 Citrix Presentation / Citrix XenApp Server and Client

Citrix Presentation server and Citrix XenApp server both enable enterprises to generate significant cost savings as well as simplify the deployment and management of applications. Citrix Presentation Server is the legacy name for what became Citrix Xenapp from version 5.0.

Citrix servers use the Independent Computing Architecture (ICA) protocol based on the proprietary ITU-T.120 and T.128 protocols. It is via this protocol that users communicate with the servers to access applications made available to them on that server.

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 Lotus Notes since the 8.0.2 client, the Citrix XenApp hardware and software likely to be in place today can be a cost-effective means of deploying Lotus Notes 8.5.2.

# 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 the overall costs—four different configurations were tested, 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 that XenApp server is currently set up and tuned may not be optimal for running the Notes client; however, by using Citrix's tuning guidelines and some specific Notes tuning, we can dramatically improve scalability. (Refer to Appendixes C, D, and E for tuning parameter details.)

By leveraging the methodology and workflows used in this analysis, similar testing scenarios can be performed 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 8.5.2 is available in two 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 Notes standard configuration is usually referred to in literature as simply “Lotus Notes.”

For analysis, IBM and Citrix leveraged a proven methodology to assess the server scalability of a XenApp Server running on five separate hardware configurations hosting the Notes 8.5.2 Standard client. The hardware configurations that were evaluated included:

- Microsoft® Windows® 2003 32-bit, 2 Dual Core Processors, 4GB RAM
- Microsoft Windows 2003 32-bit, 2 Dual Core Processors, 8GB RAM with PAE enabled
- Microsoft Windows 2008 64-bit, 2 Quad Core Processors, 16GB RAM
- Microsoft Windows 2008 64-bit, 2 Quad Core Processors, 32GB RAM

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

## 2.2 Summary of the results

Table 1 summarizes the results of the scalability tests of the Notes Standard Client. Refer to Appendix A for details of the scalability test results for the Notes Basic Client.

**Table 1. Scalability test results**

<b>Lotus Notes Standard Client Test Platform</b>	<b>Acceptable Active Sessions Range</b>	<b>Max Sessions 8.5.2</b>	<b>Max Sessions 8.5.1</b>	<b>Max Sessions 8.5</b>	<b>Max Sessions 8.0.2</b>	<b>Limiting Factor</b>
Windows 2003 32-bit 2 Dual Core Processors <b>4 GB RAM</b>	23 - 25	26	25	25	25	Memory
Windows 2003 32-bit 2 Dual Core Processors /PAE enabled <b>8 GB RAM</b>	40 - 50	56	54	55	55	Memory
Windows 2008 64-bit 2 Quad Core Processors <b>16 GB RAM</b>	65 - 72	75	70	75	75	CPU
Windows 2008 64-bit 2 Quad Core Processors <b>32 GB RAM</b>	120 - 145	150	140	125	155	CPU

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 testing, 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 because performance typically degrades due to memory-intensive applications causing frequent page swapping 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 64-bit 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, when 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 64-bit 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 Notes client optimization settings to achieve the best scalability results. Also note that, the greater the number of applications deployed to the same physical XenApp server, the less available memory and CPU each application has to utilize; therefore, it is best to plan installations and configurations beforehand.

Overall, with the enhancements made to the 8.5x client in terms of performance and memory footprint, scalability figures on XenApp are now double what was possible in Notes 8.0.1 on the same hardware.

This, in turn, results in a decrease in the number of XenApp servers required when moving to Notes Client 8.5x. With the introduction of Windows 2008 support for Notes 8.5.2 and Citrix XenApp, platforms can be extended further.

## **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:

- **Test automation.** Automated execution of workflow scenarios.
- **Manual user testing.** Exploratory testing by users without the use of specified scripting.
- **Scripted manual testing.** Users following scripted actions on the system.
- **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 Test automation**

For this method, a standard set of scripts are leveraged to control the actions of test users who are similar to typical 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 scripts is staggered, to ensure that steps taken while working in an application are not repeated simultaneously for all virtual users during the test, to avoid unrealistic peak loading on the system.

### **3.2 Manual user testing**

The second method for scalability testing is to have users log into 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. We achieved this monitoring by using Windows performance monitoring and Resource Manager for Citrix XenApp, which is designed for this purpose and can provide significant value and accuracy, assuming that a large-enough population of sample data is captured.

### **3.3 Scripted manual testing**

This method for scalability testing is a combination of scripted tests and user testing. This method involves having users access the system while executing a written set of tasks in a random order.

Developing scripts for scalability testing includes representing 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 helps 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
Test automation	<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>
Manual test	<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 customer base</li></ul>
Scripted manual test	<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 (quite complex and time consuming).</li></ul>
Combination	<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 scalability testing on the XenApp and Lotus Notes 8.5.2 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 ensuring 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, groups of users are added 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 experiences, 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 when the scripts fail to respond.

#### **4.1.2 Creating Virtual User scripts**

The Virtual Users (VUs) emulate production users interacting with the system under test conditions. The VU 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:

- 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-world usage. These scripts directed VUs to perform common functional activities when using Lotus Notes. The VUs launched an ICA session to the XenApp server and opened the Lotus Notes application like a real-user would.

After launching the application, the VUs logged in to the application and followed the steps provided by selected workflows. (Refer to Appendix G for more details on the workflows.)

#### **4.1.3 Benchmarking**

To get a more accurate scalability result, performance logging should be completed before VUs 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 yield 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 VUs will use, scripts that VUs will execute, and a specified number of VUs or VU groups that will run the scenario. In addition, determination of the rate at which users are introduced into the actual test must be done.

We emulate user load by instructing multiple VUs to perform tasks simultaneously. Configuration and scheduling should be defined before executing a scenario. This setup will determine how the load generators and VUs will behave when running the scenario.

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

While running the scenario, a monitoring tool such as Microsoft Performance Monitor (PerfMon) 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 Notes 8.5.2 and Citrix XenApp 5.0 scalability testing**

The scripted test method was leveraged to determine the scalability of Citrix XenApp servers hosting the Notes Standard 8.5.2 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 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 Notes 8.5.2 Standard application via XenApp 5.0 without overwhelming the server.

Five different test scenarios were executed to assess scalability differences among 32- and 64-bit operating systems on XenApp servers, which covered both the Windows 2003 and Windows 2008 OS and XenApp 4.5 and XenApp 5.0.

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

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

This testing established a baseline, or threshold, for the maximum number of concurrent ICA sessions a XenApp server could support effectively 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 goal of the testing was to evaluate objective factors such as memory and CPU 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.

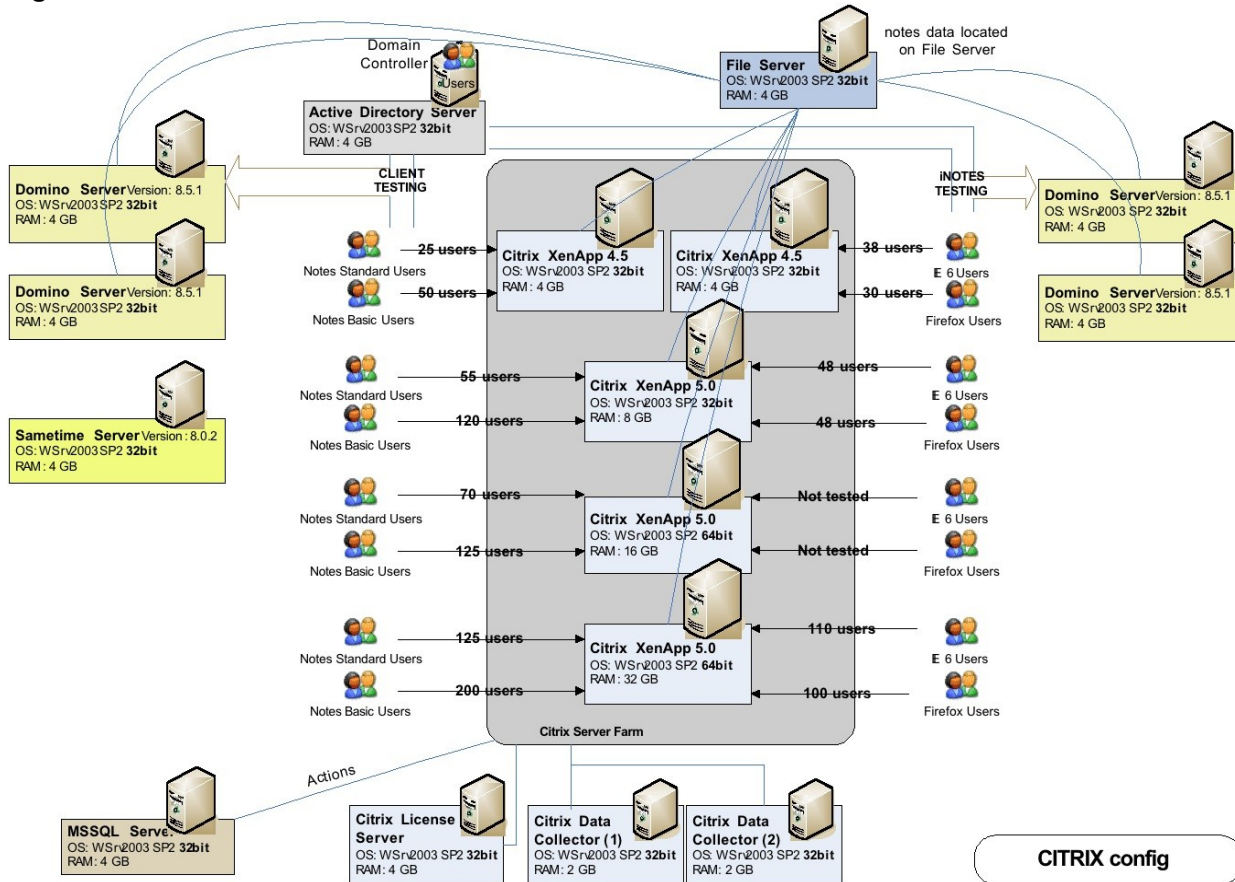
To ensure functional validity in the testing, the test team performed log-ins and limited manual application execution to evaluate application response and usability.

The number of concurrent ICA sessions was recorded by use of Microsoft's PerfMon, and the associated data was analyzed.

## 5.1 Test environment

Figure 1 shows the architecture of the testing environment used throughout the scalability analysis test cycle. The components comprising the environment are described below the figure.

Figure 1. Test environment



**XenApp Servers.** (CPS4.5 & XA5.0), allowing multi-user access to published resources. For this test, Lotus Notes was published as an application on the Citrix server, and each virtual user logged in and launched this published application. Four servers were used to host the 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 Collectors.** Poll other XenApp servers and gather performance data.

**File Server.** Hosts the Notes client data files for each user and is connected with a 1GB NW connection to the Citrix servers.

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

**Domino 8.5.2 Mail Server.** Stores the user's mail files that are accessed via the Lotus Notes client.

## 5.2 Hardware specifications

Tables 3 and 4 provide detailed information about 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	XenApp Server x64
Hardware System Type	IBM xSeries 348	IBM xSeries 348	IBM System x 3650	IBM System x 3550	IBM - xSeries 348
Bios Version	1.17	1.17	1.05	1.11	1.17
Number of Processors	2 - Dual Core	2 - Dual Core	2 - Quad Core	2 - Quad Core	2 - Dual Core
Processor Type / Speed	Xeon 3.4 GHz	Xeon 3.4 GHz	Xeon 3.0 GHz	Xeon 2.0 GHz	Xeon 3.4 GHz
Memory (GB)	4 GB (/PAE enabled)	8 GB (/PAE enabled)	16 GB	32 GB	16 GB
Disk Capacity	4 @ 73.4 GB	4 @ 73.4 GB	6 @ 148.8 GB	4 @ 73.4 GB	6 @ 73.4 GB
Disk Speed	15000 RPM	15000 RPM	15000 RPM	10000 RPM	15000 RPM
RAID	5	5	5	0	0
Maximum NIC Type / Speed	1 GB/sec	1 GB/sec	1 GB/sec	1 GB/sec	1 GB/sec
External Storage	N/A	N/A	N/A	N/A	N/A
Page file Size	6 GB	12 GB	24 GB	32 GB	24 GB
Operating System	Windows Server 2003 Enterprise Edition SP2	Windows Server 2003 Enterprise Edition SP2	Windows Server 2008 Enterprise x64 Edition	Windows Server 2008 Enterprise x64 Edition	Windows Server 2008 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	1 @ 80 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

### 5.3.1 Windows Server 2003 environment

The servers in this test environment were built with Windows Server 2003 Enterprise Edition with all updates.

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 Windows Server 2008 environment

The Windows 2008 test environment was built with Windows Server 2008 Enterprise Edition SP2 with all updates.

In addition, all Windows Server 2008 settings were configured with default options, with the exception of the Internet Explorer Enhanced Security Configuration option, which was disabled.

### 5.3.3 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 64bit 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 and XenApp 5.0 Enterprise Edition (32 bit and 64 bit)
Test Application	IBM Lotus Notes 8.5.2
Test Application Back-end	IBM Lotus Domino 8.5.2
XenApp Operating System	Windows Server 2003 SP2, Enterprise Edition (32 bit and 64 bit) Windows Server 2008 SP2, Enterprise Edition 64 bit

XenApp Server 4.5 or 5.0 (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
	64-bit Windows 2008	2 x Quad-core 3.0 GHz, 16 GB RAM, 24 GB page file
	64-bit Windows 2008	2 x Quad-core 3.4 GHz, 32 GB RAM, 48 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 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

The above counters were collected using PerfMon, and the log file was saved as a comma-separated values (CSV) file 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, and 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 K for details on this.)

## **6.2 Scenario #1 Results: XenApp 5.0 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.

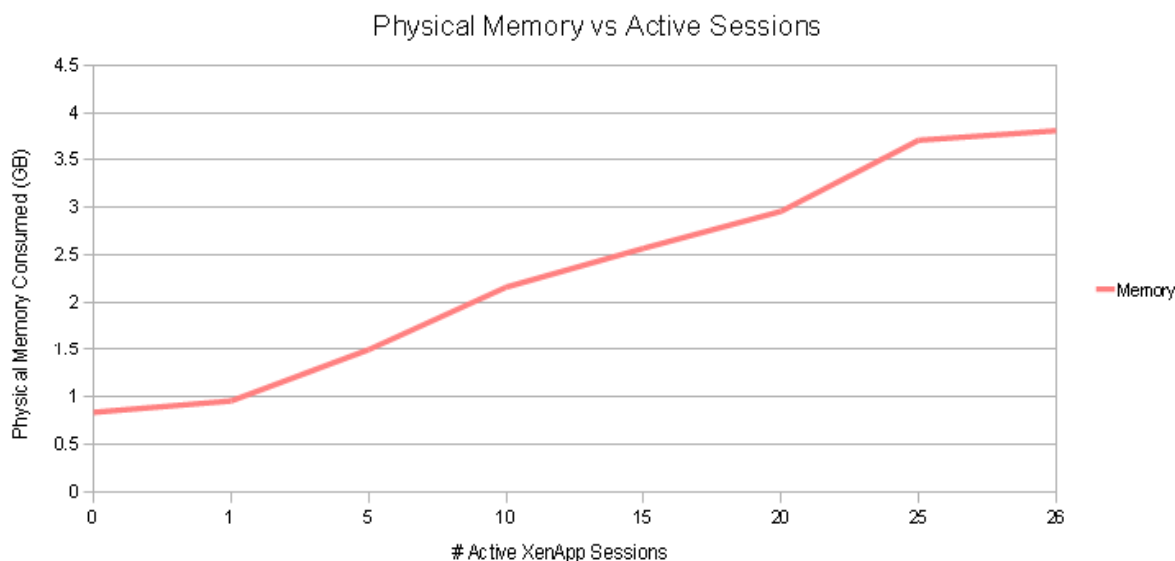
**Table 9. 32-bit Win2003 SP2, 4-GB results**

<b>Lotus Notes 8.5.2</b> <b>Standard Client</b> Windows 2003 SP3 32-bit 2 Dual Core Processors Intel Xeon CPU 3.4 GHz 4 GB RAM		CPU (%)	Available Memory (GB)	Page File in use (%)	User Experience
Baseline	2.25	3.16	0.22	Good	
1 user	3.50	3.04	0.69	Good	
5 users	5.20	2.50	2.59	Good	
10 users	9.04	1.84	6.77	Good	
15 users	12.58	1.43	18.72	Good	
20 users	17.28	1.04	32.06	Good	
25 users	21.86	0.29	52.64	Fair	
26 users	23.44	0.19	54.74	Fair	

In the Notes client on Citrix XenApp 5.0 test for the above hardware, memory was determined to be the bottleneck for 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 3GB of the 4-GB system, leaving the rest for OS and other processes on the Windows 2003 server.

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



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.

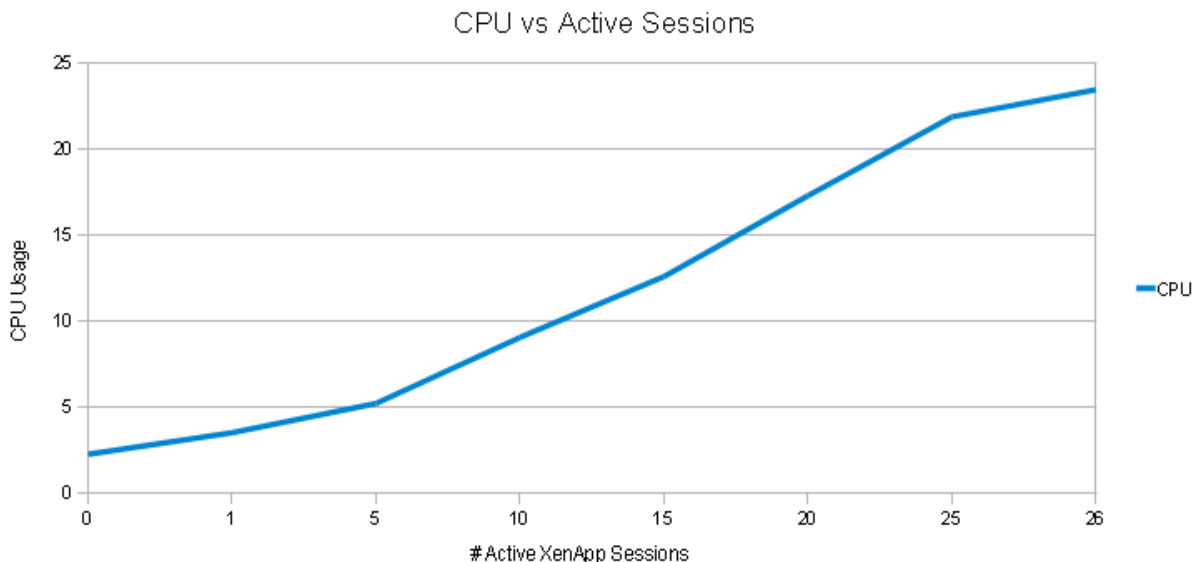
The amount of memory consumed can also be directly related to how the application is published on

XenApp; in this case the desktop was published, which would have consumed more memory than just publishing the application.

User performance began to degrade as memory consumption approached 100%, and it 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. number of active sessions**



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 actually 80%–90%, which correlates to 20–23 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 end user performance should be monitored as memory approaches 80%–90% utilization when running the Notes 8.5.2 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 table 10.

**Table 10. 32-bit Win2003 SP2, 8-GB RAM / PAE results**



## Lotus Notes 8.5.2 Standard Client

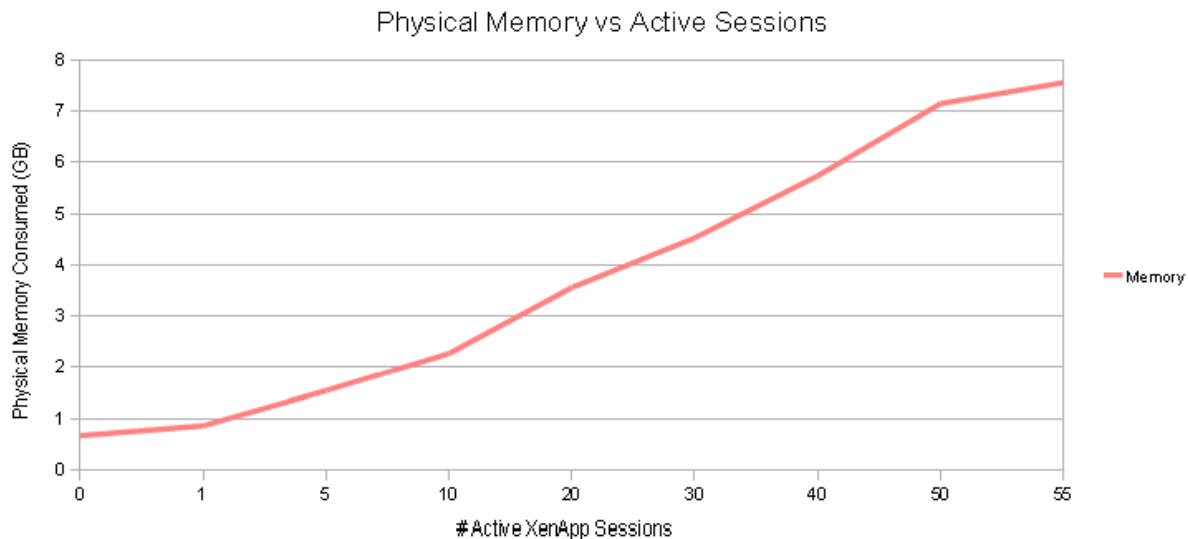
Windows 2003 SP3 32-bit  
2 Dual Core Processors  
Intel Xeon CPU 3.4 GHz  
8 GB RAM

	CPU (%)	Available Memory (GB)	Page File in use (%)	User Experience
Baseline	0.13	7.33	0.22	Good
1 user	0.89	7.14	0.40	Good
5 users	3.40	6.46	0.79	Good
10 users	6.73	5.73	2.10	Good
20 users	14.02	4.44	7.78	Good
30 users	25.46	3.47	18.86	Good
40 users	38.27	2.26	31.80	Good
50 users	72.00	0.85	41.95	Good
55 users	60.10	0.44	55.59	Fair

In the Notes-client-on-Citrix test for the above hardware, memory was determined to be the bottleneck when this scalability test was performed. 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, more than 7GB of the 8GB of available memory was consumed, leaving the rest for OS and other processes. At this point the system can start to exhibit slow response times as paging increases.

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



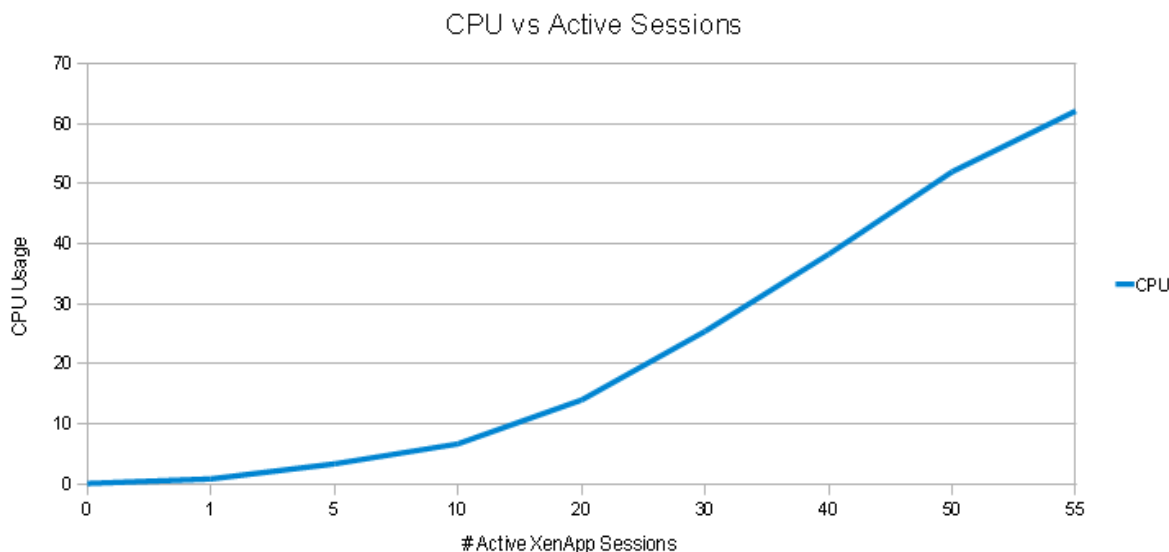
The above graph depicts the amount of consumed memory for active sessions, in gigabytes. The amount of memory consumed by each additional active ICA session was consistent, resulting in a linear trend line.

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 Notes 8.5.2 Standard client on the 2 Dual Core Processors with 8GB RAM and PAE enabled on the server.

**Figure 5. CPU Usage of 55 Active Sessions**



It can be seen that 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. Thus 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 monitoring end user performance should be carried out as memory approaches 80%–90% utilization when running the Notes 8.5.2 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**

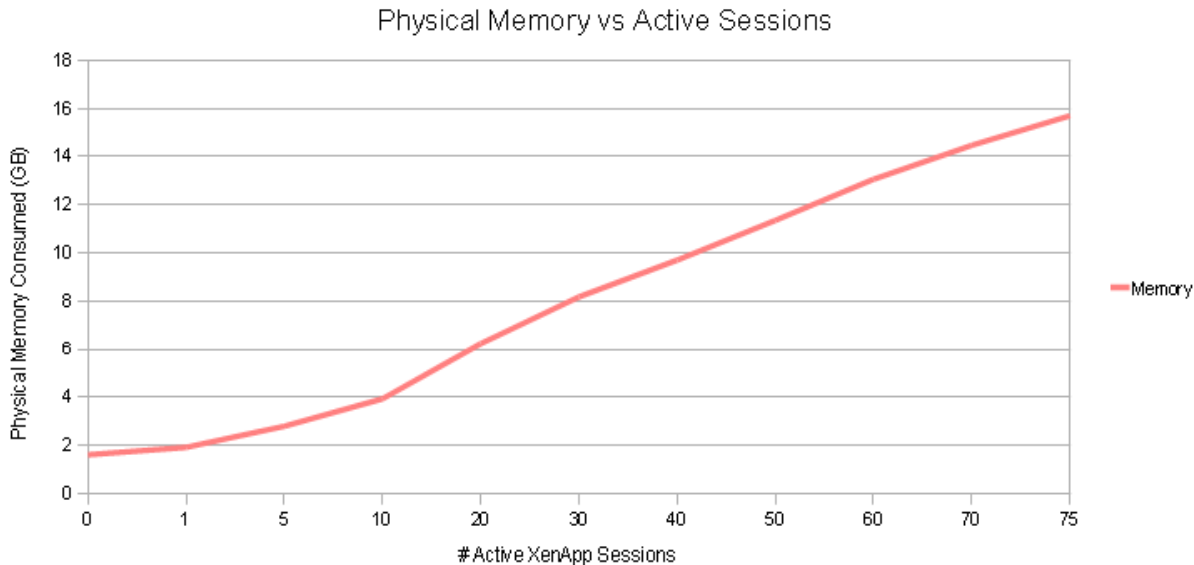
**Qualitative performance analysis.** Qualitative usability thresholds are shown in table 11.

**Table 11. 64-bit Win2003 SP2, 16-GB results**

<b>Lotus Notes 8.5.2</b> <b>Standard Client</b> Windows 2008 64-bit 2 Quad Core Processors Intel Xeon CPU 3.0 GHz 16 GB RAM				
	CPU (%)	Available Memory (GB)	Page File in use (%)	User Experience
Baseline	0.13	14.39	0	Good
1 user	0.41	14.08	0	Good
5 users	1.6	13.2	0	Good
10 users	3.5	12.06	0	Good
20 users	6.6	9.77	0	Good
30 users	10.36	7.83	1.81	Good
40 users	15.74	6.3	6.93	Good
50 users	22.83	4.65	12.15	Good
60 users	32.4	2.94	17.49	Good
70 users	73.54	1.53	22.28	Good
75 users	84.81	0.3	24.74	Fair

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, 16-GB system’s memory usage of 70 active sessions**

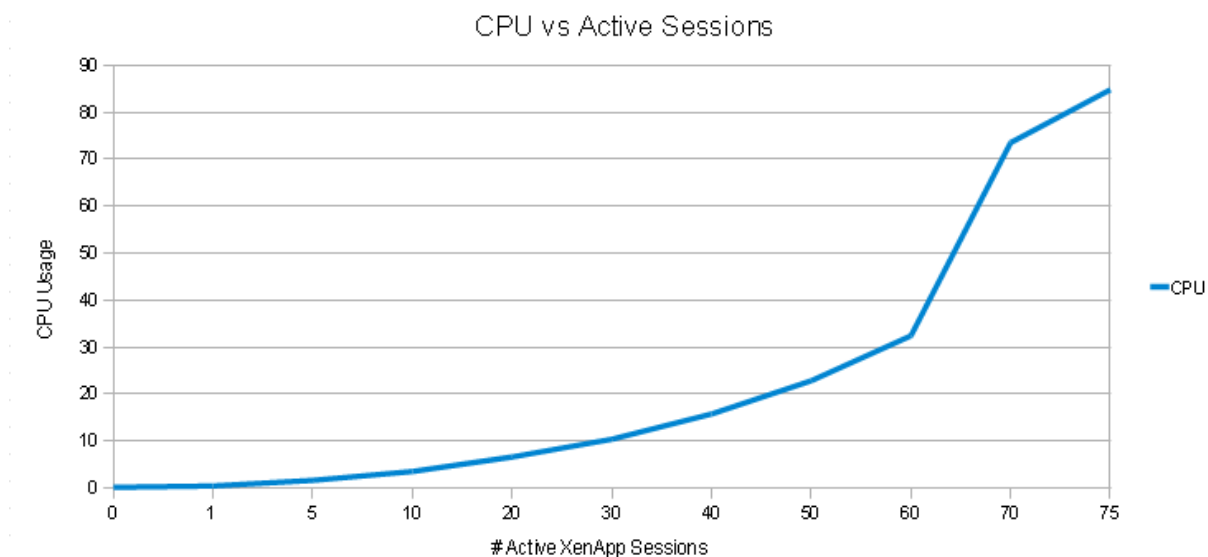


End user performance began to degrade as CPU consumption approached 70%. Memory on the box in this test was not all consumed before the CPU usage started to degrade users’ performance. However, almost 12GB of the 16GB available in the system was consumed, leaving the rest for OS and other running processes, 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, 16-GB CPU usage with 70 active sessions**



End user performance began to degrade as memory surpassed 100%. However, since a buffer should be provided for any unexpected behavior that may occur in a real-world environment, the acceptable memory threshold was 80%–90%, which correlates to 65–70 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 8.5.2 Standard client on a Citrix XenApp Server.

### **6.5 Scenario #4 Results: XenApp on a 64-bit Win2003 SP2 Enterprise Server with 32GB RAM / 2 quad core processors**

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

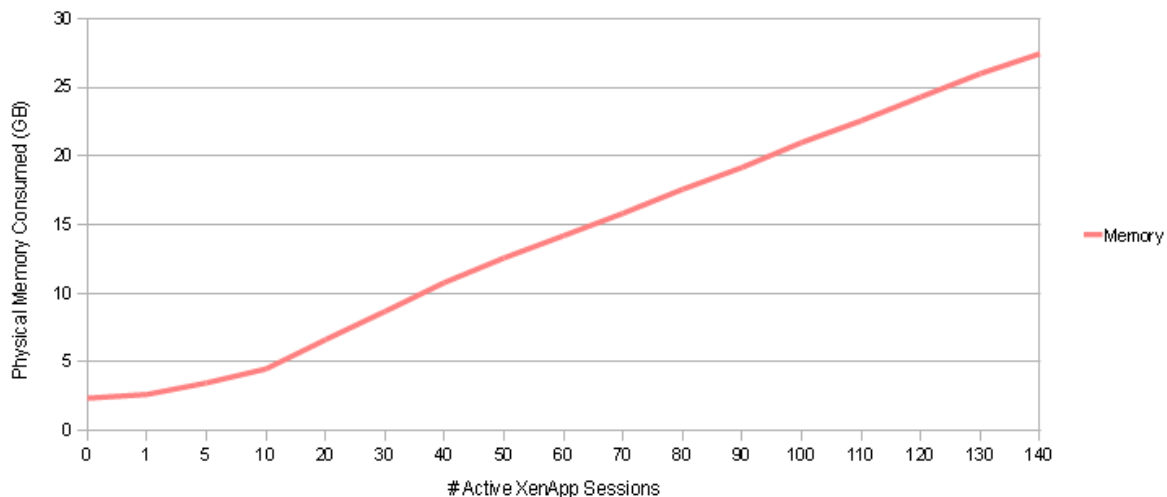
**Table 12. 64-bit Win2003 SP2, 32-GB results**

<b>Lotus Notes 8.5.2</b> <b>Standard Client</b> Windows 2008 64-bit 2 Quad Core Processors Intel Xeon CPU 3.4 GHz 32 GB RAM				
	CPU (%)	Available Memory (GB)	Page File in use (%)	User Experience
Baseline	0.31	29.67	0.0	Good
1 user	0.25	29.39	0.0	Good
5 users	0.78	28.55	0.0	Good
10 users	1.47	27.53	0.0	Good
20 users	2.70	25.40	0.0	Good
30 users	3.95	23.34	0.0	Good
40 users	5.74	21.23	0.0	Good
50 users	6.81	19.44	1.15	Good
60 users	8.81	17.82	3.21	Good
70 users	10.25	16.18	5.60	Good
80 users	12.92	14.44	8.16	Good
90 users	15.31	12.84	10.63	Good
100 users	18.17	11.02	12.97	Good
110 users	19.85	9.44	15.00	Good
120 users	20.80	7.71	16.97	Good
130 users	24.04	6.01	19.05	Good
140 users	40.22	4.55	20.70	Fair

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

**Figure 8. 64-bit, 32-GB quad core system’s memory usage with 140 active sessions**

Physical Memory vs Active Sessions

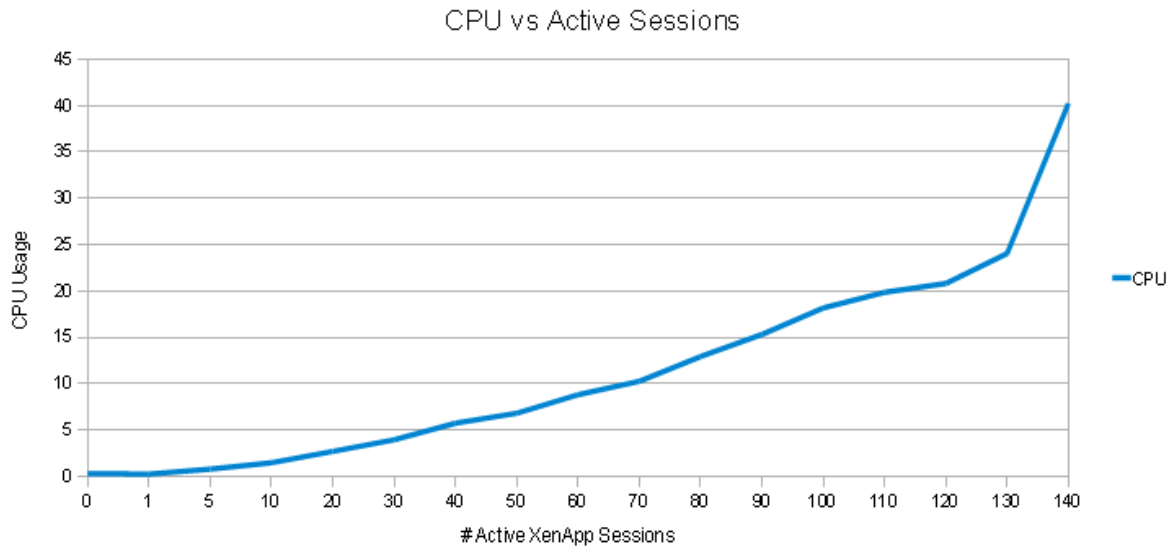


The amount of memory consumed by each additional active ICA session was consistent, resulting in a linear trend line. End user performance began to degrade as CPU consumption approached 65%. In this test, memory on the box was not all consumed before the CPU usage started to degrade users’ performance, although over 20GB of the 32GB was consumed.

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

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, 32-GB system’s CPU usage under 140 active sessions**



End user performance began to degrade as memory surpassed 100%. However, since a buffer should be provided for any unexpected behavior that may occur in a real-world environment, the acceptable memory threshold was 80%–90%, which correlates to 120–125 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 8.5.2 Standard client on a Citrix XenApp Server.

For more information, refer to IBM Support Techdoc #7019220, “[IBM Lotus Notes 8.5.2 - Detailed system requirements - Windows](#),” and Technote #1098489, “[Supported configurations and support policy for Citrix products](#).”

## 7 Conclusion

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

- Lotus Notes 8.5.2 runs on the 32-bit version of XenApp 4.5 or 5.0 with reasonable scalability levels, with 4GB of RAM. By enabling /PAE and adding more RAM, we can scale the 32-bit systems even higher. Moreover, by enabling optimizations on both XenApp servers and within the Lotus Notes client and the OS environment, we can achieve even higher scalability numbers.

- Historically Notes-client-on-Citrix customers have relied primarily on two-CPU, 4-GB RAM servers as was 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 Notes Standard and Notes Basic clients.
- To increase scalability, one option is to leverage the Windows Server 2003 PAE configuration. This allows 32-bit 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 Notes client.
- During our testing, as more processor and memory capacity was added, near-linear scalability was observed for the Notes client in terms of capacity. Therefore it is anticipated 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 Notes client in Windows 2003 64-bit with XenApp 64-bit is a supported configuration in Lotus Notes versions 8.5.2. A well tuned 64-bit XenApp 5.0 or 4.5 server is capable of hosting 140 users with good response times—a significant improvement over what we've seen with the 4-GB, 32-bit XenApp server.
- NOTE: XenApp Server 64-bit can be deployed in the same server farm with existing 32-bit versions of XenApp Server, creating a smooth migration path and helping consolidate servers to reduce costs.
- In comparison with 8.5 Citrix results there is very little difference with respect to acceptable user sessions for the Standard client with the added benefit of the 8.5.2 feature set. Considerable improvements are seen in scalability of the Basic client when compared to 8.5.

In summary, the Notes 8.5.2 Standard client scales better than ever, and with the introduction of 64-bit support in version 8.0.2, new hardware purchases can be avoided when upgrading to version 8.5.2.

## Appendix A: Summary of Lotus Notes *Basic* 8.5.2 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 2008	2 x Dual-core 3.0 GHz, 16 GB RAM, 24GB page file
	64 bit Windows 2008	2 x Quad-core 2.5 GHz, 32 GB RAM, 32GB page file
	64 bit Windows 2008 SP2	2 x Dual-core 3.4 GHz, 16GB RAM, 24GB 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

Lotus Notes Basic Client Test Platform	Acceptable Active Sessions Range	Max Sessions 8.5.2	Max Sessions 8.5.1	Max Sessions 8.5	Max Sessions 8.0.2	Limiting Factor
Windows 2003 32-bit 2 Dual Core Processors 4 GB RAM	23 - 25	54	54	40	45	Memory
Windows 2003 32-bit 2 Dual Core Processors /PAE enabled 8 GB RAM	40 - 50	125	125	80	85	Memory
Windows 2008 64-bit 2 Dual Core Processors 16 GB RAM	65 - 72	135	135	80	105	CPU
Windows 2008 64-bit 2 Quad Core Processors 32 GB RAM	120 - 145	220	200	200	225	CPU

### 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.)



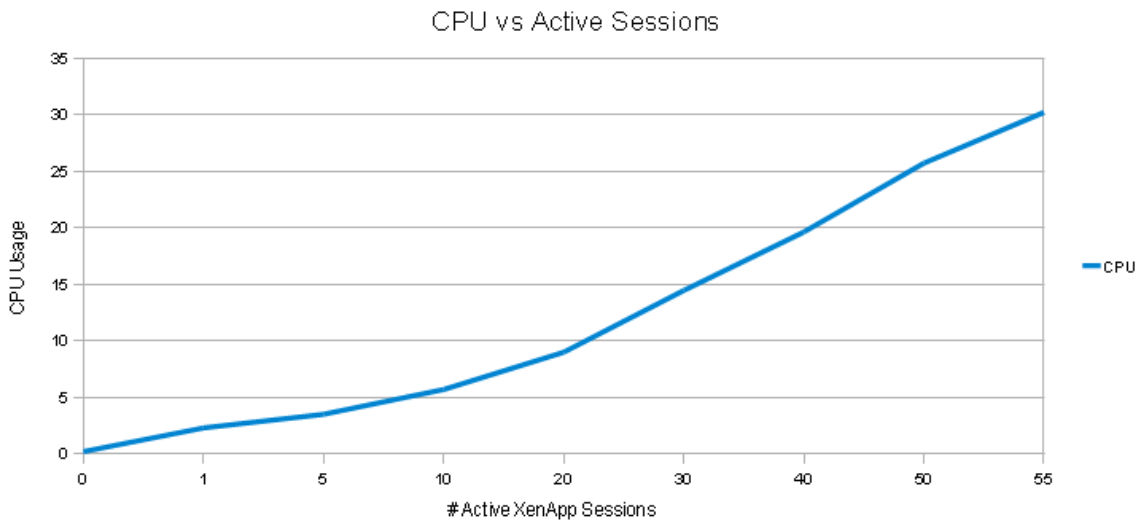
**Table 3. Qualitative usability thresholds (32-bit, 4 GB)**

<b>Lotus Notes 8.5.2 Basic Client</b> Windows 2003 SP3 32-bit 2 Dual Core Processors Intel Xeon CPU 3.4 GHz 4 GB RAM	CPU (%)	Available Memory (GB)	Page File in use (%)	User Experience
Baseline	0.20	3.19	0.21	Good
1 user	2.30	3.11	0.64	Good
5 users	3.50	2.87	2.62	Good
10 users	5.69	2.63	6.20	Good
20 users	8.99	2.16	13.74	Good
30 users	14.45	1.54	19.44	Good
40 users	19.62	1.18	30.64	Good
50 users	25.71	0.86	44.98	Fair
55 users	30.20	0.79	58.32	Fair

In the Notes client-on-Citrix XenApp 5.0 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 CPU consumption was adequate for the number of active users on the system.

**Figure 1. Available CPU with 55 active users**



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

**Table 4. Qualitative usability thresholds (32-bit, 8 GB with PAE)**

**Lotus Notes 8.5.2**

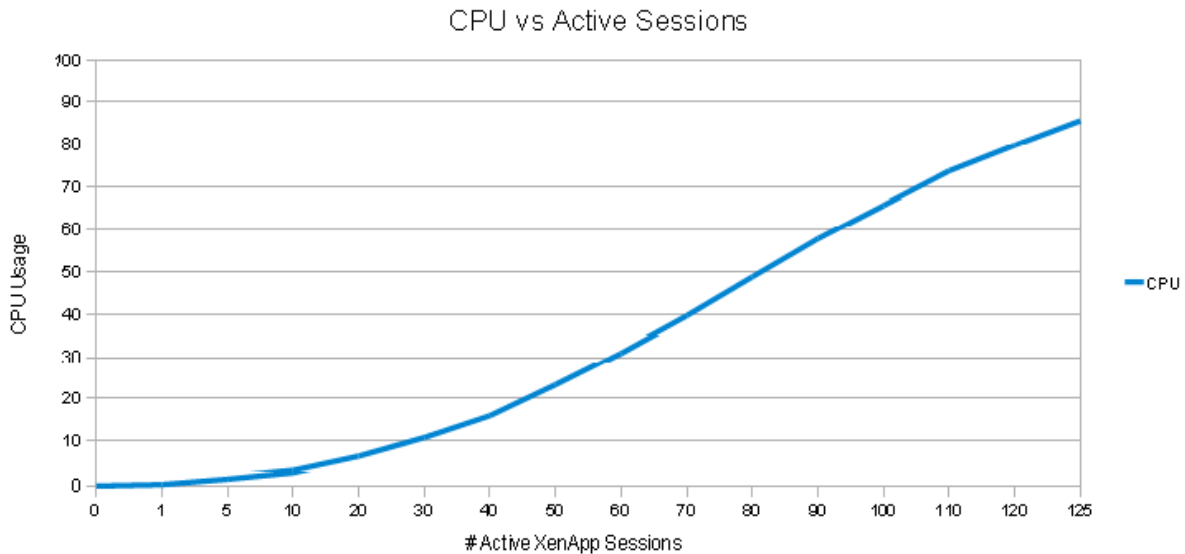
**Basic Client**

Windows 2003 SP3 32-bit  
 2 Dual Core Processors  
 Intel Xeon CPU 3.4 GHz  
 8 GB RAM

	CPU (%)	Available Memory (GB)	Page File in use (%)	User Experience
Baseline	0.02	7.26	0.09	Good
1 user	0.35	7.16	0.28	Good
5 users	1.60	6.86	0.78	Good
10 users	3.14	6.49	1.57	Good
20 users	6.48	5.81	3.86	Good
30 users	10.83	5.17	6.72	Good
40 users	15.99	4.62	10.59	Good
50 users	23.36	4.03	14.45	Good
60 users	31.10	3.47	18.30	Good
70 users	39.62	2.92	22.07	Good
80 users	48.77	2.35	25.86	Good
90 users	57.83	1.80	29.72	Good
100 users	65.81	1.22	33.54	Good
110 users	73.84	0.67	37.32	Good
120 users	79.95	0.12	41.11	Fair
125 users	85.75	1.27	58.57	Fair

In the 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 7GB of the 8GB available memory was also consumed, leaving the rest for OS and other processes. However, it was CPU that degraded users' performance before memory (figure 2).

**Figure 2. CPU usage with 125 active sessions**



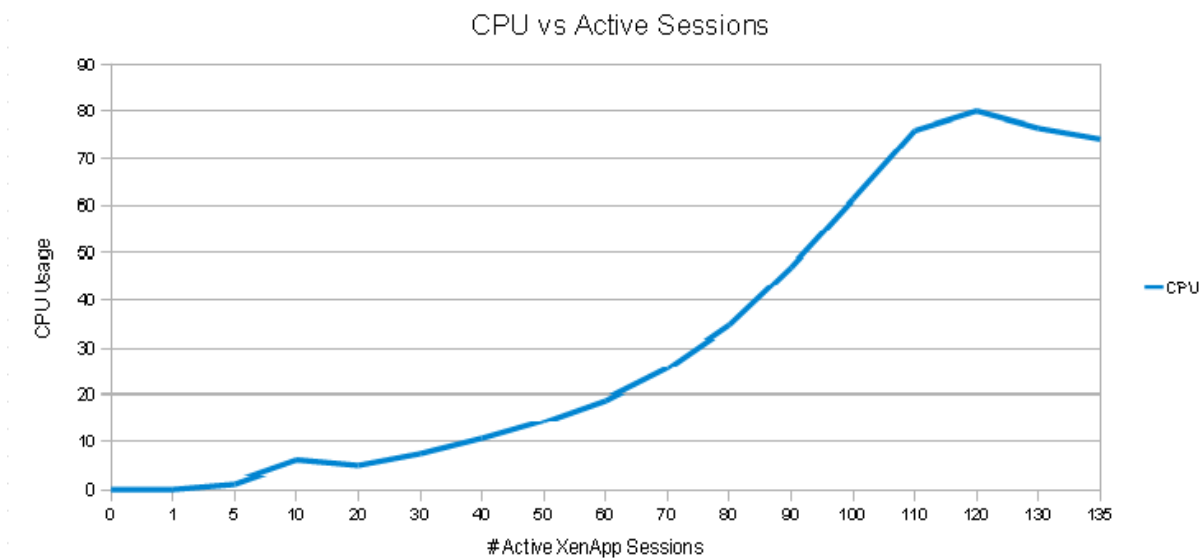
## Scenario #3 Results: XenApp running on a 64-bit Win2008 Enterprise Server with 16GB RAM /2 Dual Core Processors

Table 5. Qualitative Usability Thresholds (64-bit, 16 GB / 2 Dual Core Processors)

Lotus Notes 8.5.2 Basic Client Windows 2008 64-bit 2 Dual Core Processors Intel Xeon CPU 3.4 GHz 16 GB RAM	CPU (%)	Available Memory (GB)	Page File in use (%)	User Experience
Baseline	0.14	14.30	0.0	Good
1 user	0.17	14.15	0.0	Good
5 users	1.25	13.61	0.0	Good
10 users	5.87	12.89	0.0	Good
20 users	4.69	11.55	0.0	Good
30 users	7.19	10.20	0.0	Good
40 users	10.47	8.91	0.25	Good
50 users	14.25	7.93	2.47	Good
60 users	18.88	6.97	4.73	Good
70 users	25.51	6.00	6.76	Good
80 users	34.55	5.01	8.82	Good
90 users	47.01	4.01	10.82	Good
100 users	61.30	3.17	12.53	Good
110 users	75.98	2.14	14.01	Good
120 users	80.06	1.14	16.40	Good
130 users	76.49	0.31	21.22	Fair
135 users	74.20	1.66	29.92	Fair

The graph in figure 3 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 CPU usage of 135 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 10GB of the 16GB available in the system was consumed, leaving the rest for OS and other running processes.

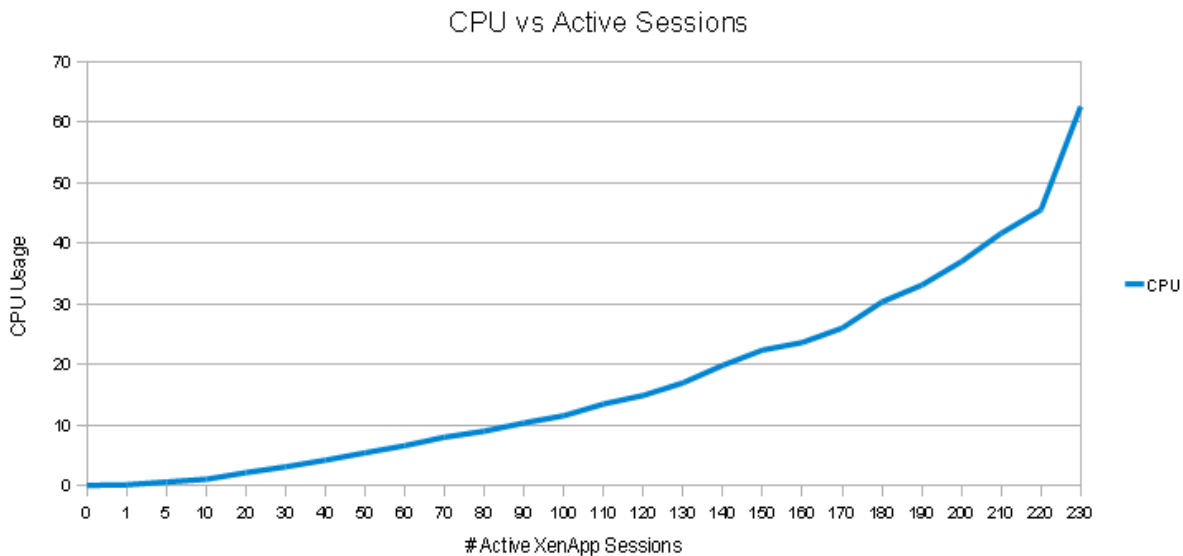
Thus the resulting limitation in this box was CPU.

### **Scenario #4 Results: XenApp running on a 64-bit Win2008 Enterprise Server with 32GB RAM / 2 Quad Core Processors**

**Table 6. Qualitative Usability Thresholds (64-bit, 32GB / 2 Quad Core Processors)**

<b>Lotus Notes 8.5.2</b> <b>Basic Client</b> Windows 2008 64-bit 2 Dual Core Processors Intel Xeon CPU 3.4 GHz 32 GB RAM	CPU (%)	Available Memory (GB)	Page File in use (%)	User Experience
Baseline	0.07	29.70	0.0	Good
1 user	0.17	29.51	0.0	Good
5 users	0.63	28.96	0.0	Good
10 users	1.08	28.31	0.0	Good
20 users	2.18	26.98	0.0	Good
30 users	3.14	25.65	0.0	Good
40 users	4.23	24.34	0.0	Good
50 users	5.44	23.02	0.0	Good
60 users	6.62	21.70	0.0	Good
70 users	8.03	20.38	0.0	Good
80 users	9.01	19.07	0.0	Good
90 users	10.38	17.96	0.53	Good
100 users	11.56	17.04	1.66	Good
110 users	13.50	16.16	3.03	Good
120 users	14.91	15.13	3.75	Good
130 users	16.99	14.25	4.68	Good
140 users	19.88	13.32	5.64	Good
150 users	22.40	12.43	6.59	Good
160 users	23.64	11.55	7.55	Good
170 users	26.01	10.71	8.55	Good
180 users	30.32	9.79	9.54	Good
190 users	33.10	8.90	10.52	Good
200 users	36.98	8.02	11.55	Good
210 users	41.65	7.10	12.44	Good
220 users	45.52	6.19	13.42	Good
230 users	62.59	5.88	13.96	Fair

**Figure 4. 64-bit, 32-GB system's CPU usage with 200 active sessions**



**Results and analysis.** End user performance began to degrade as CPU usage surpassed 30%. 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 190–200 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.

Running the Notes 8.5.2 Basic client on a XenApp Server with 32GB of RAM, CPU utilization is the limiting factor as memory available was still more than 10GB.

## Appendix B: Summary of Lotus iNotes® 8.5.2 Client scalability results

**Table 1. XenApp Server settings**

XenApp 5.0	32 bit Windows 2003	2 x Dual-core 3.4 GHz, 4 GB RAM 6 GB page file with 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 2008	2 x Quad-core 2.5 GHz, 16 GB RAM 32 GB page file
	64 bit Windows 2008	2 x Dual-core 3.4 GHz, 32 GB RAM 48GB page file

PAE = Physical Address Extension

Tables 2 and 3 summarize 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 for Lotus iNotes on Internet Explorer 8 (IE8)**

<b>Lotus iNotes IE8</b>		<b>Acceptable Active Sessions Range</b>	<b>IE8 Max Sessions 8.5.2</b>	<b>Limiting Factor</b>
<b>Test Platform</b>				
Windows 2003 32-bit 2 Dual Core Processors <b>4GB RAM</b>		25-27	30	Memory/CPU
Windows 2003 32-bit 2 Dual Core Processors /PAE enabled <b>8GB RAM</b>		38-42	45	Memory/CPU
Windows 2008 64-bit 2 Dual Core Processors <b>16GB RAM</b>		60-65	70	CPU
Windows 2008 64-bit 2 Quad Core Processors <b>32GB RAM</b>		N/A	- not tested -	- not tested -

**Table 3. Scalability results for Lotus iNotes on Firefox (FF)**

<b>Lotus iNotes FF</b>		<b>Acceptable Active Sessions Range</b>	<b>FF3 Max Sessions 8.5.2</b>	<b>Limiting Factor</b>
<b>Test Platform</b>				
Windows 2003 32-bit 2 Dual Core Processors <b>4GB RAM</b>		25-27	30	Memory
Windows 2003 32-bit 2 Dual Core Processors /PAE enabled <b>8GB RAM</b>		38-42	45	CPU
Windows 2008 64-bit 2 Dual Core Processors <b>16GB RAM</b>		60-65	70	CPU
Windows 2008 64-bit 2 Quad Core Processors <b>32GB RAM</b>		N/A	- not tested -	- not tested -

From Internet Explorer 8 testing it was found that, if a user does not close their browser at the end of the working day, then memory usage can build up to such a degree on lower-specification configurations that it could lead to the system running out of memory. Refer to Support Technote #1444437, "[iNotes 8.5.2 on IE8 in Citrix XenApp does not scale the same as iNotes 8.5.2 on IE6 in Citrix XenApp](#)," which describes this behavior.

## Appendix C: 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 found in the Citrix.net article, "[Terminal Server and XenApp Tuning](#)."

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.

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.

The XenApp user experience can be further improved 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.



**Additional Windows optimizations.** For additional tuning parameters around Citrix and OS levels, including Windows 2008 Registry tuning, refer to the Citrix.net article, "[Terminal Server and XenApp Tuning.](#)"

## Appendix D: Environment optimizations

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: 1. *.ndk 2. *.ini 3. *.nsf 4. *.ntf
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 Citrix/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 E: 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 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 the Microsoft Support article, "[Physical Address Extension - PAE Memory and Windows.](#)"

## Appendix F: Lotus Notes optimization

When running Lotus Notes Standard 8.5.2 client in a XenApp environment, it is recommended to enable the following optimization:

- The Lotus Notes Sharedclass cache for Citrix XenApp running Lotus Notes 8.5.2.

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 a reduction in memory usage for each Lotus Notes user.

To enable the Java Shared Cache Class for Notes 8.5.2:

In the [notes install path]\framework\rcp\deploy\jvm.properties file remove the ",singleJVM" option from the line:

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

Then, change the sharedclass cache location to a shared/common path in the following line from:

```
jvm.shareclasses.loc=${rcp.data}/.config/org.eclipse.osgi
```

to something like:

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

This directory should allow write access for all users.

## Appendix G: Workflows

The following actions were coded in AutoIT, and all virtual users for the Notes Client 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  
- Send  
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

Loop for variable time x

### **End Script**

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

### **Begin Script**

Login  
begin loop  
    Open message x 5  
    Send Message x 5  
    Open message x 5  
    Send message with attachment x 2  
    Open Message x 5  
    Reply x 3  
    Delete a message x 2  
    Move mails x 3  
    Open message x 5  
    Send message x 5  
    Open message x 5  
    Move mails x 2  
    Open message x 5  
    Send message with attachment x 2  
    Open message x 5  
    Delete a message x 2  
    Open message x 5  
    Reply x 3  
    Open message x 5  
    sleep for 12 hours  
end of loop  
**End Script**

## Appendix H: 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 4GB 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.
- A 1GB network connection was available between the Citrix server and the file server, which was to reduce any potential latency issues with having a remote data directory.
- All users were initialized 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 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: % Disk Time</b>	<p>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.</p> <p>If hard disk performance becomes a bottleneck, a hardware disk controller that includes both read and write cache can improve disk performance.</p>
<b>LogicalDisk: %Free Space (%)</b>	<p>Free Space is the percentage of total usable space on the selected logical disk drive that was free</p>
<b>Memory: Available Bytes</b>	<p>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.</p>
<b>Memory: Pages Input/sec</b>	<p>The rate at which pages are read from disk to resolve hard page faults.</p> <p>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.</p> <p>When a page is faulted, the system tries to read multiple contiguous pages into memory to maximize the benefit of the read operation.</p> <p>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.</p>
<b>Memory: Pages Output/sec</b>	<p>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.</p> <p>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.</p>
<b>Memory: Pages/sec</b>	<p>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.</p>
<b>Paging File: % Usage</b>	<p>The percentage of page file in use. If greater than 75% of the page file is in use, physical memory (RAM) should be increased.</p>
<b>PhysicalDisk(_Total): Current Disk Queue Length</b>	<p>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.</p> <p>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.</p> <p>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.</p>

<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	<p>Combined rate at which all CPU's are switched from one thread to the other.</p> <p>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.</p> <p>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.</p>
<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.



## 8 Resources

- IBM Support Technote #1314215, "[What install methods are supported when installing the Notes client in a Citrix environment.](#)"
- Technote #1265898, "[Steps for installing Lotus Notes 8 on a Citrix Presentation server.](#)"
- Technote #1314211, "[Lotus Notes scalability in a Citrix Presentation Server \(ZenApp\) 4.5 environment.](#)"
- Technote # 1314212, "[Does the Notes embedded Sametime client work with Citrix Presentation Server \(ZenApp\) 4.5?](#)"
- Technote # 1386866: "[Upgrading a Notes deployment on the Citrix platform -- release-specific upgrade matrix.](#)"
- Technote #1295156, "[Two users cannot launch Lotus Notes 8.0 on a Citrix server.](#)"
- developerWorks® Lotus article, "[Using IBM Rational Performance Tester V7.0.1 to load test IBM Lotus Notes standard client in a Citrix environment.](#)"
- Technote #1444437, "[Scalability differences between iNotes 8.5.2 in IE8 and IE6 on Citrix XenApp.](#)"
- [Participate in the discussion forum.](#)

## 9 About the authors

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