How mission-critical database workloads perform when virtualized with Intel® Xeon® processor 7500 series-based servers and VMware® vSphere™

A performance test commissioned by Intel Corporation
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Abstract

The volume and complexity of business data continue to grow at an accelerated pace. As the amount of data grows and organizations and customers become more reliant on that data, poor performance and downtime can result in severe costs: low transaction volume, dissatisfied customers, loss of worker productivity, and more. Today's database platforms must combine high performance with reliability to serve the needs of information-enabled organizations.

Servers equipped with the Intel® Xeon® processor 7500 series and VMware® vSphere™ 4 provide a powerful platform for today's data-driven organizations. This joint platform can enable organizations to reliably power the wide range of enterprise applications while adding advanced capabilities to help improve availability. Successfully combining leading processing power with advanced virtualization, servers with the Intel Xeon processor 7500 series and VMware vSphere 4 provide the scalable performance, reliability, and flexibility that organizations need to keep their demanding mission-critical applications running well.

This white paper documents the performance of mission-critical database workloads running on servers equipped with the Intel Xeon processor 7500 series and VMware vSphere 4. Using standard and non-standard testing tools, these tests replicate real-world scenarios found in production environments. Specifically, these tests show that the combination of the Intel Xeon processor 7500 series and VMware vSphere 4 can allow a company to achieve greater performance while dramatically reducing operating costs by using less energy and space. Servers built using this combination deliver up to 3.5 times better virtualization performance than previous generations,[1] as well as near-native performance on enterprise applications such as database, productivity, and business applications running in a virtual environment. This combination also permits greater VM density, resulting in 3.7 times higher consolidation than servers built on the prior-generation processors.[2] As a result, organizations can realize both capital and operational expense savings due to decreased hardware requirements and improved utilization.

Contents

Today's Data Management Challenges

IT managers in today's organizations are faced with numerous challenges regarding data management. Some of the more critical challenges include:

- Larger amounts of data to store and manage
- Increased demand to extract intelligence from data
- Increased reliance on IT systems
- Pressures to do more with less; increased cost pressures and higher demand for services and reliability
- Increased user expectations for improved data request responsive time

More Data to Store and Manage

Increases in electronic communication, transitions from paper-based to electronic tools, and tighter government regulation require organizations to retain increasing amounts of data.

Data generation has been focused on email and user-generated data such as word processing documents and spreadsheets. More recently, however, the focus is increasing on other forms of data, including voice and multimedia. More and more organizations are also adopting enterprise-wide management systems, such as ERP and CRM systems, resulting in massive amounts of data to store and manage.

Organizations also face ever-increasing levels of data retention required for regulatory compliance, corporate governance, and litigation support. Laws regarding data retention stretch globally. In the United States, regulations such as the Sarbanes-Oxley Act and the Health Insurance Portability and Accountability Act (HIPAA) require organizations to keep tighter controls on their data. Failure to retain and protect data can introduce avoidable risk, and in extreme situations can result in large fines or business losses.

For these and other reasons, it is more important than ever to have powerful tools to store and manage such large amounts of data. Databases continue to grow, data continues to proliferate, and newer forms of multimedia continue to gain acceptance in the workplace. IT departments face many challenges in accommodating this level of data retention and management, including slow application response times, longer backup windows, increased downtime for disaster recovery, and larger maintenance windows for system upgrades. Left unattended, these factors can lead to lower employee productivity and higher IT costs.

Business Intelligence

The growth in data makes it harder to analyze and derive useful information from it. Thus, organizations are using more sophisticated tools to transform raw data quickly into usable information. Generally these business intelligence tools rely heavily on complex queries executed on enormous data sets and need a lot of raw processing power.

Business leaders have increasingly high expectations of transforming raw data into actionable information that gives them a competitive advantage. They want to be able to extract meaningful intelligence from their data and quickly make it available to decision makers. Leaders want to be able to generate this information in real time, which often requires complex server-side data manipulation.

Furthermore, business leaders want to empower end users to do the same. In the past, executives wanting specific information often had to ask a programmer or database administrator to manually query a database to pull the information from the organization's legacy system[3]. Data can be constantly in flux, so by the time the executive's request is filled it could already be stale. Modern data analysis tools have changed that and now allow executives to create and run such reports in real-time. This sort of advanced business intelligence functionality requires increased server-side processing power.

Reliance on IT Systems

Organizations are relying more and more on their IT systems so system uptime and reliability is now a matter of strategic importance. Extended downtime of critical data systems is unacceptable. Even short outages can result in significant losses, reduced employee productivity, and damage to the brand.

IT resources are also spread thin, placing greater pressure on getting the most out of existing systems. Computing platforms must be reliable to avoid costly downtime. With IT resources overextended, it is more important than ever to have a solid and reliable platform running your organization's applications.

Budgetary Pressures

The global recession has hit many organizations hard, forcing IT leaders to trim budgets and reduce staff. Budget reductions cut deep into IT, leaving resources stretched.

Yet as the economy slowly recovers, business leaders are renewing their focus on growth, and IT must be able to rise to the challenge. The combination of Intel and VMware provides a solid platform that lets you make the most cost-efficient use of your budget and hardware resources.

Intel and VMware Meet These Challenges

The IT challenges require computing platforms that offer powerful processing ability, hardware reliability, and workload management flexibility. By combining the leading performance and reliability found in the latest Intel Xeon processors with the flexibility and efficiency found in the latest virtualization software from VMware, organizations can ensure that they are ready to meet these challenges.

Cost Savings through Increased VM Density

Intel and VMware have worked hard to ensure that their industry-leading products are designed, manufactured, and optimized to handle continually evolving data center requirements. Working together, Intel and VMware have developed multiple enhancements and optimizations to deliver the highest consolidation ratios and the greatest VM density in the industry. The companies have collaborated closely on the architectural enhancements in the Intel Xeon processor 7500 series to intelligently boost performance, increase consolidation ratios through greater VM density, and enable servers of different generations to be easily combined in the same virtualized server pool. The collaboration has also focused on exploiting the capabilities of VMware vSphere and building a solid foundation on which to deploy virtualized workloads. Translated into business terms, the increased VM density and efficiency delivered by Intel and VMware provide savings of both capital and operational expenses. Specifically:

- When running VMware vSphere 4, the Intel Xeon processor 7500 series with next-generation Intel® Virtualization Technology[4] (Intel® VT) enhances virtualization performance by up to 3.5[5] times and reduces round-trip virtualization latency. These innovations provide greater responsiveness for applications running in virtualized environments and permit greater VM density.
- Joint optimizations allow VMware's hypervisor to fully utilize the Intel Xeon processor 7500 series' performance-enhancing feature Intel® Hyper-Threading Technology[6] (Intel® HT Technology), which doubles the number of threads each core can execute during a single clock cycle. This technology allows a further increase in the number of VMs running per socket—maximizing VM density and further reducing energy costs.

Virtualization Performance: Near-Native Performance in a Virtual Environment

In the past, when the CPU, the Memory Management Unit (MMU), and their related I/O devices were virtualized, you expected an increase in processing overhead and a decrease in the overall performance and scalability of the virtualized environment. The introduction of the Intel Xeon processor 7500 series and VMware vSphere 4 means that you no longer need to make that tradeoff between the benefits of consolidation and of performance. The Intel Xeon processor 7500 series includes direct hardware support for Extended Page Tables (EPT). With this innovation, VMware vSphere 4 running on EPT-enabled Intel systems can readily handle the most demanding mission-critical applications.

The combination of VMware vSphere 4 on the Intel Xeon processor 7500 series both accelerates network performance and simplifies VM migration by allowing both 32-bit and 64-bit applications (and legacy operating systems) to run on the same physical server. This combination further reduces overhead by allowing the guest operating system to directly access processor cycles, thus reducing the need for computationally intensive software translations between the guest and host operating systems. This in turn keeps virtualized workload transaction latency at nearly the same level as that for the same application running in a physical environment.

Increased Power Efficiency

Data centers in the U.S. consume 4.5 billion kWh annually, or 1.5 percent of the country's total electrical consumption.[7] According to Gartner,[8] between 2007 and 2012 most U.S. enterprise data centers will spend as much on power and cooling as on the hardware itself. Gartner also predicts that energy costs for IT will only continue to rise and could double by 2012. With the high consolidation ratios possible with the Intel Xeon processor 7500 series and VMware vSphere 4, you can use less energy and space and dramatically reduce operating costs.

In addition, VMware® Distributed Power Management (DPM) can further reduce unnecessary power consumption by turning off servers when there is unneeded capacity. Servers are automatically powered back on when their capacity is required.

Flexibility and Scalability to Respond To Changing Business Conditions

Organizations require flexibility and performance in order to maximize agility, uptime, and business impact. Yet according to IDC, server deployments worldwide increased four-fold to 30.3 million between 1997 and 2007, using up available space in many data centers and limiting companies' ability to deploy new applications and respond to changing business conditions. VMware vSphere 4 and Intel Xeon processor 7500 series-based servers with Intel VT deliver outstanding virtualization performance and better utilization of legacy 32-bit guest applications running on virtual machines. This performance, combined with massive scalability of up to 256 sockets,[9] allows you to respond easily to new opportunities and changing business priorities.

Machine Portability

The portability of virtual machines allows organizations to eliminate planned downtime. The combination of VMware Enhanced VMotion™ (a key feature in vSphere 4) and Intel® Virtualization Technology FlexMigration (Intel® VT FlexMigration) allows IT departments to easily manage the selective migration of VMs. These technologies permit shutdown-level maintenance to be performed on host servers without requiring complex planning and overtime hours.

VMware Enhanced VMotion works with Intel VT FlexMigration to deliver the ONLY proven, enterprise-ready, live migration solution—enabling not only data center agility but also new usage models. This combination allows companies to simultaneously move multiple running VMs from one physical server to another with no impact on end users. The ability to move guests on the fly virtually eliminates planned downtime and allows companies to quickly adjust loads based on changing workload requirements and data center demands.

Intel VT FlexMigration gives IT flexibility and choice in managing and allocating VMware virtualized workloads across new and existing Intel processor-based platforms. This capability expands the pool of resources in a virtualized environment, providing agility as well as investment protection.

In addition to these two powerful tools, two others—VMware HA and VMware Fault Tolerance—combine with Intel VT FlexMigration to assure cost-effective high availability. When demand increases, VMware HA automatically restarts virtual machines on servers that have spare capacity, thus minimizing downtime and service disruption while reducing the need for dedicated standby hardware. VMware Fault Tolerance takes advantage of Intel VT FlexMigration to enable instantaneous failover and continuous availability for applications, which eliminates even the smallest service disruption.

Reliability, Accessibility, Serviceability (RAS)

The Intel® Xeon® processor series is specifically designed to provide leading reliability, accessibility, and serviceability (RAS) for physical and virtual environments. This processor series includes 20 new RAS features that enhance stability all across the microarchitecture—from memory to the CPU to the I/O hub and Intel® QuickPath Interconnect (Intel® QPI) links. These features help deliver levels of RAS that were previously available only on costly proprietary platforms. By offering exceptional reliability and industry-leading RAS features, Intel helps companies deploy an increasingly robust infrastructure while keeping their costs down and their options open.

With today's software virtualization solutions, IT groups are consolidating large numbers of applications on a single Intel Xeon processor-based server. This can dramatically improve utilization, reduce operating costs, and improve infrastructure agility. The high reliability of Intel Xeon processor 7500 series-based platforms is especially valuable in these consolidated environments, since a platform failure could impact dozens of applications.

The Intel and VMware platform make an ideal choice for mission-critical applications because of the advanced reliability made possible by new RAS features and virtualization. Organizations can virtualize these applications with confidence knowing that they are supported by new RAS features on the hardware and the inherent flexibility and mobility of vSphere virtual machines.

With vSphere 4, each virtual machine can scale to eight virtual CPUs (vCPUs), can access up to 255 GB of memory per, and can support I/O-intensive applications. Applications can also be scaled across multiple virtual machines, allowing organizations to leverage the capacity of the latest multi-core servers. Performance overhead associated with vSphere is commonly within the range of five to thirteen percent,[10] while network bandwidth can reach 40 Gbps.

Application Availability

VMware vSphere 4 allows IT to automatically provide varying levels of application availability based on the unique business requirements of each organization. As noted above, VMware HA and VMware Fault Tolerance (FT) can keep an application up and running by automatically either restarting a virtual machine (HA) or transferring control to a mirrored virtual machine (FT) on another physical server when the primary physical server experiences failure. These two features eliminate the need for costly and complex clustering solutions.

Processing Performance

The latest Intel Xeon processors are built using the Intel® microarchitecture formerly codenamed "Nehalem EX." This new microarchitecture is based on 45nm Hi-K metal gate silicon with hafnium circuitry technologies that enable Intel Xeon processor-based servers to offer leading performance. The design focus is on performance and scalability, built on a foundation of rock-solid reliability.

This new Intel microarchitecture replaces the front-side bus with Intel QPI Technology. This technology maximizes data transfer performance for multi-processor and/or multi-core platforms with two-way interconnects between processors and the I/O hub that can reach up to a blazing 25.6 GB per second for each link[11]. Having separate data paths for I/O and memory access makes both local and remote CPU memory access faster because the processor no longer has to communicate first with an external memory controller.

Intel® Turbo Boost Technology, another element of the microarchitecture, provides "performance on demand," which allows cores to run faster than their base operating frequency when they are below specified power, current, and temperature thresholds. When a processor detects that it is below these limits, it increases its clock frequency to boost the performance of the active cores. This technology gives you extra performance when and where it's needed, providing a dynamically scalable solution for spikes in workload demands.[12]

Additional performance improving features include:

- **More instructions per cycle:** enabled by more efficient algorithms and greater parallelism
- **Enhanced branch predictions:** allows processors to fetch and execute instructions without waiting for a branch to be resolved
- **Simultaneous multi-threading:** delivers Intel Hyper-Threading Technology that allows each core to process two threads at once, doubling the number of threads that can be handled by each processor[13]
- **Large last-level shared cache (Smart Cache):** provides up to 24 MB inclusive L3 (last-level) cache shared across all cores, which reduces latency and snoop traffic between cores
- **New Application Targeted Accelerators:** provide new string and text processing instructions to parse XML strings and text at much higher speed

Performance Test: Powering a Mission-critical Application with the Intel® Xeon® Processor 7500 Series and VMware vSphere™ 4

This test demonstrates that organizations can virtualize mission-critical database applications with confidence using the latest solutions from Intel and VMware. The test shows that IT can provide these applications with the processing power, throughput, and bandwidth they require while simultaneously adding the availability and flexibility benefits only realized through virtualization.

Test Goals

Our specific goals of this performance test were as follows:

- Establish baseline performance benchmarks, using a sample mission-critical database application based on Microsoft SQL Server 2008 x64 Enterprise SP1 running natively on a Microsoft Windows Server 2008 R2 Enterprise server based on the Intel Xeon processor 7500 series.
- Establish comparative performance benchmarks by virtualizing the above scenario with VMware vSphere 4.

The test measures the time it takes to complete common database actions, using industry-standard tools and testing methodologies to establish repeatable baselines, as well as custom tools designed to mimic "real-world" database deployments in regard to database size, typical transaction types, client connection loads, backups, and replication.

Test Methodology

The testing included two phases.

- **Phase 1:** In the first phase, we prepared and tested a physical server using the testing tools described below.

- **Phase 2:** In the second phase, we recreated the configuration from the first phase in a virtual machine. We then tested the virtual machine using the same testing tools and configurations.

Test Environment

Physical Infrastructure

We constructed the test environment as outlined below. For complete environmental data, see Appendix A.

- **Physical server**: Built using Intel Xeon X7560 processors. We used Windows Server 2008 R2 Enterprise as the operating system and installed SQL Server 2008 x64 Enterprise SP1 as the database system.
- **Virtual server**: Identical to the physical server; the only difference between this server and the physical server is that we installed Windows Server 2008 R2 Enterprise and SQL Server 2008 x64 Enterprise in a VMware vSphere 4 virtual machine.
- **Storage**: In order to best represent a true production environment, we used a Fibre Channel SAN to house the SQL Server data and log files.

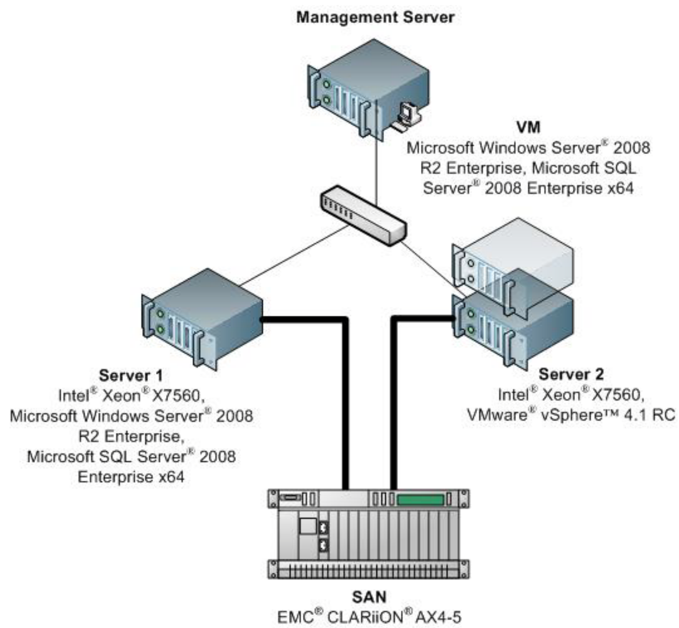

Figure 1: Physical infrastructure

- **Management server**: We used a separate physical server as the domain controller and VMware vCenter server to ensure that the only variable between the two test servers was the VMware virtual infrastructure.

Testing Tools

We selected the testing tools and methods for this test were with the following goals in mind:

- The test should recreate environmental parameters found in actual large-scale, large-transaction database applications.
- Test tools should be relatively easy to use so that the tests outlined here can be reproduced by database administrators for independent validation and lab recreation.
- The tools should produce reliable results in a repeatable fashion, and the statistics should be easily understood and clear in their relevance.
- The tools should be free and available to the public.

The tools selected were as follows:

SQLStress

SQLStress is a tool produced by David Kubelka. It is available free of charge so that anyone can use it to stress test Microsoft SQL Server installations. SQLStress can simulate multi-user and transactional scaling, can help find infrastructure problems, and can help with hardware sizing, system tuning, and benchmarking.

You can download SQLStress from http://www.sqlstress.com.

Custom Tools

To provide another level of realism to the testing, we created a custom sample database and custom TSQL commands to best simulate common SQL transactions and processes as seen in a mission-critical application.

Custom Sample Database

First, we created a sample database that would simulate a database that might be found in real-world application implementations. This database included the following attributes:

- Contained 2.8 million records
- 24 GB in size
- Used commonly used data types including INT, IMAGE, UNIQUEIDENTIFIER, and NVARCHAR
- Set to Full Recovery model
- Set to automatically grow at a rate of 10 percent as needed

Custom SQL Scripts

We then used simple, yet powerful SQL scripts against this test database to stress the SQL installation with varied operations of individual transactions types. Examples of this include CURSOR operations, conditional updates with varied data types, indexing, table joins, sequential INSERTS of data to force dynamic database file size growth, and other typical procedures and processes indicative of SQL Server business applications. The exact scripts used are detailed in Appendix B, and can be used to reproduce these tests in other environments.

We executed these scripts repeatedly and averaged the results to make sure they were statistically relevant. We captured the results of each execution using the Query Analyzer Tool.

Test Results

SQLStress Results

We used SQLStress to simulate both transactional and user scale against a mid-sized database. We executed a fixed blend of transaction types against a database designed to mimic a typical production database in a medium to large organization. This 20 GB database was hit with a set mix of deletes, inserts, updates, and selects over a 20 minute time span for each test run. We used a fixed transaction size of 8 kb in the inserts and updates. The simulated user count was varied for each test run, from 500 to 8,000. The test was run against each user count increment three times and averaged for a more accurate result. These results are summarized below:

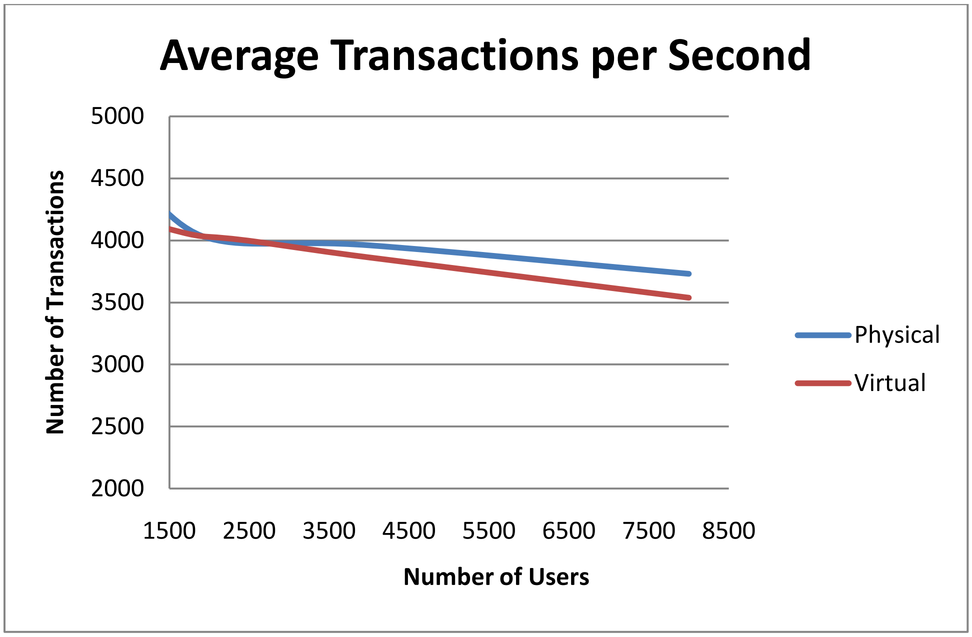

Figure 2 - Average transactions per second

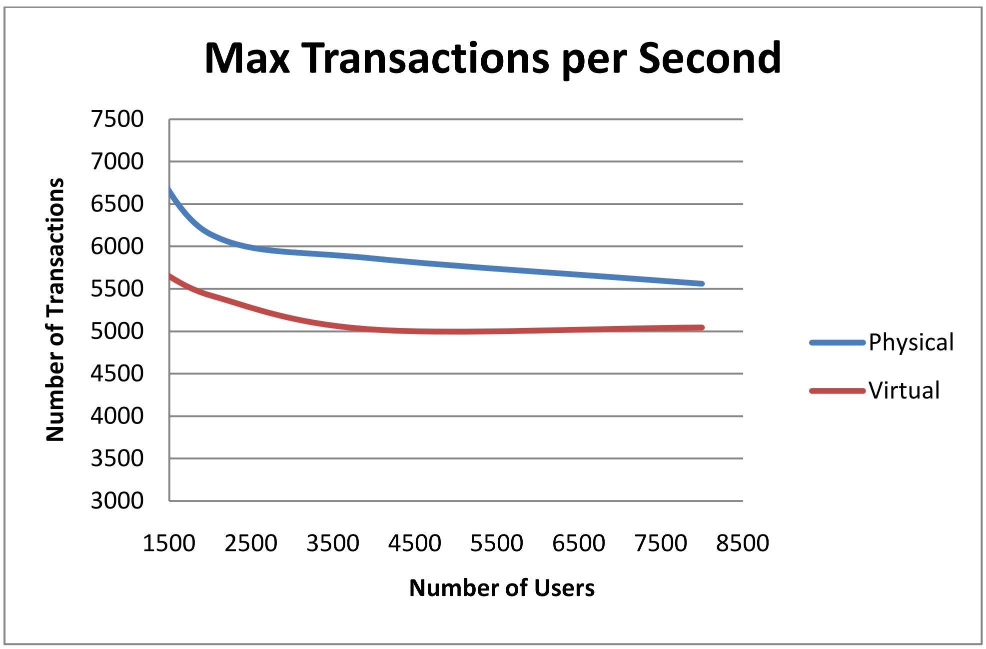

Figure 3 – Maximum transactions per second

Both the average and maximum transactions per second show that the virtualized Microsoft SQL Server 2008 workload maintained near-native performance, even as the user count reached 8,000.

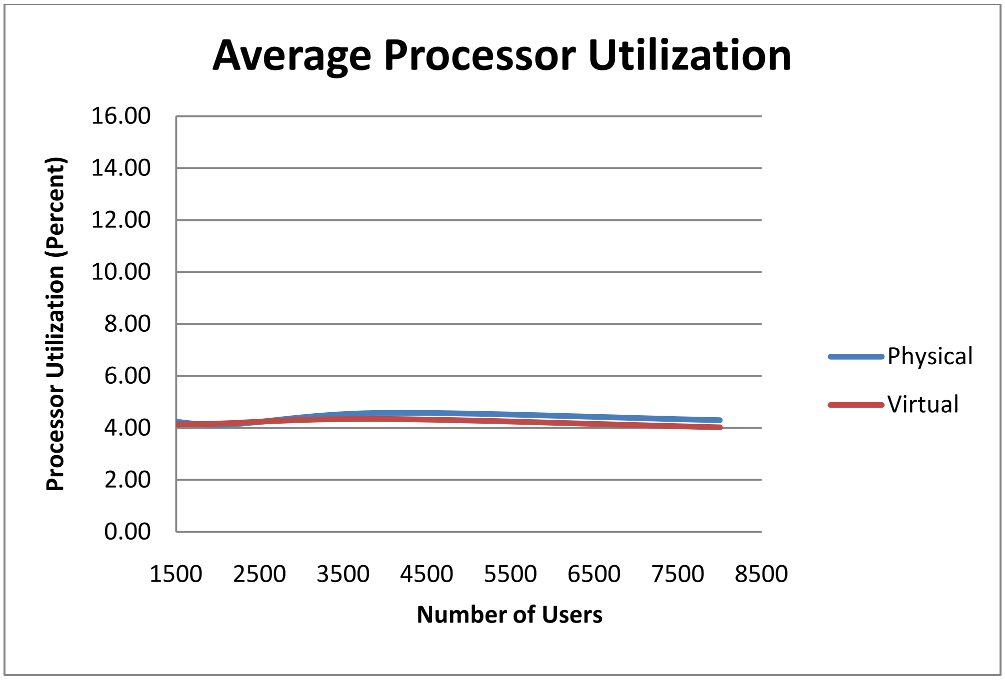

Figure 4 - Average processor utilization

Even as the number of simulated users reached 8,000, processor utilization hovered near four percent. For production systems, this means that servers based on the Intel Xeon processor 7500 series can easily power mission-critical database workloads, with headroom to spare for growth or periodic usage fluctuations.

Custom Tools Results

CURSOR Operations

This test created a named object in memory and programmatically iterated through specific records held in the CURSOR, examining each individual record. The data in the cursor record set is linked to the actual database data, which allowed the test to move through each record one at a time, performing conditional updates on individual datum.

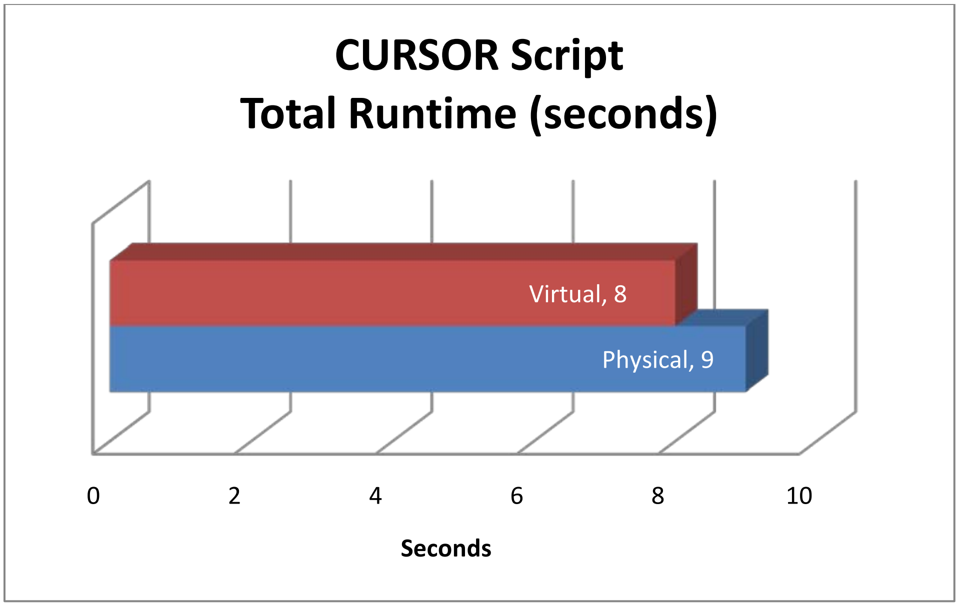

Figure 5 - Runtime for CURSOR operation

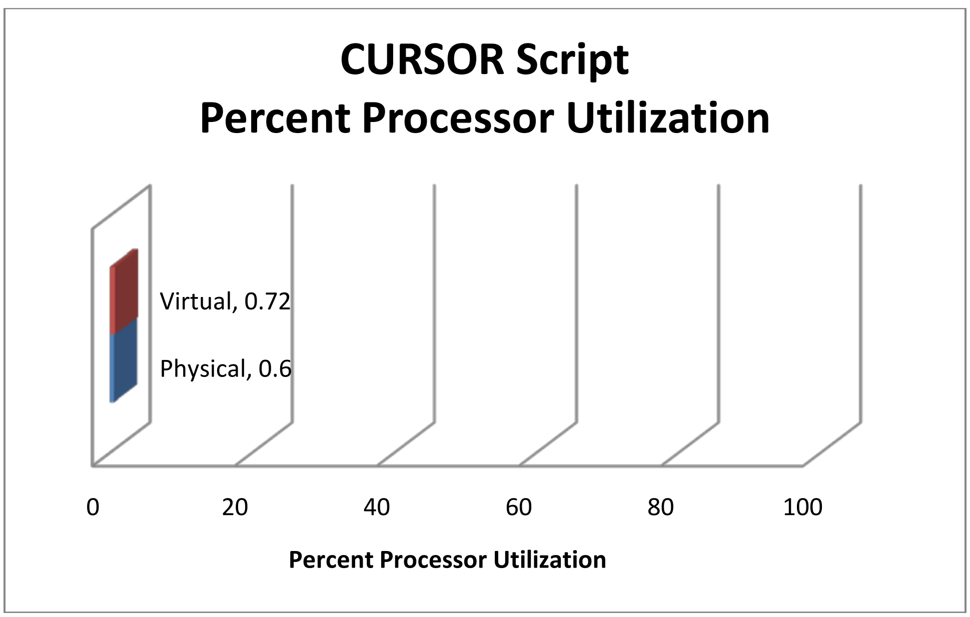

Figure 6 - Processor utilization during CURSOR operation

As Figure 5 and Figure 6 show, this CURSOR operation required only slightly less average processor power when performed on a physical server, but took one second longer to complete. While we did not expect the script to run faster in the virtual environment, it appears that the virtual machine was accessing a single NUMA node and was therefore using local memory. In contrast, the physical environment used multiple NUMA nodes and had to access remote memory.

UPDATE Operations

This test updates all the records in our test database by taking the numeric value from an existing field, adding 30 to it, and updating the field with the new value. This was executed against all 2.8 million records in the test database.

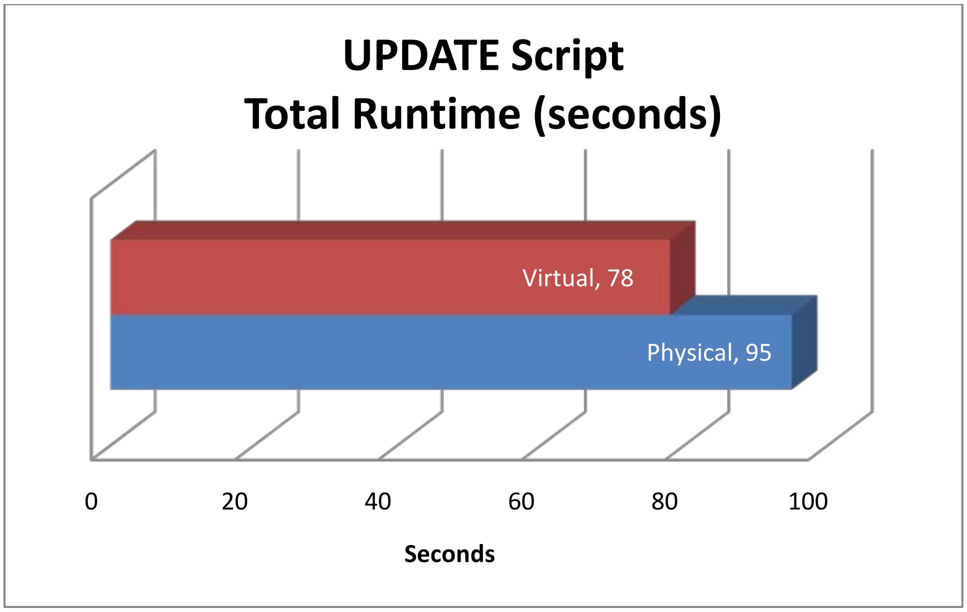

Figure 7 - Runtime for UPDATE operation

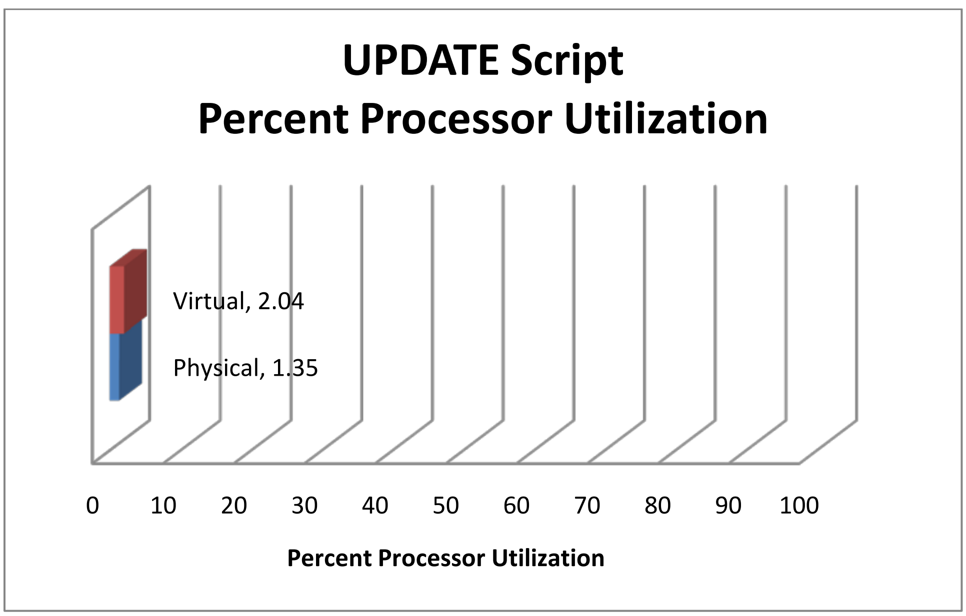

Figure 8 - Processor utilization during UPDATE operation

As Figure 7 and Figure 8 show, this UPDATE operation required only slightly less average processor power when performed on a physical server, but took 18 percent longer to complete. Remember, while we did not expect the script to run faster in the virtual environment, it appears that the virtual machine was accessing a single NUMA node and was therefore using local memory. In contrast, the physical environment used multiple NUMA nodes and had to access remote memory.

What These Results Mean For Your Organization

These tests have shown that running large mission-critical database workloads in a virtual environment can result in near-native workload performance, especially at higher scales. This fact allows organizations to realize the business continuity and flexibility benefits of virtualization without sacrificing workload performance.

The SQLStress tests indicate that as the simultaneous user count goes up, the virtualized SQL Server workload performs very similarly to a comparative physical workload. The tests executed using the custom tools indicate a similar trend, actually running faster in a virtual environment. These tests show that complex, processor-intensive SQL Server operations, run against a large production-caliber database, will return responses quickly with minimal performance overhead from the virtualization layer, while keeping processor utilization low.

These results prove that a joint platform of Intel Xeon processors and VMware vSphere 4 has the performance required to power mission-critical workloads, with headroom to spare. When these results are viewed with the added benefits an organization can gain through virtualization, it looks like there is much to gain by moving mission-critical database workloads onto a joint platform of the latest Intel Xeon processor-based servers and VMware vSphere 4.

Appendix A: Lab Configuration

Physical Server Configuration Details

System Component	Description
Processors	4 x Intel® Xeon® X7560 processor @ 2.27GHz
Memory	128 GB
Network Interface Cards	2 x Intel® PRO/1000 MT Dual Port Server Adapter
Host Bus Adapter	1 x 4 Gbps Single Channel Fibre Channel HBA
Disk Subsystem (SAN)	See Table 3 for details on SAN
Disk Configuration	• Data: D:\(500GB) – RAID Group 0; LUN 0 • Logs: L:\(500GB) – RAID Group 0; LUN 1
Operating System	Microsoft Windows Server® 2008 R2 Enterprise
Database System	Microsoft SQL Server® 2008 Enterprise x64 SP1 November CTP • Installation Type: Full • SQL Data Files: 500 GB LUN • SQL Log Files: 500 GB LUN

Table 1: Physical Windows Server® 2008 configuration

Virtualized Server Configuration Details

System Component	Description
Physical Processors	4 x Intel® Xeon® X7560 processor @ 2.27GHz
Physical Memory	128 GB
Network Interface Cards	2 x Intel® PRO/1000 MT Dual Port Server Adapter
Host Bus Adapter	1 x 4 Gbps Single Channel Fibre Channel HBA
Disk Subsystem (SAN)	See Table 3 for details on SAN
Host Operating System	VMware® ESX 4.1.0™ RC, 235786
Virtual Machine Operating System	Microsoft Windows Server® 2008 R2 Enterprise
Virtual Machine Database System	Microsoft SQL Server® 2008 Enterprise x64 SP1 November CTP • Installation Type: Full • SQL Data Files: 500 GB LUN • SQL Log Files: 500 GB LUN
Virtual Machine vCPUs	8 vCPUs
Virtual Machine Memory	127.8 GB
Virtual Machine Network Configuration	• 1 public virtual network adapter • 1 private virtual network adapter
Virtual Machine Disk Configuration	• Data: D:\(500GB) – RAID Group 1; LUN 2 • Logs: L:\(500GB) – RAID Group 1; LUN 3

Table 2: VMware® vSphere™ server configuration

SAN Configuration Details

System Component	Description
Model	EMC® CLARiiON® AX4-5
Memory Size	2 GB
Number of Disks	24 (12 per array)
HDD Details	• Model: Seagate STT30065 CLAR300 • Type: SAS • Raw Capacity: 268 GB
Base Software	FLARE® Rev. 02.23.050.5.707
RAID Configuration	• RAID 0_1 • RAID Groups: 2 @ 12 HDDs each • RAID Group 0 • Enclosure 0 • Disks: 0-11 • RAID Group 1 • Enclosure 1 • Disks: 0-11
LUN Configuration	• LUN 0 • Capacity: 500 GB • RAID Group 0 • LUN 1 • Capacity: 500 GB • RAID Group 0 • LUN 2 • Capacity: 500 GB • RAID Group 1 • LUN 3 • Capacity: 500 GB • RAID Group 1
Read / Write Cache	Disabled
Connection Speed	4 GB Fibre Channel (Per Server)

Table 3: SAN configuration

Appendix B: Custom SQL Scripts

CURSOR Operations

CURSOR operations were purposely designed to increase the load on the database. Cursor operations were in the following form:

```
BEGIN
Declare @DUser nvarchar(50),
            @Loop int

Select @Loop = 0
Declare LogCursor cursor
for select clientusername
from Base where id BETWEEN @BegID and @EndID

OPEN LogCursor

FETCH NEXT FROM LogCursor
INTO @DUser

WHILE @@FETCH_STATUS = 0
begin
 Select @Loop = @Loop + 1
 Fetch next from LogCursor into @DUser
end

Select @Loop
Close LogCursor
deallocate LogCursor
END
```

UPDATE Transactions

Update transactions were executed with varying complexity to best represent typical SQL Server environments. These took the form of UPDATE commands on a subset of data with column evaluation and conditional updates based on column data.

"Evaluative" updates took the following form:

```
UPDATE Scratch set ScratchDateColumn = ScratchDateColumn + 30 where id
BETWEEN @BegID and @EndID
```

The above statement evaluated each individual date per record and updated it to the current value plus 30 days. Note that this value was "intelligently" updated to actual calendar equivalency. i.e. "1/1/2010" would be updated to "1/31/2010" while "2/1/2010" would be updated to "3/3/2010."

The @BegID and @EndID variables were altered as necessary to select the desired number of records to update.

Appendix C: Complete Test Results

Complete SQLStress Results

Physical Server

Instances	Time (min)	Tx Size (KB)	% CPU Time	Max % CPU Time	Tnx/Sec	Max Tnx/sec	Avg Disk Queue	
							Data	Log
500	5	8	4.72	10.12	4238.37	6723.59	4.76	13.23
1000	5	8	4.55	9.22	4477.82	7341.42	4.01	13.11
2000	5	8	4.13	9.39	4015.95	6144.78	4.35	14.04
4000	5	8	4.58	10.06	3960.20	5855.66	4.87	13.46
8000	5	8	4.30	9.36	3730.07	5558.52	4.49	13.36

Virtual Server

Instances	Time (min)	Tx Size (KB)	% CPU Time	Max % CPU Time	Tnx/Sec	Max Tnx/sec	Avg Disk Queue	
							Data	Log
500	5	8	3.04	5.17	2503.66	5068.15	3.62	9.10
1000	5	8	4.00	5.87	3974.93	5841.37	3.66	11.81
2000	5	8	4.17	6.19	4028.76	5423.52	3.72	12.49
4000	5	8	4.34	6.04	3863.38	5018.75	4.74	12.77
8000	5	8	4.02	5.88	3538.64	5043.57	4.80	11.39

Complete Custom Tools Results

Platform	Cursor		Update	
	% CPU	Elapsed (ms)	% CPU	Elapsed (sec)
Physical	0.6	9	1.35	95
Virtual	0.72	8	2.04	78

References

[1] Comparison based on 4S best published results to www.vmware.com/products/vmmark/results.html as of 29 March 2010. **4S Intel® Xeon® processor X7460 based platform details:** IBM System x* 3850 M2 server system with four Intel Xeon processors X7460 (16M cache, 2.66GHz, 1066MHz FSB), 128GB (32x 4GB PC2-5300 667MHz Registered ECC DDR2 DIMMs, VMware ESX* 3.5.0 U3 GA. Referenced as published at 20.5 @ 14 tiles. For more information, see: http://www.vmware.com/files/pdf/vmmark/VMmark-IBM-2009-03-24-x3850M2.pdf. **4S Intel® Xeon® processor X7560 based platform details:** IBM System x* 3850 X5 server platform with four Intel® Xeon® Processor X7560 (24M cache, 2.26GHz, 6.40 GT/s Intel QPI), 384GB DDR3-1066 memory, VMware* ESX 4.0 Update 2. Referenced as independently published score of 71.85 @ 49 tiles. For more information, also see ftp://ftp.software.ibm.com/eserver/benchmarks/IBM_x3850X5_VMmark_Independent_Publication_033010.pdf. For all VMmark* results, see http://www.vmware.com/products/vmmark/results.html. VMware® VMmark™ is a product of VMware, Inc. VMmark utilizes SPECjbb2005® and SPECweb2005®, which are available from the Standard Performance Evaluation Corporation (SPEC).

[2] Virtualization Performance on vConsolidate profile 2 benchmark. Comparison based on Intel internally measured results as of 12 February 2010. **4S Intel® Xeon® processor X7460 based platform details:** Intel 7300 Chipset-based server system with four Intel Xeon processors X7460 (16M cache, 2.66 GHz, 1066 MHz FSB), Virtualization Technology Enabled, 32 GB (16x2GB DDR2-667 FBDIMM registered ECC), FC SAN – RAID 0 15K RPM SCSI, VMware* ESX 3.5 GA. Source: Intel internal testing as of May 2008. Score of workloads: 4.9. **4S Intel® Xeon® processor X7560 based platform details:** Intel 7500 Chipset-based reference server platform with four Intel® Xeon® Processor X7560 (24M cache, 2.26GHz, 6.40GT/s Intel QPI), Intel EIST enabled, Turbo Boost enabled, Hyper-Threading enabled, NUMA enabled, Prefetchers enabled, 128 GB (32x4GB DDR3-1066 DR registered ECC), FC SAN – RAID 0 15K RPM SCSI, VMware* ESX 4.0 u1 GA. Source: Intel internal testing as of Jan 2010. Score of workloads: 18.3.

[3] http://www.cio.com/article/16544/Business_Intelligence_Not_Just_for_Bosses_Anymore.

[4] Intel ®Virtualization Technology (Intel® VT) requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM) and, for some uses, certain platform software enabled for it. Functionality, performance or other benefits will vary depending on hardware and software configurations and may require a BIOS update. Software applications may not be compatible with all operating systems. Please check with your application vendor.

[5] See endnote 1

[6] Intel® Hyper-Threading Technology (Intel® HT Technology) requires a computer system with an Intel processor supporting Hyper-Threading Technology and an HT Technology enabled chipset, BIOS and operating system. Performance will vary depending on the specific hardware and software you use. See http://www.intel.com/info/hyperthreading/ for more information including details on which processors support HT Technology.

[7] http://www.eia.doe.gov/emeu/reps/enduse/er01_new-eng_tab1.html.

[8] Kumar, Rakesh. "US Data Centers: The Calm Before the Storm" Gartner, Sept. 25, 2007.

[9] The Intel® Xeon® processor 7500 series can support glueless configurations of up to eight sockets, and up to 256 sockets with a third-party node controller.

[10] Can occasionally be more, depending on the specific requirements of the workload.

[11] http://www.intel.com/technology/quickpath/introduction.pdf.

[12] http://www.intel.com/technology/turboboost/index.htm?iid=tech_arch_nextgen+body_turboboost.

[13] http://www.intel.com/technology/platform-technology/hyper-threading/index.htm?iid=tech_arch_nextgen+body_ht

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www.prowesscorp.com

5701 Sixth Avenue South
Suite 374
Seattle, WA 98108

206.443.1117 P
206.443.1119 F