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Advanced Micro Devices Competitive Performance Analysis of VMware ESX 3.0 on AMD and Intel Processors

Test report prepared under contract from AMD.

Executive summary

Advanced Micro Devices, Inc. ("AMD") commissioned VeriTest, a division of Lionbridge Technologies, Inc. to do performance testing based on VMware ESX Server virtualization software to conduct a competitive analysis and conduct performance testing of an AMD 4-CPU server containing soon to be released AMD Opteron™ processors supporting DDR2 (model 8820) in comparison to a 4-CPU Intel based system containing 4 dual-core 3.0Ghz Xeon™ MP processors (model 7040). VMware software virtualizes servers so that multiple applications, each encapsulated in an independent virtual machine, can run on the same physical server.

Key findings

- For the SQL workload (4 SMP SQL VMs plus 4 UP SQL VMs), the CPU utilization on the AMD-based server was nearly half (52%) that of the Intel-based server, yet the AMD-based server performed 16% more SQL requests/sec at this utilization. The SQL response times for the AMD-based server were between 3.5 times and 7 times faster than the Intel-based server as more VMs were added.
- At 96% CPU utilization on each server, the AMD-based server was able to deliver 2.6 times more WebBench requests/sec while simultaneously delivering 2.1 times more throughput (Mbps) on NetBench in a virtualized environment.
- The AMD-based server consumed up to 20.9% less power than the Intel-based server. In addition, the AMD-based server running workloads in 26 VMs consumed 4.7% less power than the Intel-based server running workloads in just 4 VMs.

The main goal of this report is to provide third-party analysis of the virtual machines that can be run on a single physical machine, using benchmark scoring as a basis for comparing the overall performance of AMD versus Intel processors, in a server consolidation environment.

VeriTest conducted the study by setting up a test bed that consisted of the AMD or Intel-based server being tested, a storage-area-network (SAN), 26 physical client servers, a 2Gb fibre channel adapter, and a gigabit Ethernet switch. The AMD or Intel-based servers under test were configured to use VMware ESX Server 3.0. Virtual machines, depending on the application, were configured to run 64-bit Windows 2003 Server Enterprise Edition, 32-bit Windows 2003 Server Enterprise Edition, or 64-bit SuSE Linux Enterprise 9.3, SP3. In addition, the test bed had pre-defined workloads that include SMP 64-bit SQL (single VM connected to, but not pinned to, two CPU cores), UP 32-bit SQL (single VM connected to, but not pinned to, a single CPU core), 64-bit WebBench, and 64-bit NetBench. Besides the 64-bit or 32-bit difference between the SQL virtual machines, the 64-bit version of SQL operated as a Symmetric Multi-Processor system (SMP) and the 32-bit version of SQL operated as a Uni-Processor system (UP).

In order to determine the relative performance between these two systems, 26 virtual machine workloads were created and then these workloads were divided into six test runs, each successive test run incorporating more workloads until all 26 were utilized or until the target platform was saturated. Overall, there were 4 SMP

64-bit SQL2005 workloads, 4 UP 32-bit SQL2005 workloads, 9 64-bit UP WebBench workloads, and 9 64-bit UP NetBench workloads.

The first goal of this study was to evaluate each server's performance for the SQL workload using a combination of large 64-bit SMP and medium 32-bit UP workloads to represent a range of database work. The large SMP SQL workloads were configured to generate 90 instances every 100ms by DBHammer, while the medium UP workloads were configured to generate 50 instances every 100ms. Four SMP VMs, each running a large 64-bit SMP SQL workload, were started and the performance measured. Additive to the SQL workloads, four UP VMs were added, each running a medium 32-bit UP workload, and the performance was subsequently measured. Though there is some variance in the work generated by DBHammer, it was expected to deliver a constant workload of 3600 requests/sec for the first 4 VM test (4 VMs x 900 instances/sec) and 5600 requests/sec for the 8 VM test (another 4VMs x 500 instances/sec). For a constant workload, CPU utilization can be used as a metric for performance but the actual requests/sec also needs to be monitored as they can vary. The CPU utilization was captured using VMware's ESXTOP utility. The PerfMon tool was used to collect the SQL batch requests/sec. This measurement revealed that at the 4 and 8 Virtual Machine level, the AMD-based server was delivering 15% more requests per second while utilizing about 50% less overall CPU than the Intel-based system.

Using the SQL VMs as a base workload, the second testing goal was to evaluate how much additional WebBench and NetBench work could be added to each server. Since WebBench and NetBench are both self-scaling, it was necessary to limit them to 1 client / 2 engines and 1 client / 4 engines respectively in order to be able to add multiple VMs of these workloads. Self-scaling connotes that the clients will issue an increasing number of requests as a server's capabilities increase up to a certain point where the clients finally self-limit.

Sets of 6 VMs (3 WebBench VMs and 3 NetBench VMs) were added until the server was approximately 95% utilized. Performance was measured by retrieving the output from the WebBench and NetBench clients. The results from this test showed a definite advantage for the AMD-based server where it was able to, on the average, serve about 2.5 times as many requests as the Intel-based server for WebBench, while simultaneously serving 2.1 times the number of Mbps for NetBench.

The final testing goal involved measuring power consumption between the AMD and Intel-based servers. This was monitored using the Power Analyzer Model 380801 by Extech Instruments. This test showed that, under any of the test loads, the AMD-based server utilized less power than the Intel-based system consumed – up to 20.9% less.

Testing Methodology

As stated in the Executive Summary, AMD commissioned VeriTest, a division of Lionbridge technologies, to conduct a structured sequence of tests in order to evaluate an AMD-based platform against an Intel-based server platform using VMware's ESX 3.0 virtualization software. Due to configuration and schedule requirements, the testing was executed onsite at AMD's facility in Austin, TX. A complete audit of the system setup and configuration was completed on all client systems and servers under test by a VeriTest engineer to confirm and validate usage of default settings.

The two servers being compared were selected as being roughly equivalent representatives of both AMD and Intel multi-processor, dual-core server technology. Each server had the following components in common:

- 4 processor sockets, each socket housing a dual-core processor representing the best server processor technology available from either manufacturer at the time of test.
- 32GB of PC4200 DDRII registered ECC RAM.
- 2 Intel PRO1000 MT Quad-port NICs, giving a total of 8 Gigabit Ethernet ports on each machine.
- 1 QLogic QLA2342 fibre-channel host bus adapter (HBA).
- 18GB, 15k rpm U320 SCSI drive.
- VMware ESX Server 3.0 RC1.

AMD supplied the server hardware for both the AMD and the Intel-based systems.

Test Environment

The test bed consisted of one of the previously mentioned servers under test, two 16-port SMC "smart" Gigabit Ethernet switches, an HP Modular Storage Array dedicated to each server being tested, and 26 physical client servers. A complete description of the test bed is revealed in Appendix A, with a graphical representation shown in Figure 5.

The test tools used for this study consisted of the following:

<u>VMware ESX Server 3.0 RC1</u>-
ESX Server 3.0 is virtualization software that allows for the partitioning of a single physical server into multiple virtual servers. Each of these virtual servers has its own virtualized hardware that includes CPUs, system memory, disk drives, and networking interfaces. In addition, each of these virtual servers can and will run its own operating system. ESX Server 3.0 maps the virtualized hardware for each of these virtual servers to the actual physical server hardware.

ESX Server 3.0 64-bit guest support is currently experimental per VMware's published documentation.

<u>SQL DBHammer</u>-
DBHammer is a software testing utility that provides database loads in order to test Microsoft SQL server. In this study, DBHammer was configured to generate workloads that would allow SQL batch commands to be tracked.

<u>WebBench</u>-
WebBench is a software testing utility that uses physical client systems to simulate users with web browsers that are requesting static or dynamic web page content. In this test, WebBench was configured to request static content only.

<u>NetBench</u>-
NetBench is a software testing utility that measures how well a file server handles file input/output requests from Windows clients. In this study, NetBench was utilized to generate workloads that would allow network throughput to be measured.

Virtual Machine Workload Configurations

To load the server systems under test, four basic workloads were developed. The first workload consisted of a 64-bit instance of Microsoft SQL Server 2005 running on a 2 processor virtual machine. The SQL workload was generated using the DBHammer utility, driven from external clients. The second workload consisted of a 32-bit instance of Microsoft SQL Server 2005 running on a single processor virtual machine. Again, the SQL workload was generated by using the DBHammer utility which was driven from external clients. The third workload consisted of a 64-bit WebBench session that utilized the Apache web server to handle requests from the external clients for static web pages. The fourth and final workload consisted of a 64-bit NetBench session that handled file requests from the external clients to a network share that was located on the attached network storage.

Testing Process

The testing process consisted of utilizing these pre-configured VM workloads and applying a specified quantity and mix of them for six testing passes. In each subsequent testing pass the VM workloads were increased in order to generate a larger overall test load. Here follows a brief description of each test pass:

Test Run #1: Idle server.
This test run consisted of loading the VM workloads utilized in Test Run #4 but having none of the workloads running. This test provides a total of 20 idle VMs.
Test Run #2: Four Virtual Machines.
This test run exclusively consists of four 2-processor, 64-bit SQL2005/DBHammer virtual machines. This test has a total of four active VMs.

Test Run #3: Eight Virtual Machines.
This test run consisted of the workload in Test Run #2 plus four 1-processor, 32-bit SQL2005/DBHammer virtual machines. This test has a total of eight active VMs.

Test Run #4: Fourteen Virtual Machines.
This test run consisted of the workload in Test Run #3 plus three 1-processor, 64-bit WebBench virtual machines and three 1-processor, 64-bit NetBench virtual machines. This test has a total of 14 active VMs.

Test Run #5: Twenty Virtual Machines.
This test run consisted of the workload in Test Run #3 plus six 1-processor, 64-bit WebBench virtual machines and six 1-processor, 64-bit NetBench virtual machines. This test has a total of 20 active VMs.

Test Run #6: Twenty Six Virtual Machines.
This test run consisted of the workload in Test Run #3 plus nine 1-processor, 64-bit WebBench virtual machines and nine 1-processor, 64-bit NetBench virtual machines. This test has a total of 26 active VMs.

Test results

The first testing goal was to provide a base SQL workload for the two servers being tested. Although there is some variance in DBHammer, the workload is intended to be a relatively constant workload of 3600 requests/sec (4 times 90 instances every 100msec) for the 4 SMP SQL VMs and an additional 2000 requests/sec (4 times 50 instances every 100msec) for the 4 UP SQL VMs. Figure 1 below represents the 4 and 8 VM cases as these were the two tests that utilized the SQL workloads exclusively. The AMD system experienced a higher request/sec workload, yet required only about half the CPU utilization of the Intel system to fulfill the requests. As stated earlier, this CPU usage was measured using VMware's ESXTOP system resource monitoring utility.

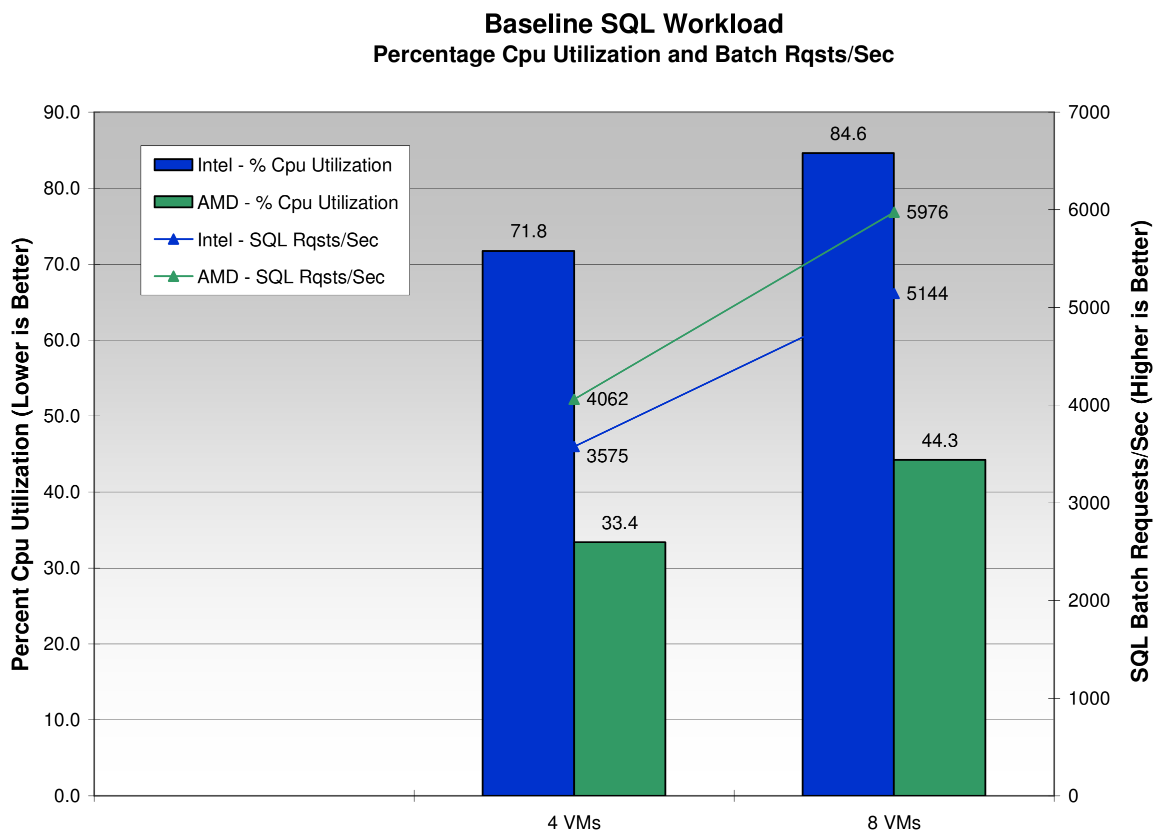

Figure 1: Baseline SQL Workload

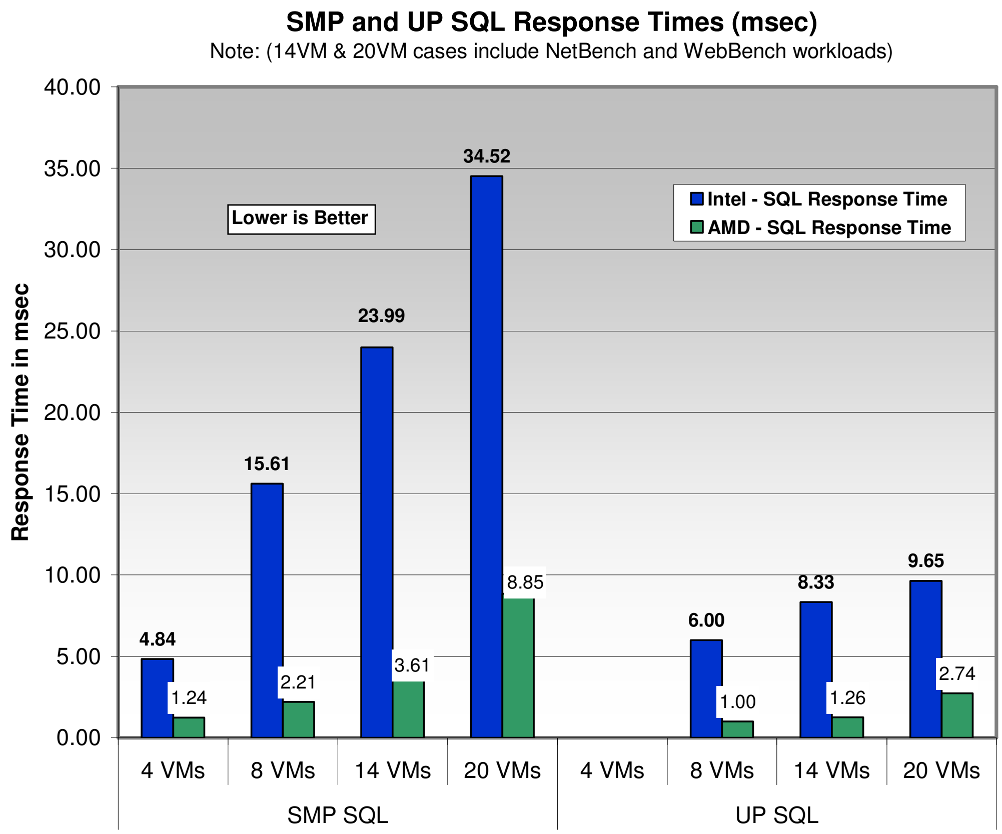

Figure 2: SMP and UP SQL Response Times

As the key metric for DB Hammer, Figure 2 depicts the associated response times for the AMD and Intel systems for each of the associated virtual machine cases. The response time for the AMD platform was approximately four times (4X) faster in most cases and at times exceeded seven times (7x) faster.

The second goal of this study was to determine how the servers perform as the additional workload of serving static web pages (with WebBench) and serving files (with NetBench) was added. The WebBench and NetBench workloads were added in sets of 6 VMs (3 WebBench VMs and 3 NetBench VMs). Figure 3 shows the results of this testing, with the 14VM case consisting of the 8 original SQL VMs plus the first set of 6 WebBench/NetBench VMs. The 20VM and 26VM cases are tests that have added more sets of the 6 VM WebBench/NetBench workload. The Intel-based platform was unable to run the 26VM case, having already saturated at 96% utilization in the 20VM case (Refer to Table 1 at the end of this section for utilization of all cases).

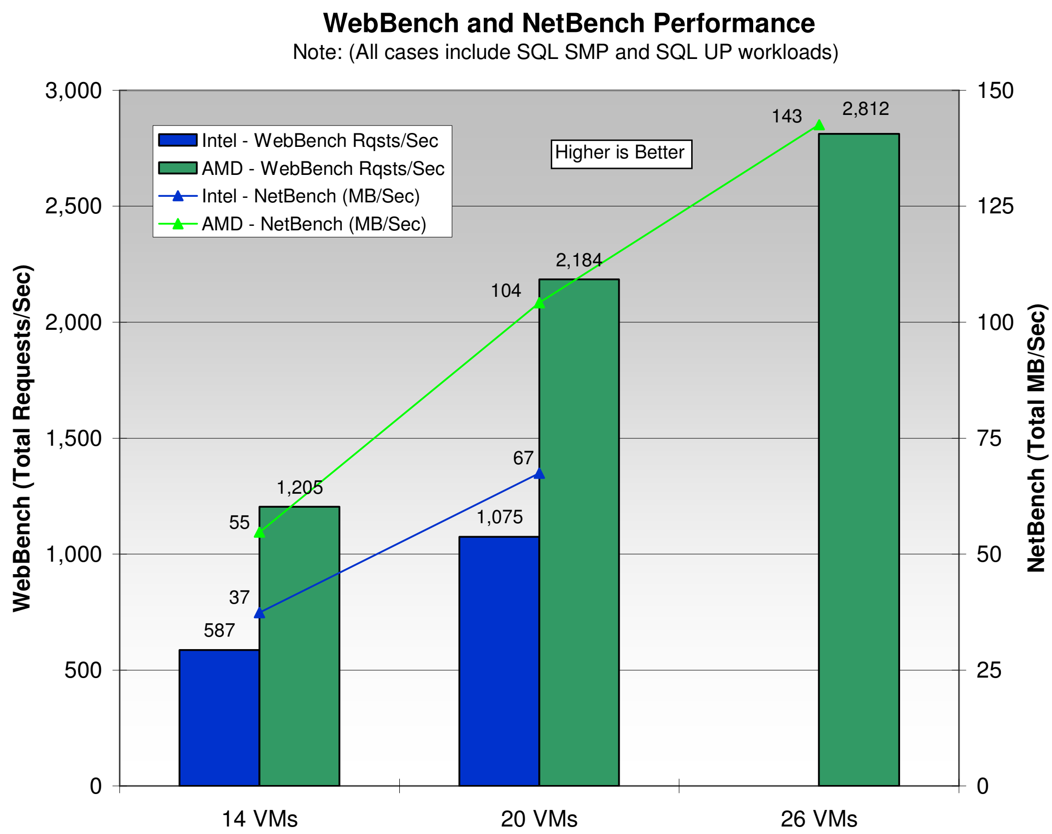

Figure 3: WebBench and NetBench Performance

At 20VMs (8 SQL VMs + 6 NetBench VMs + 6 WebBench VMs), the AMD platform was only 82% utilized versus a 96% utilization on the Intel platform. The AMD platform was able to provide 6 additional VMs before reaching 95.5% utilization (approximately that of the Intel platform). At 96% utilization, the Intel platform was able to provide 1,075 WebBench Requests/Sec and 67 Mbps for NetBench. While maintaining a sustained workload of 8 SQL VMs across all VM groups and an equivalent utilization, the AMD platform could provide over two and a half times the number of WebBench Requests/Sec (2,812) and over twice the NetBench Mbps (143 Mbps).

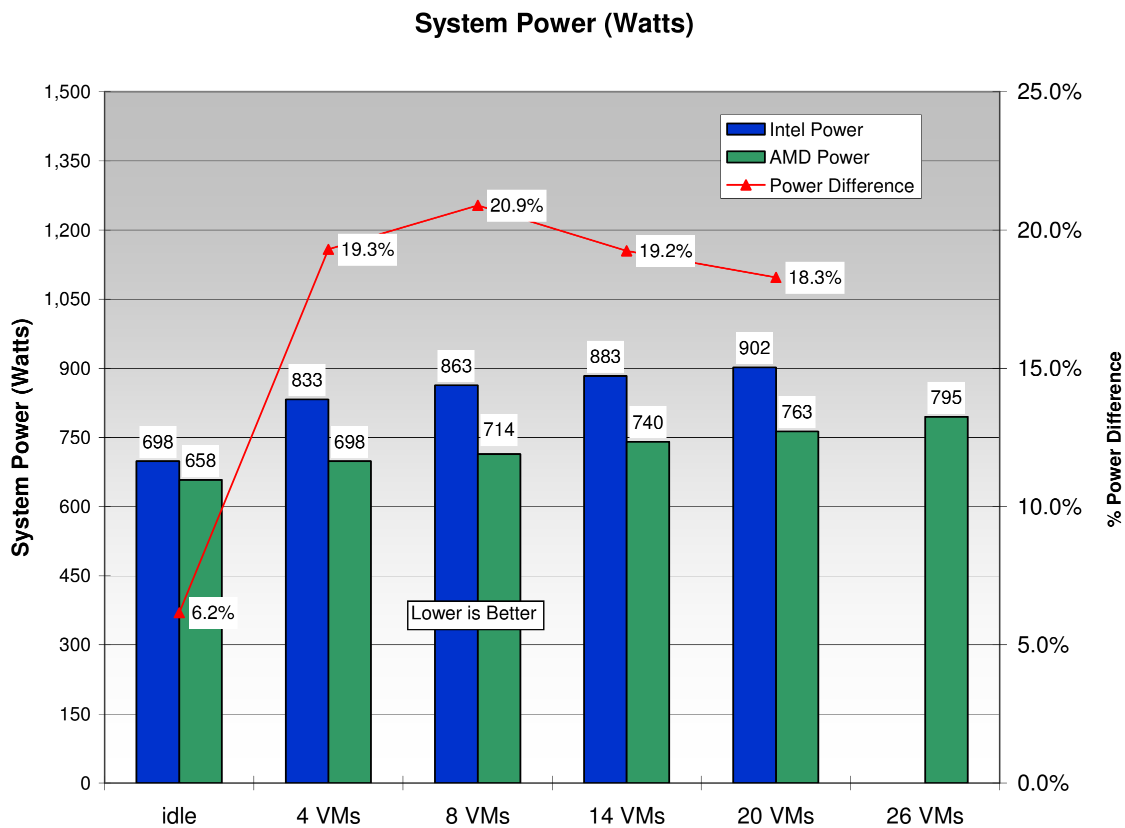

Figure 4: Electrical Power Consumption Comparison

The AMD platform consumed up to 20.9% less power while providing over 2.5 times the number of web requests and twice the amount of file server traffic in NetBench. The wattage of the AMD platform at 26VMs was 4.7% less than the wattage for the Intel platform running only 4VMs. This information was captured using the Power Analyzer Model 380801 by Extech Instruments. The software component of this device is also called Power Analyzer (version 2.11 was utilized). During the test runs the power consumption of both redundant power supplies was tracked and noted for reporting purposes after the VM workloads had stabilized. The comparative power consumption performance between the AMD-based server and the Intel-based server are shown in Figure 4. In order to ensure a comparative analysis was performed, external disk subsystems were utilized wherever possible thus ensuring the power analysis was concentrated on measuring the CPU power usage.

Average CPU Utilization Comparison (percentage)					
	4 VMs	8 VMs	14 VMs	20 VMs	26 VMs
Intel - % Cpu Utilization	71.8%	84.6%	94.1%	96.6%	
AMD - % Cpu Utilization	33.4%	44.3%	64.0%	82.0%	95.5%
Average Power Utilization Comparison (watts)					
	4 VMs	8 VMs	14 VMs	20 VMs	26 VMs
Intel Power	833	863	883	902	
AMD Power	698	714	740	763	795
Total SQL Batch Requests/Sec (SMP + UP)					
	4 VMs	8 VMs	14 VMs	20 VMs	26 VMs
Intel - SQL Rqsts/Sec	3575	5144	4785	4982	
AMD - SQL Rqsts/Sec	4062	5976	5877	5672	4729
Average SMP SQL Response Time (msec)					
	4 VMs	8 VMs	14 VMs	20 VMs	26 VMs
Intel - SMP SQL Response Time	4.84	15.61	23.99	34.52	
AMD - SMP SQL Response Time	1.24	2.21	3.61	8.85	27.51
Average UP SQL Response Time (msec)					
	4 VMs	8 VMs	14 VMs	20 VMs	26 VMs
Intel - UP SQL Response Time		6.00	8.33	9.65	
AMD - UP SQL Response Time		1.00	1.26	2.74	5.98
Total WebBench Requests/Sec					
	4 VMs	8 VMs	14 VMs	20 VMs	26 VMs
Intel - WebBench Rqsts/sec			587	1,075	
AMD - WebBench Rqsts/sec			1,205	2,184	2,812
Total NetBench Mbps					
	4 VMs	8 VMs	14 VMs	20 VMs	26 VMs
Intel - NetBench Mbps			37	67	
AMD - NetBench Mbps			55	104	143

Table 1: Table of Results

Conclusion

On behalf of AMD, VeriTest performed performance testing to evaluate AMD and Intel-based platforms using VMware ESX Server 3.0 virtualization software and to gather real-world measurements. The goal of this testing was to provide an independent, third-party analysis of the virtual machines that can be run on a single physical machine, and to use benchmark scoring as a basis for comparing the overall performance of AMD versus Intel processors, in a heterogeneous virtualized environment.

The results of this study show that, in using a series of six testing passes, each with an increasing number of virtual machine workloads, the AMD-based server outperformed the Intel-based system in many important metrics that are critical to end users. The first, in the case of the SQL workload, the CPU utilization on the AMD-based server was nearly half (52%) that of the Intel-based server, yet the AMD-based server performed 16% more SQL requests/sec at this utilization. The SQL response times for the AMD-based server were from 3.5 times to 7 times faster than the Intel-based server as more VMs were added. Availability of free CPU cycles and ability to processes more workload at attractive response times directly contributes to overall productivity improvements of an end user. Customers can further improve their server consolidation by running more applications with the free CPU cycles. The second observation was that the AMD-based system was able to serve over 2.5 times as many static web page read requests as was the Intel-based system, while simultaneously transferring over twice as many network files. And finally, during the processing of all of these tests, the AMD-based server was consuming an average of 20.9% less electrical power as did the Intel-based system.

Appendix A: Test Bed Configuration

Workload

Virtual Machines (VMs)
 4 x 2 Processor (4 cores) VMs of 64bit SQL2005
 4 x 1 Processor (2 cores) VMs of 32bit SQL2005
 9 x 1 Processor (2 cores) VMs of 64bit WebBench (64bit Linux/Apache)
 9 x 1 Processor (2 cores) VMs of 64bit NetBench (64bit Linux/Samba)
26 Total VMs

Workloads

- 2 Processor SMP SQL
  - 64-bit Microsoft SQL Server 2005
  - DBHammer, driven from external clients with 90 instances and 100ms
  - Single network card connected using e1000 driver
  - C: drive located on OS LUN
  - D: drive located on SQL LUN for database and log
- 1 Processor UP SQL
  - 32-bit Microsoft SQL Server 2005
  - DBHammer, driven from external clients with 50 instances and 100ms Single network card connected using flexible VMware driver
  - C: drive located on OS LUN
  - D: drive located on SQL LUN for database and log
- 1 Processor WebBench
  - WebBench version 5.0
  - Apache version 2-2.0.49-27.38
  - Static workload only
  - 1 client/2 engine from 1 physical client per WebBench VM
  - / drive located on OS LUN (file set on OS LUN also)
  - Single NIC per VM, connected to private subnet
- 1 Processor NetBench
  - NetBench version 7.0.3
  - / drive located on OS LUN
  - Samba share drive located on NB LUN for database
  - 1 client / 4 engine from 1 physical client per NetBench VM
  - Single NIC per VM, connected to private subnet.

Metrics

- System
  - CPU utilization from ESXTOP utility with 2 second sample rate.
  - Average disk Reads/sec from each LUN – OS, SQL, NetBench (fm ESXTOP)
  - Average disk Writes/sec from each LUN – OS, SQL, NetBench (fm ESXTOP)
  - Collect performance data for 25 minutes (covers entire NetBench and WebBench runs)
- SMP SQL
  - SQL Batch Requests/sec from each SQL VM (from PerfMon)
  - Average Response Time from each SQL VM (from DBHammer)
  - Run SQL and collect performance data for 25 minutes
- UP SQL
  - SQL Batch Requests/sec from each SQL VM (from PerfMon)
  - Average Response Time from each SQL VM (from DBHammer)

        - Run SQL and collect performance data for 25 minutes
    - WebBench
        - Requests/sec and Response Time from each WebBench VM
        - Run 3, 300sec iterations, reporting score from 2nd iteration
    - NetBench
        - Throughput and Average Response Time from each NetBench VM
        - Run 2, 660sec iterations, reporting score from 2nd iteration, and a final 3rd iteration to run during SQL data collection.

Tests

Run tests 1 through 4 on Intel-based box (Test 4 will saturate it)
Run tests 1 through 6 on AMD box

Test Run	Description
1	Idle (Measure total CPU Utilization with all VMs of Test 4 booted but no workload running) **20 Total Idle VMs**
2	4 x 2P VMs of 64bit SQL2005/DBHammer with 90 instances and 100ms **4 Total VMs**
3	4 x 2P VMs of 64bit SQL2005/DBHammer with 90 instances and 100ms 4 x 1P VMs of 32bit SQL2005/DBHammer with 50 instances and 100ms **8 Total VMs**
4	4 x 2P VMs of 64bit SQL2005/DBHammer with 90 instances and 100ms 4 x 1P VMs of 32bit SQL2005/DBHammer with 50 instances and 100ms 3 x 1P VMs of 64bit WebBench (64bit Linux/Apache) 3 x 1P VMs of 64bit NetBench (64bit Linux/Samba) **14 Total VMs**
5	4 x 2P VMs of 64bit SQL2005/DBHammer with 90 instances and 100ms 4 x 1P VMs of 32bit SQL2005/DBHammer with 50 instances and 100ms 6 x 1P VMs of 64bit WebBench (64bit Linux/Apache) 6 x 1P VMs of 64bit NetBench (64bit Linux/Samba) **20 Total VMs**
6	4 x 2P VMs of 64bit SQL2005/DBHammer with 90 instances and 100ms 4 x 1P VMs of 32bit SQL2005/DBHammer with 50 instances and 100ms 9 x 1P VMs of 64bit WebBench (64bit Linux/Apache) 9 x 1P VMs of 64bit NetBench (64bit Linux/Samba) **26 Total VMs**

Software

ESX

- ESX 3.0 RC BUILD 24788
- Primary Partitions
    - /boot = 100MB
    - Swap = 1600MB
    - / = 6000MB
- Extended Partitions
    - /var = 8000MB (should be plenty for logs)
    - /vmimages = 16,000MB
    - /home = 12,000MB
    - /vmfs = ~50GB

- System memory allocation
  - 272MB - service console (default)
  - 8GB for SMP SQL VMs (2GB per VM)
  - 4GB for UP SQL VMs (1GB per VM)
  - 9GB for WebBench VMs (1GB per VM)
  - 9GB for NetBench VMs (1GB per VM)
  - ~1GB free
- No affinity set for any VMs

Guest Operating Systems

- 64-bit Windows 2003 Server Enterprise Edition for SMP SQL
  - SQL 2005 standard install as service
- 32-bit Windows 2003 Server Enterprise Edition SP1 for UP SQL VMs
  - SQL 2005 standard install as service
- 64-bit SLES9.3 SP3 for WebBench and NetBench
  - Apache version 2-2.0.49-27.38 standard install
  - Samba standard install for sharing
  - Linux only based ESX edits:
    - Ethernet0.dontSkipPagedBuffers = “TRUE”
    - Ethernet0.buffersToPrefetch = “20”

Hardware

Intel

- 4-socket Intel-based server
- 4 dual-core Intel Xeon™ MP Processors 3.0GHz/667MHz with 4MB L2 (Model 7040)
- 32GB of PC2-4200 DDRII (2GB DIMMs) REG ECC
- 2 Intel PRO1000 MT Quad Port NICs
- Fibre Channel QLogic QLA2342
- 18GB 15k rpm U320 SCSI Drive with ESX 3.0 RC1
- 1300W 220V 2/2 Power Supply (2 supplies, 1300W combined)

AMD

- 4-socket “Warthog” (AMD internal development system for Socket F (1207) processors)
- 4 AMD Opteron™ processors Model 8820 SE (120W, 2.8GHz/1GHz HT with 1MB L2 per core)
- 32GB of PC2-4200 DDRII (2GB DIMMs) REG ECC
- 2 Intel PRO1000 MT Quad Port NICs
- Fibre Channel QLogic QLA2342
- 18GB 15k rpm U320 SCSI Drive with ESX 3.0 RC1
- 1250W 220V 2/2 Power Supply (2 supplies, 1250W combined)

AMD Test System Notes:

- The AMD system in this test is an internal development vehicle. The system platform design is similar or reference-able to OEM systems that are being shipped within 90 days. This processor will be available within 90 days of this test GA. This will allow analysts to have the capability to reproduce these test results utilizing the same systems that were used by VeriTest.

SAN

- Each System under Test has it’s own SAN consisting of:
  - HP Modular Storage Array (MSA1500)
  - 2 MSA30 drive enclosures, each with 14 15k rpm 36GB Ultra320 SCSI drives for a total of 28 drives (1,008GB)
  - 1 2GB fibre connection to SAN

- Array configured as 3 LUNs:
  - OS LUN: 200GB RAID5 for Guest VMs
    - 8GB per Guest OS
  - SQL LUN: 160GB RAID10 for SQL Databases
    - 4 5GB databases for SMP SQL
    - 4 5GB databases for UP SQL
  - NB LUN: 120GB RAID10 for NetBench Databases
    - 4 5GB databases

<u>Clients</u>

- 26 Physical Clients all consisting of:
  - 2 AMD Opteron processors Model 248 - Sun Microsystems Sun Fire V20z (2.2GHz)
  - 2 GB DDR1
  - Onboard Broadcom NetXtreme Gigabit Ethernet (1 port used)
  - 69 GB Fujitsu SCSI drive NTFS formatted
  - Windows Server 2003 Enterprise Edition SP1

<u>Control PC</u>

- 2 Processor – AMD Opteron based system (2.0GHz)
- 4GB DDR1
- Onboard Broadcom NetXtreme Gigabit Ethernet (2 ports used)
- 1 Intel PRO1000 MT Dual Port NIC
- Fibre Channel QLogic QLA2342
- 18 GB Seagate SCSI drive for OS
- 73 GB Seagate SCSI drive for Images and ISO's
- Windows Server 2003 Enterprise Edition SP1

<u>Power Monitoring Equipment</u>

- Power Analyzer, Model 380801 by Extech Instruments
- Power Analyzer software, version 2.11

<u>Network</u>

- 2 SMC TigerSwitch 8624T 10/100/1000 Gigabit-E Switches
- See network chart in Figure 5 for network configuration.

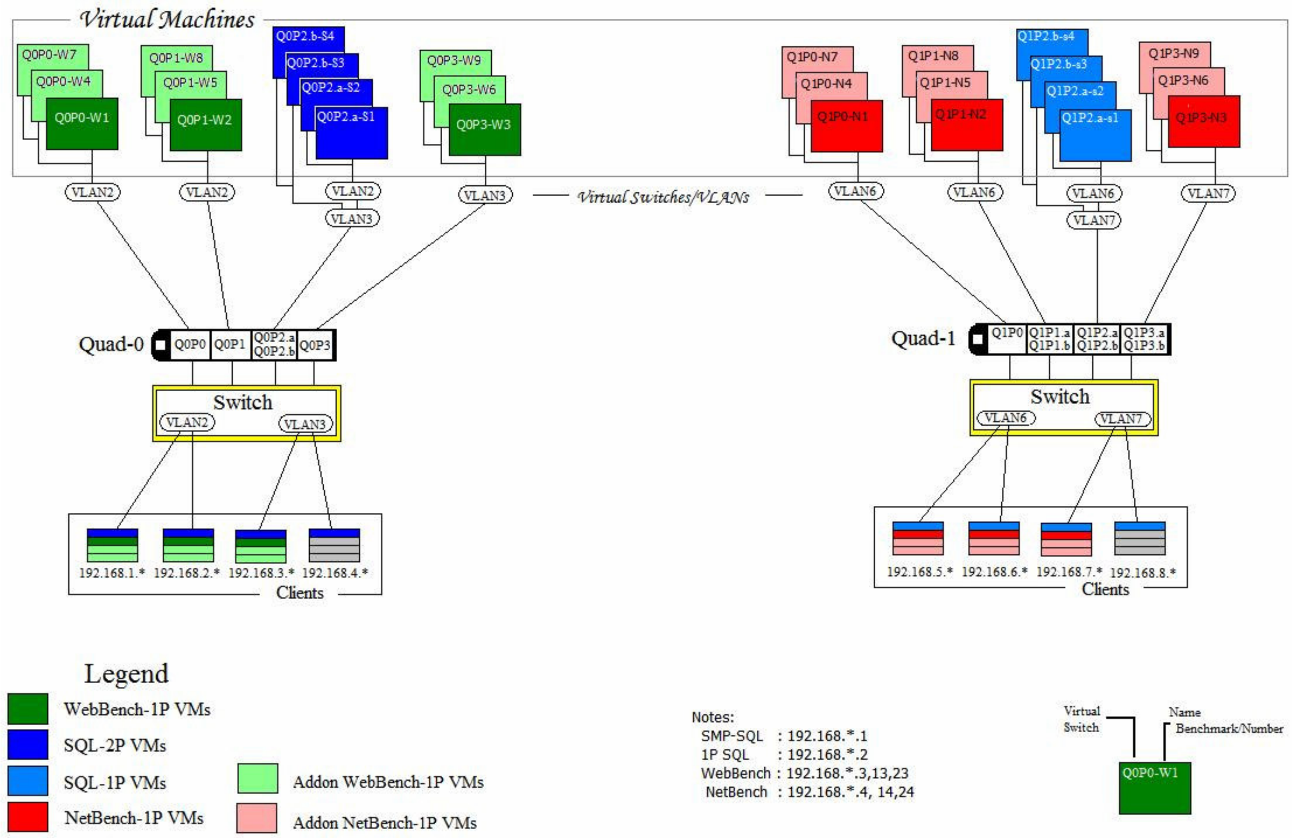

Figure 5: Test Bed Network Configuration

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