Principled Technologies®

TEST REPORT
JULY 2006

SysBench performance on Intel- and AMD-processor-based servers in a virtualized environment

Executive summary

Intel Corporation (Intel) commissioned Principled Technologies (PT) to measure the performance of multiple instances of SysBench in a server virtualization environment on dual-processor servers using the following two processors:

- Dual-Core AMD Opteron 285 (Hewlett-Packard Proliant DL385)
- Dual-Core Intel Xeon processor 5160 (Supermicro SuperServer 7045B-8R+B)

To create the server virtualization, we used the experimental 64-bit guest support of VMware's ESX Server, version 3.0 (www.vmware.com/products/vi/esx/). We created four virtual machines, each running Windows 2003 Server Enterprise x64 Edition. We tested the benchmark using one, two, and four virtual machines environments, each instance initialized simultaneously. We set up each of these virtual machine environments to have one processor and 1800 MB of RAM.

KEY FINDINGS

- The Dual-Core Intel Xeon processor 5160-based server out performed the Dual-Core AMD Opteron 285-based server in all virtual machine environments running SysBench.
- The Dual-Core Intel Xeon processor 5160-based server delivered 65 percent higher peak performance than the Dual-Core AMD Opteron 285-based server in the two virtual machine environment (see Figure 1).
- In the one and four virtual machine environments, the Dual-Core Intel Xeon processor 5160-based server delivered 64 and 39 percent higher peak performance, respectively, than the Dual-Core AMD Opteron 285-based server (see Figure 1).

SysBench is a benchmarking tool produced by the developers at SourceForge.net (sourceforge.net). It is designed to test various aspects of a server's capabilities, such as system and application throughput, CPU throughput, memory bandwidth performance, scheduler performance, and database performance using Online Transaction Processing (or OLTP) throughput. SysBench (sysbench.sourceforge.net) is developed to work with MySQL (www.mysql.com). For the purposes of our project, we used Microsoft SQL Server 2005 64-bit version (www.microsoft.com/sql/editions/64bit/default.mspx). In this workload, SysBench creates a table of a predetermined size in a SQL database and runs a simulated intensive batch of OLTP transactions. In our results, we report the length of time to complete this workload in each virtual machine.

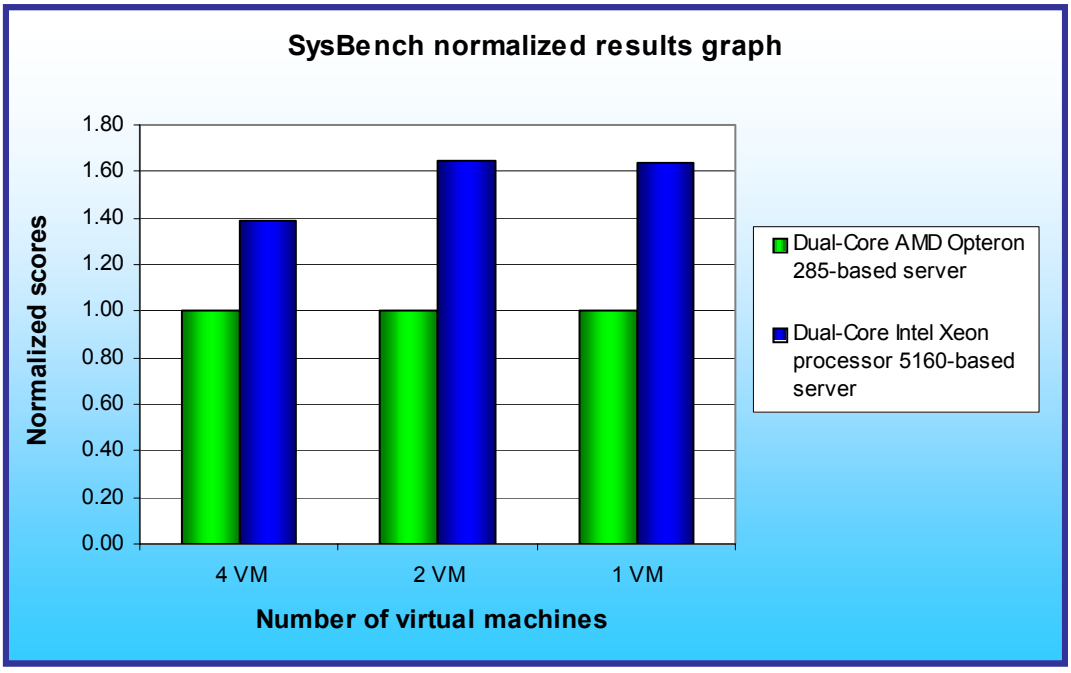

Figure 1: Normalized SysBench results for the two test servers in the one, two, and four virtual machine environments. Higher numbers are better.

Figure 1 shows the normalized SysBench test results of the two test servers running one, two, and four virtual machines.

Each result is the normalized median peak score of three runs of the benchmark. In this performance chart, we normalized the results to the completion time of the slower configuration. The slower system's result is thus always 1.00. The Dual-Core Intel Xeon processor 5160-based server produced higher results in each of the three environments. In the one virtual machine environment, the Dual-Core Intel Xeon processor 5160-based server was 64 percent faster over the Dual-Core AMD Opteron 285-based server. In the two virtual machines environment, the difference was 65 percent while in the four virtual machines environment, the Dual-Core Intel Xeon processor 5160-based server was 39 percent faster.

See the Test Results section for the median scores from all the runs of SysBench.

Test results

Figures 2 through 4 show the median SysBench results for both servers in the one, two, and four virtual machine environments. We set up these virtual machine environments each to have one processor and 1800 MB of RAM. (See Installing VMware ESX Server 3.0 for more details on the set up of the virtual machine environment.) We calculated the completion time, in minutes, by time stamping the log file in each virtual machine when the workload began and when it finished. We calculated the transactions per minute based on the number of transactions completed overall. For example, in the one virtual machine environment with only one instance of SysBench running, the workload runs 100,000 transactions. In the four virtual machine environment, four instances of SysBench are running, each performing 100,000.Thus, the total number of transactions is 400,000.

SysBench results in the one virtual machine environment – time of completion and transactions per minute		
Server	**Dual-Core AMD Opteron 285-based server**	**Dual-Core Intel Xeon processor 5160-based server**
Time of completion (in minutes)	22.50	13.70
Transactions completed	100,000	100,000
Transactions per minute	4,444.44	7,299.27

Figure 2: SysBench median results for the two test servers in the one virtual machine environment. Lower numbers are better for time of completion. Higher numbers are better for transactions per minute.

SysBench results in the two virtual machine environment – time of completion and transactions per minute		
Server	**Dual-Core AMD Opteron 285-based server**	**Dual-Core Intel Xeon processor 5160-based server**
Time of completion (in minutes)	23.45	14.18
Transactions completed	200,000	200,000
Transactions per minute	8,528.78	14,104.37

Figure 3: SysBench median results for the two test servers in the two virtual machine environment. Lower numbers are better for time of completion. Higher numbers are better for transactions per minute.

SysBench results in the four virtual machine environment – time of completion and transactions per minute		
Server	**Dual-Core AMD Opteron 285-based server**	**Dual-Core Intel Xeon processor 5160-based server**
Time of completion (in minutes)	24.50	17.67
Transactions completed	400,000	400,000
Transactions per minute	16,326.53	22,637.24

Figure 4: SysBench median results for the two test servers in the four virtual machine environment. Lower numbers are better for time of completion. Higher numbers are better for transactions per minute.

Test methodology

Figure 5 summarizes some key aspects of the configurations of the two server systems; Appendix A provides detailed configuration information.

Server	**Dual-Core AMD Opteron 285-based server**	**Dual-Core Intel Xeon processor 5160-based server**
Vendor	Hewlett-Packard	Supermicro
Model	Proliant DL385	SuperServer 7045B-8R+B
Processor frequency (GHz)	2.6GHz	3.0GHz
Single/Dual-Core processors	Dual	Dual
Motherboard	HP Proliant DL385 G1 399684-001	Supermicro X7DB8+
Chipset	AMD 8111/8131 chipset	Intel 5000P Chipset
RAM (8GB in each)	8 x 1GB PC-3200	8 x 1GB PC2-4400 FBDIMM
Hard Drive	4 x Seagate Cheetah ST336754LC 15K RPM 37 GB drives attached through Adaptec 39320A-R PCI-X 133MHz SCSI controller	4 x Seagate Cheetah ST336754LC 15K RPM 37 GB drives attached through Adaptec 39320A-R PCI-X 133MHz SCSI controller

Figure 5: Summary of some key aspects of the server configurations.

Intel configured and provided both servers.

The difference in RAM types reflects the capabilities of the two motherboards: The Supermicro X7DB8+ motherboard offered two independent front-side busses at a speed of 1333 MHz and contained Fully-Buffered DIMM (FBDIMM) modules that used commodity DDR2 PC2-4400 533MHz memory components. The HP Proliant DL385 G1 motherboard supported 184-pin DDR memory, and the highest memory speed available for the Dual-Core AMD Opteron 285-based server was DDR PC3200 400MHz RAM.

With the following exceptions, we used the default BIOS settings on each server: we disabled the HW Prefetcher and the Adjacent Cache Line Prefetcher on the Dual-Core Intel Xeon processor 5160-based server. These options were not available on the Dual-Core AMD Opteron 285-based server.

We began by installing a fresh copy of Microsoft Windows 2003 Server x64 Enterprise Edition Service Pack 1 on each server on one of the SCSI drives. We followed this process for each installation:

1. Assign a computer name of “AMD” or “INTEL”, depending on the server.
2. For the licensing mode, use the default setting of five concurrent connections.

3. Enter the password “password” for the administrator log on.
4. Select Eastern Time Zone.
5. Use specific IP address for the Network installation.
6. Use the default name “WORKGROUP” for the workgroup.

We applied the following updates from the Microsoft Windows Update site:

- Security Update for Windows Server 2003 x64 Edition (KB911280)
- Security Update for Windows Server 2003 x64 Edition (KB917953)
- Security Update for Windows Server 2003 x64 Edition (KB918439)
- Security Update for Windows Server 2003 x64 Edition (KB917344)
- Security Update for Windows Server 2003 x64 Edition (KB914389)
- Security Update for Windows Server 2003 x64 Edition (KB917734)
- Security Update for Windows Server 2003 x64 Edition (KB908531)
- Security Update for Windows Server 2003 x64 Edition (KB911562)
- Security Update for Windows Server 2003 x64 Edition (KB911927)
- Security Update for Windows Server 2003 x64 Edition (KB908519)
- Security Update for Windows Server 2003 x64 Edition (KB912919)
- Security Update for Windows Server 2003 x64 Edition (KB896424)
- Security Update for Windows Server 2003 x64 Edition (KB900725)
- Security Update for Windows Server 2003 x64 Edition (KB902400)
- Security Update for Windows Server 2003 x64 Edition (KB904706)
- Security Update for Windows Server 2003 x64 Edition (KB901017)
- Security Update for Windows Server 2003 x64 Edition (KB890046)
- Security Update for Windows Server 2003 x64 Edition (KB899587)
- Security Update for Windows Server 2003 x64 Edition (KB899591)
- Security Update for Windows Server 2003 x64 Edition (KB893756)
- Security Update for Windows Server 2003 x64 Edition (KB899588)
- Security Update for Windows Server 2003 x64 Edition (KB901214)
- Security Update for Windows Server 2003 x64 Edition (KB896422)
- Security Update for Windows Server 2003 x64 Edition (KB896358)
- Security Update for Windows Server 2003 x64 Edition (KB896428)
- Security Update for Windows Media Player Plug-in (KB911564)
- Update for Windows Server 2003 x64 Edition (KB898715)
- Update for Windows Server 2003 x64 Edition (KB914784)
- Update for Windows Server 2003 x64 Edition (KB910437)
- Cumulative Security Update for Internet Explorer for Windows Server 2003 x64 Edition (KB916281)
- Cumulative Security Update for Outlook Express for Windows Server 2003 x64 Edition (KB911567)

We then used the following steps to move the pagefile to the 4100MB partition we designated on another of the SCSI drives.

1. Right click on My Computer and select Properties.
2. Click on the Advanced tab.
3. Click on the Settings button in the Performance section.
4. Click on the Advanced tab.
5. In the Virtual Memory section, click Change.
6. Highlight the partition designated for the pagefile and enter the custom size of 2048MB for Initial size and 4079MB for Maximum size.
7. Reduce the custom size of the pagefile in the operating system partition to 400MB Initial size and 400MB Maximum size.
8. Click OK, click OK again, click OK again to exit the My Computer Properties box.
9. Restart the server.

Installing the server and configuring the SCSI drives

The purpose of this test was to run the SysBench benchmarks in the VMware ESX 3.0 server virtual machines while also in a native Windows 2003 Server environment. In order to accomplish this, we partitioned off an area of one of the SCSI drives to install Windows 2003 Server. We then installed VMware ESX 3.0 and edited the Grub loader to dual boot between the operating systems.

Figure 6 shows how we configured the four SCSI drives in each server and the partition scheme we used to accommodate both operating systems and four virtual machines.

SCSI drives	Partition type	Partition size
SCSI Drive No. 1		
Windows boot partition	ntfs	20MB
/boot	ext3	100MB
/	ext3	4000MB
Swap	swap	544MB
Vmkore	vmkore	100MB
Virtual machine storage (x2)	vmfs	29000MB
SCSI Drive No. 2		
/var/log	ext3	2000MB
Virtual machine storage (x2)	vmfs	29000MB
SCSI Drive No. 3		
Windows 2003 Server Enterprise x64 Edition	ntfs	6000MB
Virtual machine storage (x2)	vmfs	29000MB
SCSI Drive No. 4		
Windows Pagefile partition	ntfs	4100MB
Virtual machine storage (x2)	vmfs	29000MB

Figure 6: SCSI drive configurations for both operating systems and virtual machines.

Installing VMware ESX Server 3.0

After installing Windows 2003 Server Enterprise x64 Edition, we then installed VMware ESX Server 3.0 by following this process:

1. Reboot the server with the VMware ESX Server CD in the CD-ROM drive.
2. The installation wizard will guide the installation process
3. Assign a host name “amd.localhost” or “intel.localhost”, depending on the server.
4. Enter the password “password” for the administrator log on.
5. Select Eastern/New York Time Zone.
6. Use specific IP addresses for each server.
7. Once the installation is complete, reboot the server.
8. Log into the VMware ESX 3.0 Server.
9. Edit the Grub configuration file (grub.conf) found in the boot/grub directory to add the following lines:

```
title Windows 2003 Server Enterprise x64 Edition
      rootnoverify (hd0,0)
      chainloader +1
```

10. Attach one desktop system directly to each server using a crossover Cat 5 network cable.

11. Apply IP addresses in the same subnet as the IP address used in the installation process above.
12. On each desktop system, use the browser to operate the web interface available in VMware ESX 3.0 server.
13. Download and install the VMware Virtual Infrastructure Client 2.0 from the VMware ESX 3.0 Server, which serves as a management console to the VMware ESX Server and is used to build and set the resources for each of the virtual machines.
14. Mount the vmfs partitions as specified in Figure 6.
15. In the Configuration tab of the Virtual Infrastructure Client, click on the Storage (SCSI, SAN, and NFS) item under Hardware.
16. Use the Add Storage… wizard to mount each directory.
17. Accept all default settings with one exception: only mount the partition designated above for the virtual machine storage, not the entire SCSI drive.
18. Repeat this three more times and name the four storage partitions storage1 through storage4.
19. Create the first virtual machine using the New Virtual Machine Wizard with the following parameters:
    - Storage area: storage1
    - Guest Operating System: Microsoft Windows Server 2003, Enterprise Edition (64-bit)
    - Memory: 1800MB
    - Number of NICs: 1
    - Hard disk space: 10GB
    - CPUs: 1 virtual processor
    - SCSI Controller Type: LSI Logic
    - Virtual Machine Name: windows64-1
20. After creating the first virtual machine with the VMware Infrastructure Client, place the Windows 2003 Server CD in the management desktop system
21. Power on the virtual machine.
22. Mount the virtual CDROM connecting the virtual machine to the CDROM on the management desktop system.
23. The virtual machine will boot up and detect the bootable installation disk.
24. Install Windows 2003 Server Enterprise x64 Edition with the same configuration and updates as shown above.
25. Install VMware tools by clicking Inventory->Virtual Machine->Install VMware Tools.
26. Follow the installation wizard accepting all of the default settings.
27. Shutdown Windows and make sure the virtual machine is completely powered down.

Cloning the virtual machines

In order to create the other VMs, we did the following:

1. On the VMware ESX Server, push the Alt and F1 keys together to switch to a console.
2. Log in as root.
3. Maneuver to the first storage area where the newly created virtual machine resides: /vmfs/volumes.
4. The storage areas defined above reside here, storage1 through storage4.
5. VMware has already created a directory in storage1 named windows64-1 for the first virtual machine built.
6. Create the directories using the mkdir command for the other virtual machines, spreading them out so that there are two directories in each storage area (for example: mkdir ./storage2/windows64-2, mkdir ./storage3/windows64-3, mkdir ./storage4/windows64-4). Once completed, each storage1 partition should have at least one directory for each virtual machine.
7. Maneuver to the directory where the first virtual machine is stored: /vmfs/volumes/storage1/windows64-1.
8. Copy the two core files, windows64-1.vmdk and windows64-1-flat.vmdk to one of the newly created directories using the cp command (for example, cp *.vmdk /vmfs/volumes/storage2/windows64-2, cp *.vmdk /vmfs/volumes/storage3/windows64-3, cp *.vmdk /vmfs/volumes/storage4/windows64-4).
9. On the desktop system running VMware Virtual Infrastructure Client, click on the Virtual Machines tab.
10. Click File->New->Virtual Machine…
11. Use the Custom selection for Wizard Type and configure each with the same parameters as above.
12. At the Select a Disk screen, choose Use an existing virtual disk.

13. Click Next.
14. Maneuver to the directory of the next virtual machine.
15. Repeat Steps 9 through 14 for the remaining virtual machines.
16. Boot up each virtual machine one at a time starting with virtual machine No. 2.
17. Change the IP address to the next one in chronological order.
18. Change the computer name to the next in succession (for example, windows64-2, and windows64-3).
19. Reboot the virtual machine.

Installing and configuring SysBench

Before using SysBench, we installed Microsoft SQL Server 2005 x64 Edition, which also required us to install Microsoft IIS Services available in Windows 2003 Server. We installed this service using the Manage Your Server wizard.

After placing the Microsoft SQL Server CD in the CD-ROM drive, the installation wizard automatically appeared. We used the following steps to install and configure Microsoft SQL Server for preparation of the SysBench benchmark.

1. At the Feature Selection Setup Screen, select:
   - Database Services
   - Integration Services
   - Client Components
2. For Instance Name, select the Default and click Next.
3. At Service Account, select Use the built-in System account, chose Local system, and click Next.
4. At the Authentication Mode, select Windows Authentication Mode and click Next.
5. For the Collation Settings screen, keep all the default settings and click Next.
6. For Error and Usage Report Settings screen, keep both check boxes unchecked and click Next.
7. At the Ready to Install screen, click Install.
8. When the Installation Complete screen, click Finish.
9. Reboot the server.

We followed the following steps to create the database named “sbtest” (the default database name for SysBench):

1. Click Start->All Programs->SQL Server 2005->SQL Management Console.
2. When the console opens, right click on Databases in the left pane.
3. Select Create Database.
4. When the Create Database dialog box opens, enter sbtest in the Database Name prompt and click OK.
5. Close the SQL Server management console.

The SysBench benchmark is a self-contained executable with a list of options for the type of workload to run and the parameters under which to run them and therefore does not require an installation process.

We copied the SysBench executable on the root C: drive.

We used the following batch file to launch the SysBench benchmark using the database throughput performance:

```
c:\sysbench.exe --test=oltp --oltp-table-size=1000000 --num-threads=4 --max-requests=100000
run 1>>sysbench.log 2>>sysbench.err
```

Launching the benchmarks simultaneously in multi-virtual machine environments

When running SysBench using multiple virtual machines, we ran a DOS batch file to ensure that all the virtual machines launched the workload simultaneously. When launched, the DOS batch file ran a simple loop with a sleep delay of one second in each loop. The loop continued until it located a specific file in the same directory before moving on to the next steps in which it launched the workload.

We placed the looping batch file in the root directory of each virtual machine. From our desktop management system, we mapped network drives to each of the four virtual machines and created another batch file in the desktop management system to copy the launching file to each virtual machine. Once the looping batch file was launched in each virtual machine, we moved to the desktop system in which we launched the copying batch file.

For SysBench, we launched a batch file, run.bat, in each virtual machine. This batch file started by cleaning up and preparing the table in the database sbtest. Once the database was ready, the next step launched a loop as it searched for the batch file, runSysBench.bat, which launched SysBench with the command line options and parameters shown in the above section, SysBench installation and configuration. Again, from the desktop management system, we launched a batch file that copied our master copy of runSysbench.bat to each virtual machine. Once run.bat found runSysBench.bat, it created a time stamp in a log file in the hh:mm:ss.ss format before launching SysBench and then, once the SysBench workload has completed, creates a final time stamp. We used the two time stamps to calculate the time of completion.

After each test run, we powered off the virtual machines and restarted VMware ESX Server before running the test again.

Appendix A – Test server configuration information

This appendix provides detailed configuration information about each of the test server systems, which we list in alphabetical order.

Processors	Dual-Core AMD Opteron 285	Dual-Core Intel Xeon processor 5160
System configuration information		
General		
Vendor	Hewlett-Packard	Supermicro
Model	Proliant DL385	SuperServer 7045B-8R+B
Processor and OS kernel: (physical, core, logical) / (UP, MP)	2P4C4L / MP	2P4C4L / MP
Number of physical processors	2	2
Single/Dual-core processors	Dual	Dual
System Power Management Policy	Always On	Always On
CPU		
Vendor	AMD	Intel
Name	Dual-Core AMD Opteron 285	Dual-Core Intel Xeon processor 5160
Stepping	2	4
Socket type	940	LGA 775
Core frequency (GHz)	2.6 GHz	3.0 GHz
Front-side bus frequency (MHz)	2000MHz HyperTransport	1333MHz Dual Independent Busses (DIB)
L1 Cache	64 KB + 64 KB	32 KB + 32 KB
L2 Cache	2 MB (1 MB per core)	4 MB (Shared)
Platform		
Vendor	Dual-Core AMD Opteron 285 server	Dual-Core Intel Xeon processor 5160 server
Motherboard model number	HP Proliant DL385 G1, P98330CRHSQ06H	Supermicro X7DB8+
Motherboard chipset	AMD 8111/8131 chipset	Intel 5000P Chipset
Motherboard revision number	C03	92
Motherboard serial number	USE606N50M	TM63S03434
BIOS name and version	Hewlett Packard, version A05, 12/15/2005	Phoenix Technologies LTD, version 6.00, 05/03/2006
BIOS settings	Default	HW Prefetcher and Adjacent Cache Line Prefetcher disabled
Chipset INF driver	Microsoft Version 5.2.3790.1830	Microsoft Version 5.2.3790.1830
Memory module(s)		
Vendor and model number	Viking VI4CR287228ETPA2	Micron MT18HTF12872FDY
Type	PC-3200 Registered DIMM	FB-DIMM using PC2-4400 components
Speed (MHz)	400	533
Speed in the system currently running @ (MHz)	400	533
Timing/Latency (tCL-tRCD-iRP-tRASmin)	3-3-3-8	4-4-4-12
Size	8192 MB	8192 MB
Number of RAM modules	8	8

Chip organization	Double-sided	Double-sided
Channel	Dual	Dual
Hard disk		
Vendor and model number	Seagate ST336754LC	Seagate ST336754LC
Number of disks in system	4	4
Size	37 GB	37 GB
Buffer Size	8 MB	8 MB
RPM	15,000	15,000
Type	SCSI	SCSI
Controller	Adaptec SCSI 39320A-R PCI-X 133MHz (VMware ESX Server) LSI Logic PCI-X Ultra 320 SCSI Host Adapter (Windows virtual machine)	Adaptec SCSI 39320A-R PCI-X 133MHz (VMware ESX Server) LSI Logic PCI-X Ultra 320 SCSI Host Adapter (Windows virtual machine)
Controller driver	VMware Version 6.3.9 (Adaptec) Microsoft Version 5.2.3790.1830 (LSI Logic)	VMware Version 6.3.9 (Adaptec) Microsoft Version 5.2.3790.1830 (LSI Logic)
Operating system (Windows)		
Name	Microsoft Windows 2003 Server, x64 Enterprise Edition	Microsoft Windows 2003 Server, x64 Enterprise Edition
Build number	3790	3790
Service Pack	SP1	SP1
Microsoft Windows update date	06/28/2006	06/28/2006
File system	NTFS	NTFS
Kernel	ACPI Multiprocessor x64-based PC	ACPI Multiprocessor x64-based PC
Language	English	English
Microsoft DirectX version	DirectX 9.0c	DirectX 9.0c
Operating system (VMware)		
Name	VMware ESX Server 3.0	VMware ESX Server 3.0
File system	ext3 (server) vmfs (virtual machines)	ext3 (server) vmfs (virtual machines)
Kernel	Version 2.4.21-37.0.2	Version 2.4.21-37.0.2
Language	English	English
Graphics		
Vendor and model number	ATI Rage XL	ATI Rage XL
Chipset	ATI Rage XL PCI (B41)	ATI Rage XL PCI (B41)
BIOS version	GR-xlcpq-5.882-4.333	GR-xlints3y.09a-4.332
Type	Integrated	Integrated
Memory size	8 MB	8 MB
Resolution	800 x 600	800 x 600
Driver	VMware SVGA II, VMware Inc., Version 11.2.0.0	VMware SVGA II, VMware Inc., Version 11.2.0.0
Network card/subsystem		
Vendor and model number	Broadcom dual NetXtreme Gigabit	Intel PRO/1000 EB Network Connection
Type	Integrated	Integrated
Driver	Microsoft Intel PRO/2000 MT Version 8.1.8.0 (VMware)	Microsoft Intel PRO/2000 MT Version 8.1.8.0 (VMware)
Optical drive		
Vendor and model number	Samsung SN-124	LITE-ON SOHC-5236V

Type	CD-ROM	DVD/CD-ROM
Interface	Internal	Internal
USB ports		
# of ports	3 (1 front, 2 back)	4 (2 front, 2 back)
Type of ports (USB 1.1, USB 2.0)	USB 1.1	USB 2.0

Figure 7: Detailed configuration information for the two test servers.

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