

SUPPORT MORE VIRTUAL MACHINES WITH KINGSTON MEMORY

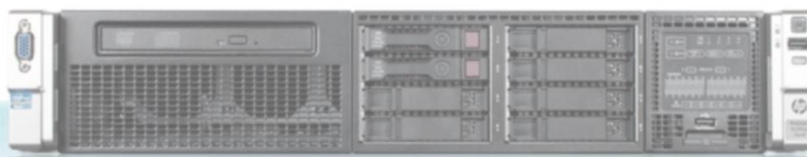
More Kingston server memory, more database virtual machines.



30 VMs
with 768 GB

10 VMs
with 256 GB

7 VMs
with 192 GB



with 1vCPU and 25GB RAM per VM on an HP ProLiant DL380p Gen8



As your enterprise grows, it requires more infrastructure and greater performance. The traditional way to meet this demand was to upgrade with more servers and more powerful storage. With a virtual machine environment, however, it is possible to gain significant performance improvement with a simple RAM upgrade.

Larger-capacity memory modules allow your server to host more VMs, which improves the way your server uses other hardware resources. By consolidating multiple virtual machines (VMs) onto a single server with more memory, you can increase your energy efficiency and reduce the associated management and data center costs of adding more servers.

Kingston® server RAM is a solution designed to provide you with these benefits. In our labs, we tested multiple memory configurations in a series of scenarios to determine how much improvement you could see in your enterprise environment as memory increases. We found that the same server with 768 GB of RAM can support 30 of our test VMs, with 256 GB of RAM can support 10 of our test VMs, and with 192 GB of RAM can support 7 of our test VMs—in all cases delivering excellent database performance.



INCREASE RAM TO PERFORM COST-EFFICIENT UPGRADES

As your business grows, you can find that your hardware no longer delivers the performance it once did. Limited processing power isn't always the reason—sometimes the memory capacity of the server can't keep up with the increasing demands of your company's success. Adding or replacing the system RAM of your servers is a cost-effective way to gain a significant performance boost, as well as improve your servers' efficiency, as they are able to handle more VMs and distribute the load more effectively. Another benefit to installing more RAM in your servers is that it can be far more cost-effective than increasing the number of drives and arrays in a SAN to increase database performance.

To show how upgrading a server's memory capacity can boost the performance of online transaction processing (OLTP) database workloads, we tested the same server using Kingston server RAM in several different models and capacities. We ran a VM environment on VMware® vSphere® ESXi 5.1 hosting a group of Microsoft® Windows Server® 2012 VMs on an HP ProLiant DL380p Gen8 server to run. The VMs, with 1vCPU and 25 GB of dedicated RAM each, ran a large online transaction processing (OLTP) workload to evaluate the performance and energy efficiency of the server with a variety of memory configurations.

More RAM means better performance and greater efficiency

By boosting the amount of RAM available to the host server, the administrator can either allocate memory to new VMs to distribute the load across more machines, or increase the available memory for existing VMs depending on their current usage pattern.

This also allows for the consolidation of multiple physical servers onto a single, more powerful server, which can reduce energy usage, use processing power more efficiently, save on data center space, and lower management costs.

In the Principled Technologies labs, we found that a server with Kingston® memory supported the following configurations, all while delivering excellent database performance:

- 768 GB of RAM supported 30 of our test VMs
- 256 GB of RAM supported 10 of our test VMs
- 192 GB of RAM supported 7 of our test VMs

Additionally, we found that the server delivered greater energy efficiency per VM as the amount of RAM and number of VMs increased. While running the test workloads, the 192GB configuration used 34.80 Watts (W) per VM, the 256GB configuration used 26.63W per VM, and the 768GB configuration used 13.33W per VM.

As Figure 1 shows, the 768GB configuration achieved a DVD Store 2.1 (DS2) result of 99,796 orders per minute (OPM), a 173.3 percent increase over the 256GB configuration, which achieved a result of 36,513 OPM, and a 288.9 percent increase over the 192GB configuration, which achieved a result of 25,664 OPM.

Figure 1. Total orders per minute across the three configurations we tested.

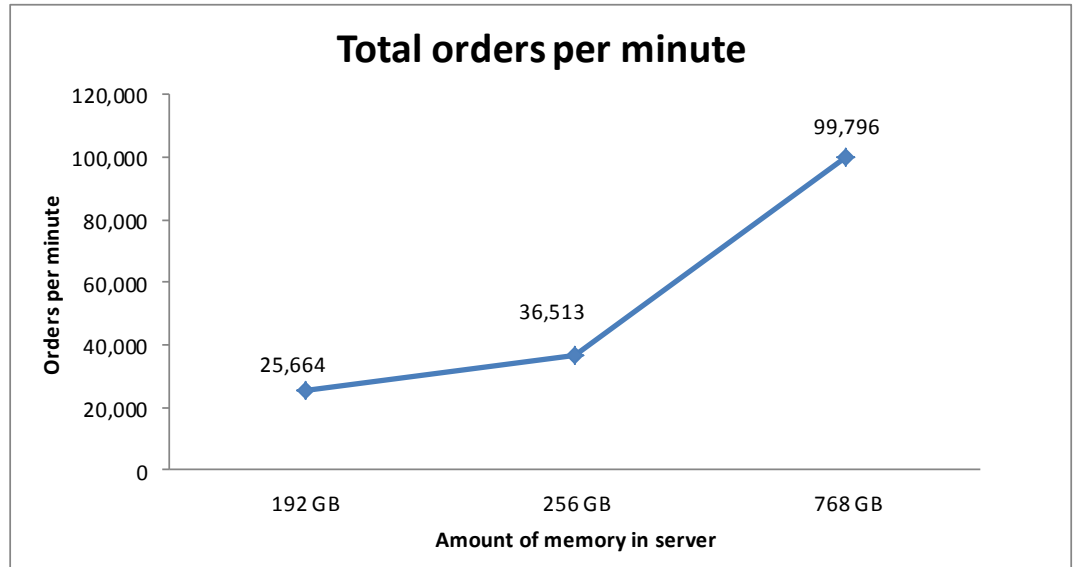
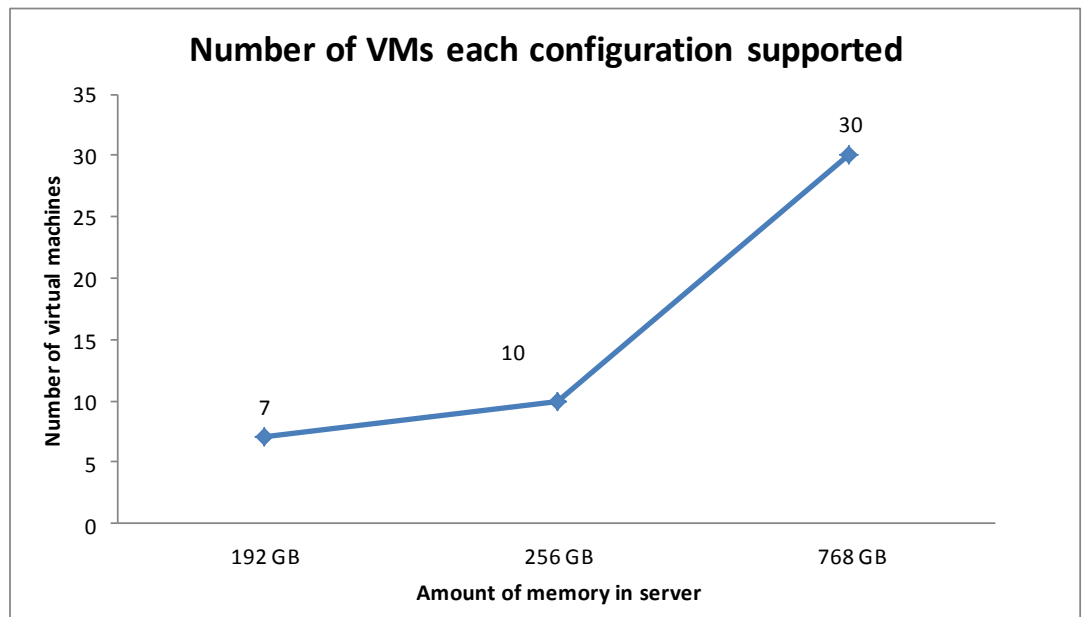


Figure 2 shows the number of VMs that the server supported with each memory configuration.

Figure 2. Number of virtual machines each configuration supported.



For each memory configuration, we used the maximum number of simultaneous virtual machines that could run without oversubscribing memory. Oversubscribing and then fully using virtual memory tends to utilize the storage more

heavily to leverage the lack of sufficient physical memory. This means that performance can be affected by the quality of the storage. For our tests, because we wanted to see the direct effects of the memory on supported VMs and performance while minimizing the impact of storage system performance we did not allow for the memory in the server to be overcommitted. We performed three runs at the total number of virtual machines to verify the OPM results met these standards. We report the median of the three runs.

Figure 3 shows the average percentage CPU utilization during testing for each of the memory configurations. Although CPU utilization and demand may vary depending on the applications running in the VMs, having a higher memory configuration and subsequently hosting more VMs on your server allows you to more efficiently utilize the processing power available in your server.

	192GB configuration (24 x 8GB) 7 VMs	256GB configuration (16 x 16GB) 10 VMs	768GB configuration (24 x 32GB) 30 VMs
Average percentage CPU utilization	12.44	17.92	56.11

Figure 3. Average percentage CPU utilization across the three memory configurations.

Figure 4 shows the OPM results for each VM for each memory configuration. The results show the OPM recorded by each test client and the total OPM for each configuration.

Client	192GB configuration	256GB configuration	768GB configuration
Client 1	3,656	3,629	3,270
Client 2	3,683	3,660	3,314
Client 3	3,683	3,656	3,325
Client 4	3,642	3,650	3,270
Client 5	3,680	3,639	3,290
Client 6	3,681	3,668	3,365
Client 7	3,639	3,641	3,259
Client 8		3,644	3,351
Client 9		3,673	3,389
Client 10		3,653	3,329
Client 11			3,345
Client 12			3,372
Client 13			3,358
Client 14			3,356
Client 15			3,379
Client 16			3,334
Client 17			3,356
Client 18			3,384
Client 19			3,342
Client 20			3,384

Client	192GB configuration	256GB configuration	768GB configuration
Client 21			3,300
Client 22			3,326
Client 23			3,257
Client 24			3,257
Client 25			3,329
Client 26			3,341
Client 27			3,292
Client 28			3,216
Client 29			3,328
Client 30			3,378
Total OPM	25,664	36,513	99,796

Figure 4. OPM from the median run of DVD Store Version 2 for each configuration. Higher numbers are better.

We focused our analysis on the overall improvement of the system caused only by adding memory. As Figure 4 shows, per-VM OPM decreased modestly at the higher VM counts. This is likely due to the changing variables we encountered during different phases of the testing. A combination of these changing variables could have affected the performance of the database VMs. The factors that affect the OPM performance include an increase in CPU utilization at higher VM counts, the effects of NUMA scheduling, as well as the effects of Hyper-Threading.

Power usage comparison

During our tests, we measured power utilization for the three memory configurations to determine the power efficiency for each. Figure 5 shows the results of our power measurements.

	192GB configuration (24 x 8GB) 7 VMs	256GB configuration (16 x 16GB) 10 VMs	768GB configuration (24 x 32GB) 30 VMs
Idle power (W)	203.52	198.25	251.10
Active power (W)	243.61	266.32	399.98
Active power per VM (W)	34.80	26.63	13.33

Figure 5. Power utilization across the three memory configurations.

As Figure 5 illustrates, we found that as the amount of memory and number of supported VMs in the server increases, the server becomes significantly more power efficient per workload. The 768GB configuration supporting 30 VMs used 13.33 Watts of power per VM, which is 62 percent more power efficient when compared to the 192GB configuration supporting 7 VMs.

Please note that the difference in idle power draw for the 256GB configuration compared to the 192GB configuration is likely due to the lower number of memory

modules (16 x 16GB DIMMs for the 256GB configuration vs. 24 x 8GB DIMMs for the 192GB configuration).

WHAT WE TESTED

This report presents the performance benefit one can expect when adding memory to a server under similar conditions. We tested the virtualized database performance of our server with three memory configurations:

- 192GB at 1066MHz = 24 x 8GB PC3-12800R modules
- 256GB at 1600MHz = 16 x 16GB PC3-12800R modules
- 768GB at 1066MHz = 24 x 32GB PC3-10600R modules (LRDIMM)

Our server ran VMware vSphere ESXi 5.1, and the VMs ran Microsoft Windows Server® 2012 Datacenter Edition with Microsoft SQL Server® 2012. We used the open-source DS2 benchmark, which provides a workload representative of a real-world database application. For more information about how we ran DS2 see [Appendix E](#).

IN CONCLUSION

Memory capacity and speed are two of the most crucial factors in determining the performance of a server in a high-performance enterprise environment. Installing higher-density RAM to increase the total amount of memory available to the server allows you to use your processor power more efficiently and therefore run more VMs without a significant investment in processing power while making each virtualized workload more energy efficient. Additionally, greater memory capacity can increase the performance within your VMs by allowing applications, such as SQL Server, to cache a greater amount of information to memory and make it more readily accessible than having to read from the disk every time.

We found that using Kingston memory in 192GB, 256GB, and 768GB configurations yielded a capacity of 7, 10, and 30 VMs respectively, with each simultaneously running the workloads and delivering excellent performance in our test environment. Additionally, as the amount of RAM allowed for a greater number of VMs, we found that the server became more energy efficient per VM while under stress.

These results demonstrate the significant improvements in performance that a simple RAM upgrade can deliver, and show that one of your first considerations for a datacenter upgrade should be increasing the memory capacity of your servers.

APPENDIX A – SERVER CONFIGURATION INFORMATION

Figure 6 provides detailed configuration information for the test system.

System	HP ProLiant DL380p Gen8
Power supplies	
Total number	2
Vendor and model number	HP DPS-750RB
Wattage of each (W)	750
Cooling fans	
Total number	6
Vendor and model number	Delta PFR0612XHE
Dimensions (h x w) of each	2.5" x 2.5"
Volts	12
Amps	3.30
General	
Number of processor packages	2
Number of cores per processor	8
Number of hardware threads per core	2
System power management policy	Balanced
CPU	
Vendor	Intel®
Name	Xeon®
Model number	E5-2680
Stepping	C1
Socket type	LGA2011
Core frequency (GHz)	2.70
Bus frequency (GT/s)	8.0
L1 cache	32 KB + 32 KB (per core)
L2 cache	256 KB (per core)
L3 cache	20 MB
Platform	
Vendor and model number	HP ProLiant DL380p Gen8
Motherboard model number	FXNESSN-001P
BIOS name and version	HP P70, 2/25/2012
BIOS settings	Default
Operating system	
Name	ESXi 5.1.0
Build number	838463
File system	VMFS
Language	English
Graphics	
Vendor and model number	Matrox G200eH
RAID controller	
Vendor and model number	Smart Array P420i
Firmware version	2.14

System	HP ProLiant DL380p Gen8
Cache size	1 GB
Hard drive	
Vendor and model number	HP EG0300FBDBR
Number of disks in system	2
Size (GB)	300
Buffer size (MB)	64
RPM	10,000
Type	SAS
Ethernet adapters	
Vendor and model number	HP 331FLR
Type	Integrated
Optical drive(s)	
Vendor and model number	DS-8D3SH
Type	DVD-ROM
USB ports	
Number	5 external, 1 internal
Type	2.0

Figure 6. Configuration details for our test server.

APPENDIX B – VIRTUAL MACHINE AND STORAGE CONFIGURATION

We configured our external storage to host the VM OS, SQL logs, and SQL database volumes. Our Fibre channel (FC) storage consisted of six trays with 14 x 73GB drives configured into six RAID 5 groups. We connected this storage to our test server using a QLogic QLE2562 dual-port FC adapter. We divided our VMs so that the OS and SQL log volumes were evenly distributed across three of the RAID 5 groups, and the SQL database volumes were also evenly distributed across the other three RAID 5 groups. Figure 7 shows the settings we used on the test server's virtual machines.

VM specifications	VM settings
vCPU	1
Memory (GB)	25
Virtual NIC type	VMXNET 3
Number of virtual disks	3 (OS, SQL logs, SQL database)

Figure 7. VM configuration used for testing.

APPENDIX C – MEMORY CONFIGURATION COMPARISON

Figure 8 shows a side-by-side comparison of the memory configurations we tested. We used the same physical server for all configurations.

Memory specifications	192GB configuration	256GB configuration	768GB configuration
Vendor and model number	Kingston 9965516-057.A00LF	Kingston 9965516-071.A00LF	Kingston 9931966-003.A00G (LRDIMM)
Type	PC3-12800R	PC3-12800R	PC3-10600R
Speed (MHz)	1,600	1,600	1,333
Speed running in system (MHz)	1,066	1,600	1,066
Size (GB)	8	16	32
Total memory in system (GB)	192 (24 x 8 GB)	256 (16 x 16 GB)	768 (24 x 32 GB)

Figure 8. Memory configurations.

We configured VMware ESXi 5.1 on an internal USB drive. We installed Microsoft Windows Server 2008 R2 and SQL Server 2012 inside the virtual machines. We stored all virtual machines on a leading SAN solution, which we connected to the server via a QLogic QLE2462 dual-port Fibre controller.

APPENDIX D – SETTING UP THE SERVER – VMWARE VSPHERE 5.1

Installing VMware vSphere 5.1 (ESXi) on the HP ProLiant DL380p Gen8

1. Insert the disk, and select Boot from disk.
2. On the Welcome screen, press Enter.
3. On the End User License Agreement (EULA) screen, press F11.
4. On the Select a Disk to Install or Upgrade Screen, select the relevant volume on which to install ESXi, and press Enter.
5. On the Please Select a Keyboard Layout screen, press Enter.
6. On the Enter a Root Password Screen, assign a root password and confirm it by entering it again. Press Enter to continue.
7. On the Confirm Install Screen, press F11 to install.
8. On the Installation complete screen, press Enter to reboot.

Setting up vCenter Server

1. Execute the vCenter 5.1 installer on the host controller machine.
2. Accept all the default settings during the install process.
3. Reboot the machine when finished and begin adding the hosts to the controller.

Configuring ESXi after Installation

1. On the 5.1 ESXi screen, press F2, enter the root password, and press Enter.
2. On the System Customization screen, select Troubleshooting Options, and press Enter.
3. On the Troubleshooting Mode Options screen, select enable ESXi Shell, and press Enter.
4. Select Enable SSH, press Enter, and press ESC.
5. On the System Customization screen, select Configure Management Network.
6. On the Configure Management Network screen, select IP Configuration.
7. On the IP Configuration screen, select set static IP, enter an IP address, subnet mask, and default gateway, and press Enter.
8. On the Configure Management Network screen, press Esc. When asked to apply the changes, press Y.

Configuring VM networking on ESXi

1. Using the vSphere Web client from another machine, connect to the ESXi server:
 - a. In vCenter, navigate to the Configuration → Networking tab for the ESXi host machine.
 - b. Confirm that the Management Network is connected and the necessary vSwitch for the network has been automatically created in vCenter.

Configuring the external volumes in VMware vSphere 5.1

1. In the vSphere Web client, select the host.
1. Click the Configuration tab.
2. Click Storage, and click Add Storage...
3. Choose Disk/LUN.
4. Select the first LUN assigned to ESX and click Next.
5. Accept the default of VMFS-5 for the file system.
6. Review the disk layout, and click Next.
7. Enter the datastore name, and click Next.
8. Accept the default of using maximum capacity, and click Next.
9. Click Finish.
10. Repeat steps 3 through 9 for the remaining LUNs.

Creating the first VM

1. In the vSphere Web client, connect to the vCenter Server, and browse to the ESXi host that will serve as the system under test.
2. Click the Virtual Machines tab.
3. Right-click, and choose New Virtual Machine.
4. Choose Custom, and click Next.
5. Assign a name to the virtual machine, and click Next.
6. Select the first assigned OS Datastore on the external storage, and click Next.
7. Choose Virtual Machine Version 9, and click Next.
8. Choose Windows, and choose Microsoft Windows Server 2012 (64-bit), and click Next.
9. Choose one virtual socket, and assign 1 virtual processor. Click Next.
10. Choose 245,767MB RAM, and click Next.
11. Click 1 for the number of NICs, select VMXNET3, and click Next.
12. Leave the default virtual storage controller, and click Next.
13. Choose to create a new virtual disk, and click Next.
14. Make the OS virtual disk size 40 GB, choose thick-provisioned eager zeroed, specify the OS datastore on the external storage, and click Next.
15. Keep the default virtual device node (0:0), and click Next.
16. Click Finish.
17. Right-click the VM, and choose Edit Settings.
18. On the Hardware tab, click Add...
19. Click Hard Disk, and click Next.
20. Click Create a new virtual disk, and click Next.
21. Specify 45GB for the virtual disk size, choose thick-provisioned eager zeroed, and specify the datastore for SQL Server data usage (storage pool 2).
22. Choose SCSI(1:0) for the device node, and click Next.
23. Right-click the VM, and choose Edit Settings.
24. On the Hardware tab, click Add...
25. Click Hard Disk, and click Next.
26. Click Create a new virtual disk, and click Next.
27. Specify 25GB for the virtual disk size, choose thick-provisioned eager zeroed, and specify the datastore for SQL Server log file usage (storage pool 2).
28. Choose SCSI(1:1) for the device node, and click Next.
29. Click SCSI Controller 1, and choose Change Type.
30. Choose VMware Paravirtual, and click OK.
31. Click Finish, and click OK.
32. Click the Resources tab, and click Memory.
33. Start the VM.
34. Attach the Windows Server 2012 ISO image to the VM and install Windows Server 2012 on your VM.

APPENDIX E – CONFIGURING THE VMS ON EACH HYPERVISOR

See the above sections regarding the initial creation of the virtual machines on the system under test. We provide steps below for installing the operating system, Microsoft SQL Server, and configurations of the VMs.

Installing the operating system on the Windows VM

1. Insert the installation DVD for Windows Server 2012 into the DVD drive, and attach the physical DVD drive to the VM. Alternatively, use an ISO image and connect to the ISO image from the VM console.
2. Open the VM console on vSphere.
3. At the Language Selection Screen, click Next.
4. Click Install Now.
5. Select Windows Server 2012 Datacenter (Server with a GUI), and click Next.
6. Click the I accept the license terms check box, and click Next.
7. Click Custom: Install Windows Only.
8. Under Drive options select New partition, choose the default (maximum) disk size, format it, and click Next to install Windows.
9. At the User's password must be changed before logging on warning screen, click OK.
10. Enter the desired password for the administrator in both fields, and click the arrow to continue.
11. At the Your password has been changed screen, click OK.
12. Install the latest VMware Tools package on the VM. Restart as necessary.
13. Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.
14. Enable remote desktop access.
15. Change the hostname and reboot when prompted.
16. Create a shared folder to store test script files. Set permissions as needed.
17. Turn Windows Firewall off.
18. Turn IE Enhanced Security Configuration off.
19. Install .NET Framework 3.5 (prerequisite for SQL Server 2012):
 - a. Click Manage → Add Roles and Features → click Next four times, and under the Features selection, check the box next to .NET Framework 3.5.
 - b. Click Install, close when finished and restart.
20. Set up networking:
 - a. Click Start → Control Panel, right-click Network Connections, and choose Open.
 - b. Right-click the VM management network NIC, and choose Properties.
 - c. Select TCP/IP (v4), and choose Properties.
 - d. Set the IP address and subnet for the virtual NIC, which will handle outgoing server traffic. Click OK, and click Close.
21. In the VM, configure the VM storage:
 - a. In the taskbar, click the Server Manager icon.
 - b. In the left pane, expand Storage, and click Disk Management.
 - c. Right-click the first volume, and choose Initialize Disk.
 - d. In the right pane, right-click the volume and choose New Simple Volume...
 - e. At the welcome window, click Next.
 - f. At the Specify Volume Size window, leave the default selection, and click Next.
 - g. At the Assign Drive Letter or Path window, choose a drive letter, and click Next.
 - h. At the Format Partition window, choose NTFS and 64K allocation unit size, and click Next.
 - i. At the Completing the New Simple Volume Wizard window, click Finish.
 - j. Repeat steps c through i for the remaining VM volumes.

22. Copy the pre-created DVD Store backup file to the C:\ drive inside the first VM.

Installing SQL Server 2012 on the first VM

1. Open the vSphere console for the VM.
2. Log into the virtual machine.
3. Insert the installation DVD for SQL Server 2012 into the appropriate vSphere host server's DVD drive.
4. Attach the physical DVD drive to the VM.
5. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2012 DVD, and double-click.
6. If the installer prompts you with a .NET installation prompt, click Yes to enable the .NET Framework Core role.
7. In the left pane, click Installation.
8. Click New installation or add features to an existing installation.
9. At the Setup Support Rules screen, wait for the check to complete. If there are no failures or relevant warnings, click OK.
10. Select the Evaluation edition, and click Next.
11. Click the checkbox to accept the license terms, and click Next.
12. Click Install to install the setup support files.
13. If there are no failures displayed, click Next. You may see a Computer domain controller warning and a Windows Firewall warning. For now, ignore these.
14. At the Setup Role screen, choose SQL Server Feature Installation.
15. At the Feature Selection screen, select Database Engine Services, Full-Text Search, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools –Basic, and Management Tools – Complete. Click Next.
16. At the Installation Rules screen, click Next once the check completes.
17. At the Instance configuration screen, leave the default selection of default instance, and click Next.
18. At the Disk space requirements screen, click Next.
19. At the Server configuration screen, choose NT AUTHORITY\SYSTEM for SQL Server Agent, and choose NT AUTHORITY\SYSTEM for SQL Server Database Engine. Click Next.
20. At the Database Engine Configuration screen, select Mixed Mode.
21. Enter and confirm a password for the system administrator account.
22. Click Add Current user. This may take several seconds.
23. Click Next.
24. At the Error and usage reporting screen, click Next.
25. At the Installation Configuration rules screen, check that there are no failures or relevant warnings, and click Next.
26. At the Ready to Install screen, click Install.
27. After installation completes, click Close.

Configuring the database (DS2)

About DVD Store Version 2.1

DVD Store Version 2.1 is an accessible, open-source, flexible framework with which we can model a typical OLTP database. DS2, which simulates an online e-commerce DVD store, has database components and Web server components, and includes driver programs that put heavy loads on the server. We opted to use the included driver program to stress the database layer directly, and bypassed the Web interface.

When DS2 is executing, simulated customers log in; browse movies by actor, title, or category; and purchase movies. Each DS2 order consists of a customer login, a number of searches for movies, and a purchase. Each search is by

title, actor, or category. The title and actor searches use full-text search. The other customer actions, including adding new customers, exercise a wide range of database functions.

The main DS2 metric is orders per minute, which the driver program calculates and reports via the Windows Performance Monitor utility on the client machines. While the DVD Store client application outputs OPM at 10-second intervals visually, we chose to collect this OPM metric via the performance monitor counter on each client at 1-second intervals. We ran this workload on the virtual machines for 1 hour and 30 minutes: the first hour as a warm-up time to allow SQL Server to cache the database into memory to reflect a real-world scenario where a database server is always running, and recorded the last 30 minutes to measure performance. We report the last OPM measurement the benchmark reported. We determined excellent performance as each VM achieving 3,200 OPM or greater (85 percent of the theoretical maximum, which is 3840 OPM per VM) to account for the think time in each thread.

We ran one Microsoft SQL Server 2012 instance on each virtual machine, each with a 25GB database. We used the default DS2 parameters and setup configuration, with the exceptions we note below.

Each client machine ran a single instance of DS2, with 32 threads, which simulate users executing actions within the application. This simulated a heavily loaded environment; the load-generating client VMs ran with 0.5 seconds think time. For more details on the DS2 tool, see <http://www.delltechcenter.com/page/DVD+Store>.

Data generation overview

We generated the data using the Install.pl script included with DVD Store version 2.1, providing the parameters for our 20GB database size and the database platform on which we ran: Microsoft SQL Server. We ran the Install.pl script on a utility system running Linux. The database schema was also generated by the Install.pl script.

After processing the data generation, we transferred the data files and schema creation files to a Windows-based system running SQL Server 2012. We built the 20GB database in SQL Server 2012, and then performed a full backup, storing the backup file on the C: drive for quick access. We used that backup file to restore on both servers between test runs. We performed this procedure once, and used the same backup file for all VMware vSphere 5.1 virtual machines.

The only modification we made to the schema creation scripts were the specified file sizes for our database. We explicitly set the file sizes higher than necessary to ensure that no file-growth activity would affect the outputs of the test. Besides this file size modification, the database schema was created and loaded according to the DVD Store documentation. Specifically, we followed the steps below:

1. We generated the data and created the database and file structure using database creation scripts in the DS2 download. We made size modifications specific to our 20GB database and the appropriate changes to drive letters.
2. We transferred the files from our Linux data generation system to a Windows system running SQL Server.
3. We created database tables, stored procedures, and objects using the provided DVD Store scripts.
4. We set the database recovery model to bulk-logged to prevent excess logging.
5. We loaded the data we generated into the database. For data loading, we used the import wizard in SQL Server Management Studio. Where necessary, we retained options from the original scripts, such as Enable Identity Insert.
6. We created indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. We updated statistics on each table according to database-creation scripts, which sample 18 percent of the table data.

8. On the SQL Server instance, we created a ds2user SQL Server login using the following Transact SQL (TSQL) script:

```
USE [master]
GO
CREATE LOGIN [ds2user] WITH PASSWORD=N'',
    DEFAULT_DATABASE=[master],
    DEFAULT_LANGUAGE=[us_english],
    CHECK_EXPIRATION=OFF,
    CHECK_POLICY=OFF
GO
```

9. We set the database recovery model back to full.
10. We created the necessary full text index using SQL Server Management Studio.
11. We created a database user and mapped this user to the SQL Server login.
12. We then performed a full backup of the database. This backup allowed us to restore the databases to a pristine state relatively quickly between tests.

Setting up the servers for DVD Store

Our DVD Store test bed consisted of an HP ProLiant DL380p Gen8 server under test with multiple VMs, each with its own 20GB database. Each SUT VM had a corresponding client VM that was hosted on a second HP ProLiant DL380p Gen8. We connected the systems via one Gigabit network switch. We installed a fresh copy of Windows Server 2008 R2 Enterprise Edition on the client VMs.

Installing Windows Server 2008 R2 Enterprise Edition

1. Boot the server, and insert the Windows Server 2008 R2 installation DVD in the DVD-ROM drive.
2. At the Language Selection screen, click Next.
3. Click Install Now.
4. Select Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
5. Click the I accept the license terms check box, and click Next.
6. Click Custom.
7. At the Where to Install Windows screen, click Drive options (advanced).
8. Ensure you select the proper drive, and click New.
9. Enter the partition size, and click Apply. (We used the entire disk.)
10. At the pop-up informing you Windows will create additional partitions, click OK.
11. At the Where to Install Windows screen, click Next.
12. At the User's password must be changed before logging on warning screen, click OK.
13. Enter a password as the new password in both fields, and click the arrow to continue.
14. At the Your password has been changed screen, click OK.

Setting up the network configuration on the server

1. Click Start→Control Panel→Network and Internet→Network and Sharing Center, and click Change Adapter Settings.
2. Right-click on the network adapter, and select Properties from the drop-down menu.
3. Select Internet Protocol Version 4 (TCP/IPv4), and click Properties.
4. At the Internet Protocol Version 4 (TCP/IPv4) Properties screen, select the Use the following IP address radio button.

5. Enter a valid static IP address, subnet mask, and default gateway.
6. Click OK to close the window.
7. At the Local Area Connection Properties window, click Close.
8. Close the Network Connection window.

Installing system updates in Windows Server 2008 R2

We installed all critical updates on the server using the Windows Update feature.

Running the DVD Store tests

We created a series of batch files, SQL scripts, and shell scripts to automate the complete test cycle. DVD Store outputs an orders-per-minute metric, which is a running average calculated through the test. In this report, we report the last OPM reported by each client/target pair.

Each complete test cycle consisted of the general steps listed below. For each scenario, we ran three test cycles, and chose the median outcome.

1. Clean up prior outputs from the host system and all client systems.
2. Drop all databases from all target VMs.
3. Restore all databases on all target VMs.
4. Shut down all VMs.
5. Reboot the host system and all client systems.
6. Wait for a ping response from the server under test (the hypervisor system), all client systems, and all VMs.
7. Let the test server idle for one half hour.
8. Start the DVD Store driver on all respective clients.

We used the following DVD Store parameters for testing the virtual machines in this study:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30 --  
n_threads=32 --db_size=20GB --think_time=0.5 --database_name=ds2 --  
detailed_view=Y --warmup_time=60
```

Measuring power usage

To record power consumption during each test, we used an Extech Instruments (www.extech.com) 380803 Power Analyzer/Datalogger. We connected the power supplies to the Power Analyzer's output load power outlet using a two-connection splitter cable. We then plugged the power cord from the Power Analyzer's input voltage connection into a 120-volt outlet.

We used the Power Analyzer's Data Acquisition Software (version 2.11) to capture all recordings. We installed the software on a separate system, which we connected to the Power Analyzer via an RS-232 cable.

We recorded the power usage in watts for idle and active power usage at one-second intervals. To compute the idle power usage, we averaged the power usage during a 2-minute time period after rebooting the server under test and allowing the server to sit idle for 5 minutes. To compute the average power usage, we averaged the power usage during the 30-minute DVD Store run time when the system was under peak performance load.

ABOUT PRINCIPLED TECHNOLOGIES



Principled Technologies, Inc.
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