

## Dell™ PowerEdge™ M915 with AMD Opteron™ 6276 processors



When it is time to refresh your company's blade chassis or expand your blade hardware, you want a server that can run the number of virtual machines (VMs) you need at a minimum cost per VM. The key to achieving this is having a processor-server solution that allows for a high VM density with a minimal hardware and software CAPEX cost, which results in a low cost per VM.

In our labs at Principled Technologies, we compared the cost-per-VM value of two blade server solutions in quantities supporting 160 VMs and delivering similar performance at a target density:

- Dell PowerEdge M915 blade servers with four AMD Opteron™ 6276 processor sockets running Microsoft® Windows Server® 2008 R2 with Hyper-V™ (Dell/AMD/Microsoft)
- HP ProLiant BL680c G7 blade servers with four Intel® Xeon® Processor E7-8867L sockets running VMware® vSphere® 5 (HP/Intel/VMware)

We set up each server to support 20 VMs running our test workload and each was able to deliver equal workload outputs to within a few percentage points. We then compare the pricing for a total of eight servers in order to support the goal of 160 VMs. We priced hardware and operating system software and calculated cost per VM for the two solutions.

Based on our results, we would save 62 percent on hardware and operating system software costs with the Dell/AMD/Microsoft solution. The considerable VM density capacity and competitive price point of the AMD Opteron 6276 processor-powered Dell PowerEdge M915 blade server and chassis solution running Hyper-V makes it a solution that delivers impressive cost-per-VM results.



# COST AND PERFORMANCE OVERVIEW

In evaluating a large IT capital expense, the main points to consider are usually cost and performance. Will my company be able to achieve its service-level agreements and its performance levels? If yes, is the company achieving those performance levels in the most cost-effective manner? Our analysis and performance tests below answer these questions.

## Cost analysis overview

We performed our cost analysis with a hypothetical enterprise in mind. This enterprise wants to select blade servers and a hypervisor platform to run its virtualized servers with Windows Server 2008 R2. In decisions such as these, both the hardware and software layers of the solution stack matter when it comes to determining the final cost to the business. In our case, when considering the costs of the hardware and software, Dell, AMD, and Microsoft Hyper-V offer tremendous savings over the competing HP/Intel/VMware solution.

We chose a target VM count of 160 VMs for the enterprise and then calculated how many servers and licenses it would take to fulfill these requirements. We then researched hardware and operating system (OS) software costs for each hardware and software configuration – both Dell/AMD/Microsoft and HP/Intel/VMware. Based on the total solution cost of each environment, we were able to compare a cost per VM, which overwhelmingly shows the cost advantages of the Dell/AMD/Microsoft solution.

Figure 1 shows the cost per VM for the two solutions.

Cost per VM for a configuration that supports 160 VMs	
Dell/AMD/Microsoft solution	\$1,587.05
HP/Intel/VMware solution	\$4,185.04
<b>Savings per VM for Dell/AMD/Microsoft solution</b>	<b>\$2,597.99</b>
<b>Percentage savings per VM</b>	<b>62.08%</b>

Figure 1: Cost per VM for each solution. Lower costs and higher percentage savings are better.

## Performance equity

Along with cost considerations, IT organizations need to know if the solution will perform equally for their users. Is there a performance penalty when a company chooses to make more cost-effective purchasing decisions? In this case, the answer is no. The Dell solution, powered by AMD processors and Microsoft Hyper-V, achieved similar performance as the competing solution at the tested VM densities.

We ran a SQL Server workload in each of our VMs to demonstrate performance equity between the two competing solution stacks. We defined a database workload to run in the VMs, defined workload performance goals and real-world processor

utilization ranges, and tested to ensure that each server could run our 20 VMs while keeping within those ranges.

We chose a common database benchmark, DVD Store 2 (DS2), as our workload. This workload simulates an online e-commerce DVD store. The main DS2 metric is orders per minute (OPM). Note that while you may use a different workload to complete a different task, these test results provide an indication of the processing power and VM density capabilities of two servers. To ensure that storage bottlenecks did not occur during our comparison testing, we disabled SQL Server checkpoints to remove that factor from our comparison.

Our hypothetical enterprise wants to provide a certain service level within its virtualized environment – all VMs must perform at a certain level, and they must perform evenly. The enterprise wants to utilize its servers at acceptable levels, not necessarily oversubscribing RAM or processor capacities - they want to stay within a 40 to 70 percent range of processor utilization with 2 vCPU VMs, which will allow for future growth or load spikes.

In our tests, we reached the 40 to 70 percent target CPU utilization level for each server, and we demonstrated that either server could run 20 VMs with two vCPUs each and achieve equitable output per VM, to within 4.4 percent of each other. Neither server was oversubscribed on CPU or RAM – each server had resources available to it to run the workload. The goal was to evaluate if each solution stack could run an equal workload with 20 VMs, and we found that the two platforms did just that.

Both test servers had 128 GB (32 x 4 GB) and four processors to support the memory and processing demands of the workloads. We used the same storage connected to each server: three trays of Dell EqualLogic™ iSCSI storage, each filled with 15K SAS drives.

## 62 PERCENT LOWER COST WITH THE DELL/AMD/MICROSOFT SOLUTION

### Impressive hardware and software savings

In this section, we review the specific cost analysis breakdown of each solution, for both hardware and software. Based on our performance calculations, we used the extrapolated assumptions of an eight-server solution to research costs as well. We calculated hardware, software, and per-VM costs for both solutions for the two eight-blade configurations. We included blades, enclosures, and operating system purchase and support costs in the analysis.

In our analysis, the 16-core AMD Opteron 6276 processors that powered the Dell server gave it a considerable cost advantage for our workload over the HP server, which was powered by the 10-core Intel Xeon Processor E7-8867L. Hyper-V added additional savings over VMware vSphere 5.

We do not include the costs of external storage in the cost analysis, as it is the same for each solution in our test bed. Additionally, we recognize that the typical enterprise would have a mix of underlying applications, therefore we also do not include SQL Server costs in the cost analysis.

### Hardware cost comparison - 64 percent savings

Figure 2 presents the two hardware configurations we used for the pricing comparison. One Dell PowerEdge M1000e enclosure holds all eight of the hypothetical full-height four-socket Dell PowerEdge M915 blade servers, considering that the PowerEdge M915 has a full-height, single-width form factor. However, because of the thicker form factor of the four-socket HP ProLiant BL680c G7 servers, each HP BladeSystem c7000 enclosure holds only four of these servers. The eight servers in our hypothetical configuration therefore need two of the HP blade server enclosures.

	Dell solution	HP solution
Servers	8 Dell PowerEdge M915 blade servers	8 HP ProLiant BL680c G7 blade servers
Total Processors	32 AMD Opteron 6276 processors	32 Intel Xeon Processor E7-8867L sockets
Total RAM	1TB total RAM (128 GB per server)	1TB total RAM (128 GB per server)
Blade enclosures	1 Dell PowerEdge M1000e modular blade enclosure	2 HP BladeSystem c-Class c7000 ROHS Enclosures
Blade switches	2 Dell PowerConnect M6220 blade modules	4 HP 1/10Gb Virtual Connect Ethernet Modules

Figure 2: Server and chassis for the two solutions.

Figure 3 shows the hardware costs of the eight blades and their enclosures for the two solutions. The HP/Intel/VMware solution requires two HP BladeSystem c-Class c7000 ROHS Enclosures to hold the eight full-height, double-width blades. A single Dell PowerEdge M1000e Blade Enclosure holds the eight full-height, single-width Dell blades. The Dell/AMD/Microsoft solution delivers \$219,934.74 savings on hardware costs compared to the HP/Intel/VMware solution, a savings of 64.85 percent.

Dell provided us with the list price for the Dell hardware. We received list prices for the HP hardware in the online HP Small and Medium Business Store.<sup>1</sup>

Prices include support. We include 3-year ProSupport and Mission Critical 4HR 7x24 Onsite Pack in the pricing for the Dell blades and enclosure and HP Care Pack 3-year, 6-Hour, Call-to-Repair Hardware Support in the prices for the HP blades and enclosure.

<sup>1</sup> <http://h71016.www7.hp.com/dstore/home.asp?oi=E9CED&BEID=19701&SBLID=>

	Dell/AMD/Microsoft solution	HP/Intel/VMware solution
8 PowerEdge M915 servers vs. 8 ProLiant BL680c G7 servers	\$104,488	\$296,400
1 Dell Enclosure vs. 2 HP Enclosures	\$14,735	\$42,758
<b>Total</b>	<b>\$119,223</b>	<b>\$339,158</b>
<b>Hardware savings with Dell/AMD/Microsoft</b>	<b>\$219,934</b>	
<b>Hardware percentage savings</b>	<b>64.85%</b>	

Figure 3: Hardware costs for each solution.

### Software cost comparison - 59 percent savings

Our hypothetical enterprise is choosing not only hardware vendors, but also a hypervisor platform. The two hypervisor providers in our scenario have differing costs and licensing models that make one more appealing to enterprises looking to stretch their dollar.

VMware vSphere 5 requires licensing each host running the VMware software. But an enterprise needs more than a host running hypervisor software – an enterprise needs guest VMs running operating systems that host their critical business applications. These guest VMs have licensing costs as well. Therefore, for the VMware platform, the enterprise must pay for VMware vSphere, as well as for Microsoft Windows Server for its guest VM operating systems.

However, by choosing Dell PowerEdge Servers powered by AMD, and running Microsoft Windows Server Datacenter Edition with Hyper-V, the enterprise pays only once for the complete machine. Windows Server Datacenter Edition includes not only the license for the host operating system that runs the hypervisor services, but also unlimited licensing for the guest VMs operating systems running Windows Server. An enterprise pays only once.

Figure 4 lists the guest and host operating systems we used for the pricing comparison.

Dell/AMD/Microsoft solution	HP/Intel/VMware solution
Host and Guest OS: Windows Server 2008 R2 Datacenter Edition	Guest OS: Windows Server 2008 R2 Datacenter Edition
	Host OS: VMware vSphere 5 Enterprise Plus

Figure 4: Guest and host operating systems for the two solutions.

Figure 5 shows the software costs of the eight four-socket blade servers for the two solutions. The Dell/AMD/Microsoft solution delivers \$195,744 savings on software costs compared to the HP/Intel/VMware solution, a savings of 59.24 percent.

	Dell/AMD/Microsoft solution	HP/Intel/VMware solution
Eight blade servers	\$134,704	\$195,744
	Windows Server 2008 R2 Datacenter Edition licenses for 32 sockets at \$4,209.50 per socket	vSphere 5 Enterprise Plus licenses for 32 sockets at \$6,117.00 per socket
Enclosures for eight blade servers	Windows Server 2008 R2 Datacenter edition included in above	\$134,704
		Windows Server 2008 R2 Datacenter edition licenses for 32 sockets at \$4,209.50 per socket
<b>Total</b>	<b>\$134,704</b>	<b>\$330,448</b>
<b>Savings</b>	<b>\$195,744</b>	
<b>Percentage savings</b>	<b>59.24%</b>	

Figure 5: Software costs for each solution.

These software prices include support. We include 3-year Software Assurance (SA) costs for Microsoft software and 3-year Production support and subscription (SaS) for VMware software.

The AMD-powered Dell servers require one host license for Windows Server 2008 R2 Datacenter Edition per socket, allowing you to run the host OS and as many guest VMs as you need. Its overall software costs are considerably lower than the costs of the Intel-powered HP server, which requires one license per socket for both VMware vSphere 5 for the host OS and Windows Server 2008 R2 Datacenter for the guest OS/VMs.

Figure 6 shows the total hardware and software cost and savings per VM for the two solutions. The Dell/AMD/Microsoft solution delivers \$2,597 savings per VM compared to the HP/Intel/VMware solution, a savings of 62.08 percent.

	Dell/AMD/Microsoft solution	HP/Intel/VMware solution
Hardware and software cost	\$253,927	\$669,606
Cost per VM	\$1,587	\$4,185
<b>Savings per VM for Dell/AMD/Microsoft solution</b>	<b>\$2,597</b>	
<b>Percentage savings per VM</b>	<b>62.08%</b>	

Figure 6: VM costs for each solution.

We present cost calculations in [Appendix A](#), test configuration review in [Appendix B](#), our storage configuration procedure in [Appendix C](#), our environment set ups in [Appendix D](#) and [Appendix E](#), our VM configurations in [Appendix F](#), our database configurations in [Appendix G](#), and our server and storage configurations in [Appendix H](#).

## ABOUT THE DELL/AMD/MICROSOFT SOLUTION WE TESTED

### Dell PowerEdge M915 server

The Dell PowerEdge M915 is a four-socket, full-height blade that provides up to 64 processor cores. Because eight M915 servers can fit inside a single M1000e chassis, it is possible to attain 512 processor cores per chassis if using 16-core AMD processors. High-availability of data, efficient power usage, and a simple and centralized update process are additional features of the Dell PowerEdge M915 server.

To learn more about the Dell PowerEdge M915 server, see [http://i.dell.com/sites/content/shared-content/data-sheets/en/Documents/M915\\_Spec\\_Sheet.pdf](http://i.dell.com/sites/content/shared-content/data-sheets/en/Documents/M915_Spec_Sheet.pdf).

### AMD Opteron 6276 processor

The AMD Opteron 6276 processor, part of the 6200 series, features 16 cores, multiprocessing for up to 4 processors, and supports up to 12 DIMMs per socket of memory. The AMD Opteron 6276 processor also supports HyperTransport 3.0 technology.

To learn more about the AMD Opteron 6200 processor series, visit <http://server.amd.com/LP=237>.

### Microsoft Windows Server 2008 R2 Datacenter Edition

Microsoft Windows Server 2008 R2 Datacenter Edition is designed for large-scale virtualized workloads, so it provides unlimited virtualization rights so you can run as many VMs as you like, and have them be licensed with Windows Server 2008 R2 Datacenter. The included Hyper-V virtualization technology helps you virtualize your server workloads at a reduced cost when compared to VMware vSphere.

The Datacenter Edition of Windows Server 2008 R2 supports up to 64 physical processors, offers high availability of data, failover clustering to help ensure consistent service, and dynamic hardware partitioning.

To learn more about Microsoft Server 2008 R2 Datacenter Edition and Hyper-V Server, visit <http://www.microsoft.com/en-us/server-cloud/windows-server/2008-r2-datacenter.aspx>.

## DELL ADVANCED INFRASTRUCTURE MANAGER

In the cost study above, we discuss the fact that organizations are striving to do more with less – at no cost to performance. We also show that a Dell/AMD/Microsoft solution can offer significantly lower costs per VMs over HP/Intel/VMware. The next question might be how hard is it to move VMs from the HP solution over to the Dell solution. There are many ways to make this happen, ranging from manual backup-style solutions to more automated products like Dell Advanced Infrastructure Manager (AIM).

With the Dell Server Migration Utility (SMU) and Dell AIM, you can migrate existing VMware VMs to a shared SAN environment, then retarget that VM's disk image to the Hyper-V solution – the Dell utilities and software handles all necessary driver injection to make this possible. It can take just minutes per VM to make the transition. For example, our sample 40GB virtual disk took less than two minutes to copy to our shared storage location.

To make this transition into your existing Dell AIM environment, an administrator uses the Dell Server Migration Utility (SMU) to prepare the existing Windows image for the appropriate boot source drivers and copy the volume to the relevant shared SAN environment. Then in Dell AIM, the new virtual machine image, now called a “persona” in Dell AIM, can be booted to any available physical or virtual server. The basic steps necessary are:

1. Create and mount the LUN for the converted Windows image.
2. Copy the image to the shared storage location, using the Dell SMU to inject the appropriate drivers.
3. Add the persona, Dell AIM's implementation of abstracted physical or virtual workloads, to the Dell AIM console. Then boot the persona.

We cover each of these in more detail below.

1. Create and mount the LUN for the converted Windows image.

In order for Dell AIM to boot VM's disk from a shared SAN, that SAN must expose a volume to the compute sources, either physical or virtual, where the workload will boot. Work with your storage administrator to provision the appropriate LUNs on your SAN. Alternatively, if you have Dell EqualLogic iSCSI storage, you can provision new LUNs directly from the Dell SMU, as we did (see Figure 7 below). Simply boot the source image to the Dell SMU utility, and choose “Go to Advanced Operations”, then “Provision iSCSI LUN”.

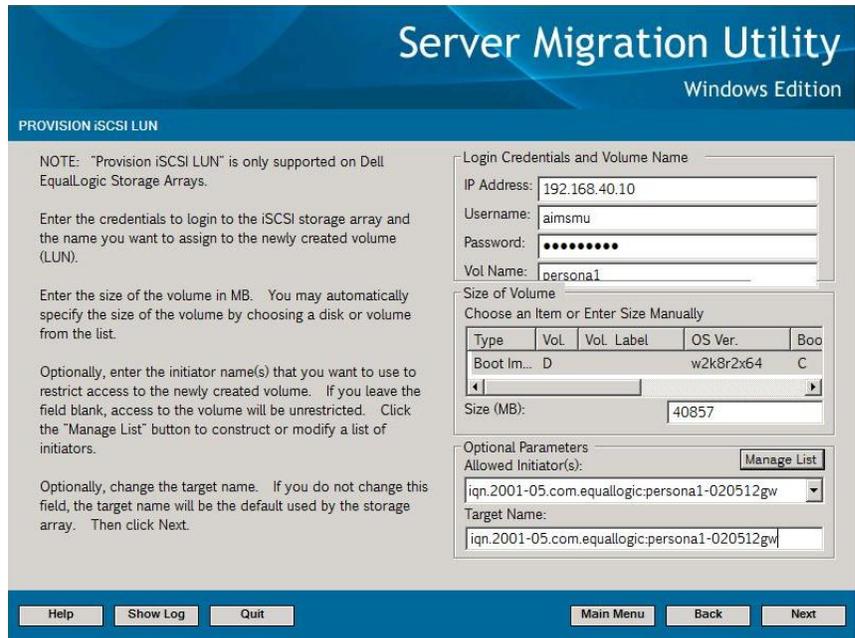


Figure 7: Dell SMU – provisioning a Dell EqualLogic volume directly from the Dell SMU.

Note that a DHCP server must exist in your storage network if using iSCSI. This allows Dell SMU to communicate with the storage after boot. Next, mount the newly created iSCSI LUN from the Dell SMU, as we show in Figure 8 below.

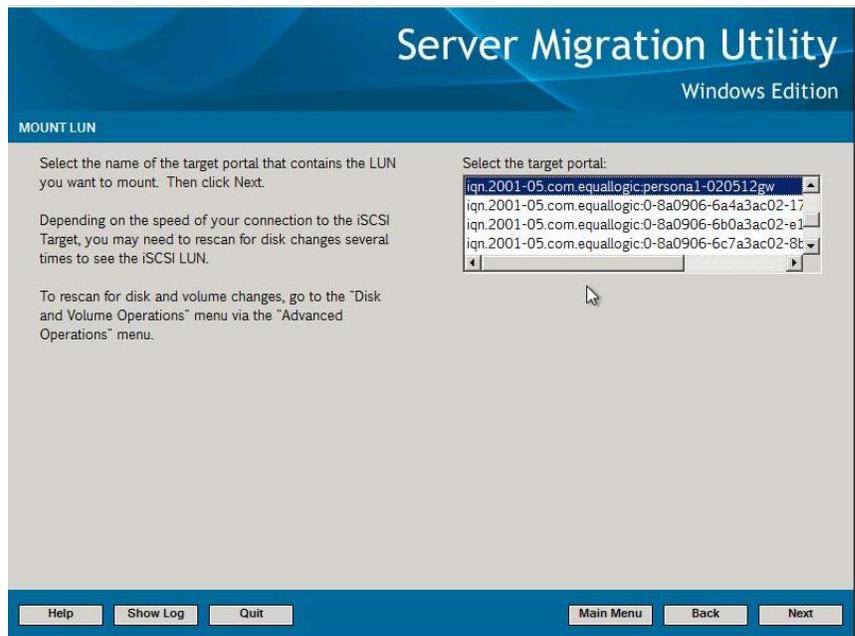


Figure 8: Dell SMU – mounting the LUN for image copy.

2. Copy the image to the shared storage location, using the Dell SMU to inject the appropriate drivers.

One of the main features of Dell AIM is the ability to retarget workloads to heterogeneous compute sources: physical servers, Microsoft Hyper-V virtual machines, and VMware vSphere virtual machines. The Dell AIM controller use PXE boot to direct the machine to its assigned boot image on the shared SAN. To accomplish this, prior to copying the Windows image it is necessary to inject the drivers for the Hyper-V virtual disk and any other disk drivers you wish to target in your environment. During the boot image copy operation, simply choose the drivers you wish to inject, as we show in Figure 9 below.

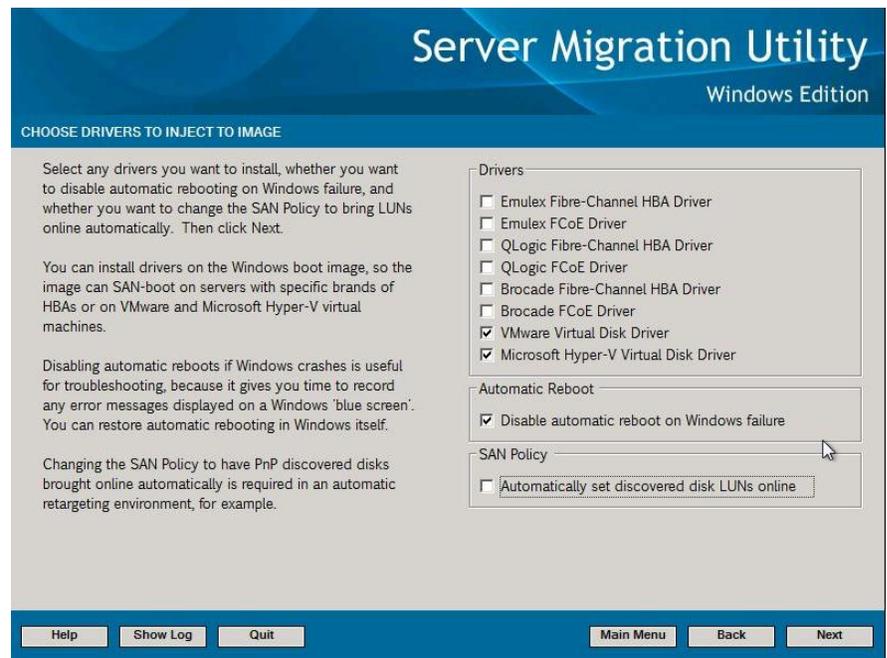


Figure 9: Dell SMU – injecting drivers into the Windows image.

Next, copy the image to the SAN LUN. Our sample VMware 40GB image took less than two minutes (see Figure 10).

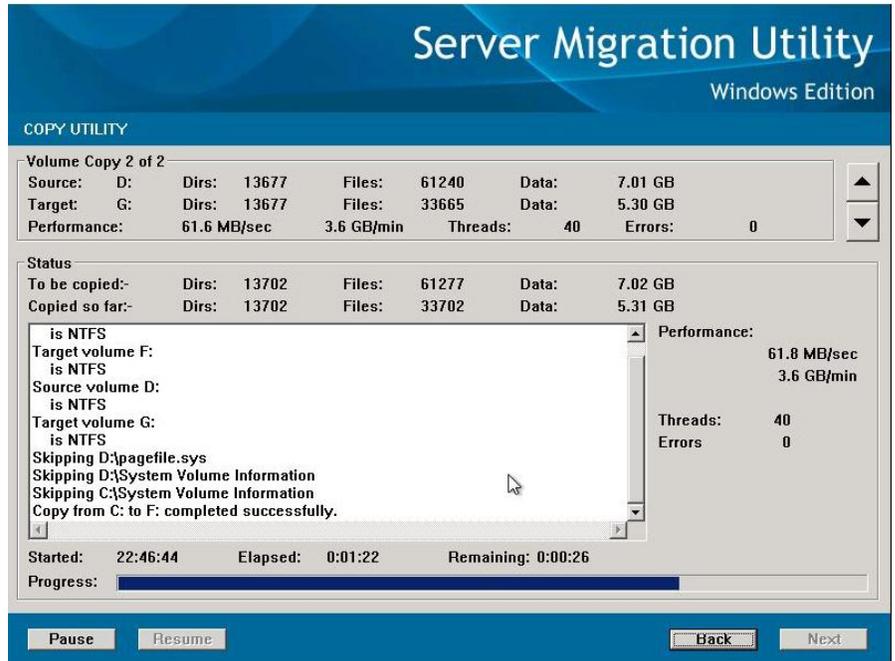


Figure 10: Dell SMU – Copying the windows boot image to the shared storage location.

3. Add the persona, Dell AIM’s implementation of abstracted physical or virtual workloads, to the Dell AIM console. Then boot the persona.

Once you copy the image to the shared storage location, the persona can be added to the Dell AIM environment. Dell AIM provides a step-by-step wizard where the administrator can configure this new persona, which we show below in Figure 11.

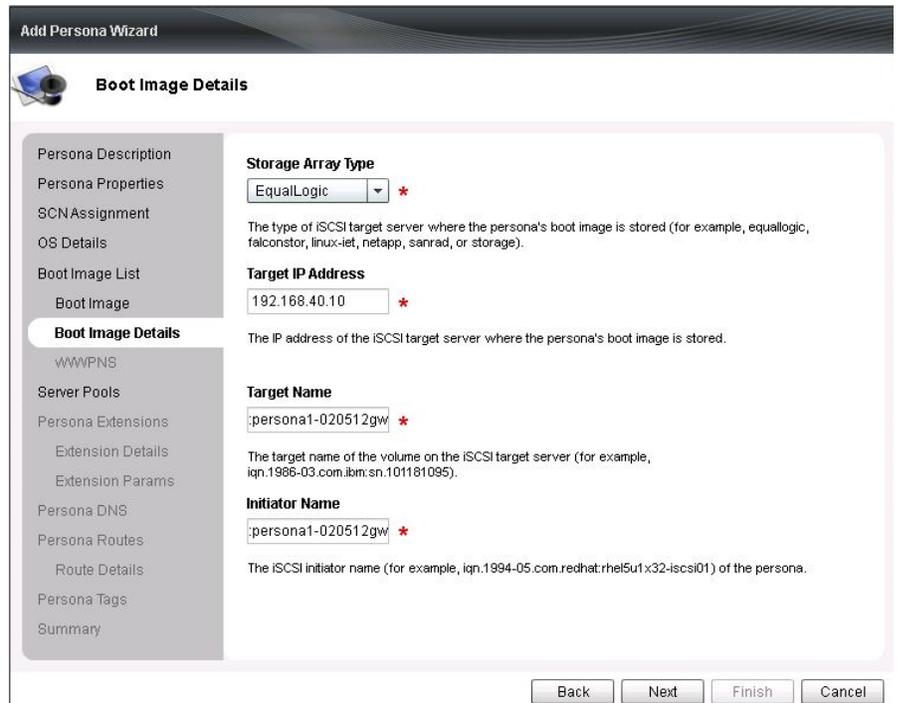


Figure 11: Dell AIM – Creating the new persona and adding storage details for the boot image.

Finally, boot the persona and direct the workload to the desired server (Figure 12).

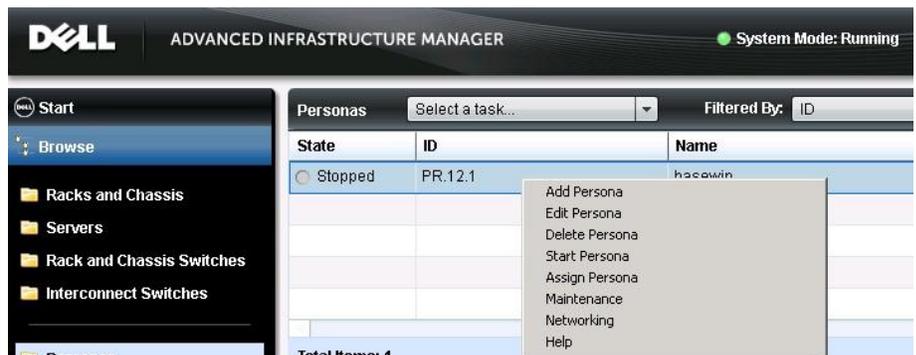


Figure 12: Dell AIM – Starting the new persona.

By using the Dell SMU and Dell AIM, you can easily transition workloads from practically any existing environment, especially operationally expensive environments, to the cost effective Dell PowerEdge M915 solution that we discuss in our cost comparisons above.

## CONCLUSION

Dell PowerEdge M915 blade servers with four AMD Opteron 6276 processors running Microsoft Windows Server 2008 R2 with Hyper-V is a solution capable of delivering significant cost-per-VM value and strong performance to your enterprise. With a hardware and software savings of 62 percent over a performance-comparable HP/Intel/VMware solution, the Dell/AMD/Microsoft solution is one to consider. In addition, using tools like Dell AIM and the Dell SMU, you can migrate VMs from the HP/Intel/VMware to the Dell/AMD/Microsoft solution in just minutes.

## APPENDIX A – COST CALCULATIONS

Figure 13 summarizes the hardware configurations and prices.

Hardware details	Dell/AMD/Microsoft	HP/Intel/VMware
<b>Servers</b>	<b>Dell PowerEdge M915 Blade Server</b>	<b>HP ProLiant BL680c G7 Server Blade</b>
Processor	4 x AMD Opteron 6276 processors	4 x Intel® Xeon® Processor E7-8867L
Memory	128GB (32x4GB)	128GB (32x4GB)
Embedded management	iDRAC6 Enterprise	Integrated Lights Out 3 (iLO 3) Management
Network card	Broadcom 5709 Dual Port 1GbE NIC with TOE	6 x Embedded HP NC553i 10Gb FlexFabric Adapters
Hard drives	2x146GB 15K RPM	2x146GB 15K RPM
Hardware support services	3 Year ProSupport and Mission Critical 4HR 7x24 Onsite Pack	HP Care Pack 3-year, 6-Hour, Call-to-Repair BL6XXc Server Blade Hardware Support - electronic
Cost per server	\$13,061.00	\$37,050.00
<b>Enclosures</b>	<b>Dell M1000e Modular Blade Enclosure</b>	<b>HP BladeSystem c-Class c7000 ROHS Enclosure</b>
Modules	2x Dell PowerConnect M6220 blade modules	2 HP 1/10Gb-F Virtual Connect Ethernet Modules for c-Class BladeSystem <sup>2</sup>
Power supplies	6 x 2700W power supplies	6 X 2400W gold hot plug factory integrated power supplies
Hardware support services	3 Year ProSupport and Mission Critical 4HR 7x24 Onsite Pack	HP Care Pack 3-year, 6-Hour, 24x7 Call-to-Repair c7000 Enclosure Hardware Support
Cost per enclosure	\$14,735.26	\$21,379.00

Figure 13: Hardware configurations and prices for each solution.

<sup>2</sup> Pricing was unavailable for the modules we used in testing, the 2 HP 1/10Gb Virtual Connect Ethernet Modules for c-Class BladeSystem. Therefore for pricing we quoted two very similar modules, the 2 HP 1/10Gb-F Virtual Connect Ethernet Modules for c-Class BladeSystem.

Figure 14 lists the software costs we included in our analysis.

<b>Windows Server 2008 R2 Datacenter edition</b>	
Price per processor	\$4,209.50
Source	<a href="http://www.microsoft.com/licensing/mla/quickquote.aspx">http://www.microsoft.com/licensing/mla/quickquote.aspx</a>
Licensing type	Open license no level
Support included	Price for license plus three year Software Assurance (1 year SA calculated at ¼ license cost)
<b>vSphere 5 Enterprise Plus</b>	
Price per processor	\$6,117.00
Source	<a href="http://www.vmware.com/products/vsphere/pricing.html">http://www.vmware.com/products/vsphere/pricing.html</a>
Licensing type	VMware vSphere 5 Enterprise Plus for 1 processor (with 96 GB vRAM entitlement per processor)
Support included	3-year total for Enterprise Plus license with Production Support and Subscription (SaS)
Notes	All editions must be used in conjunction with an existing or separately purchased vCenter Server edition. Editions have specific CPU and virtual memory entitlements.

**Figure 14: Software prices for each solution.**

## APPENDIX B – TEST CONFIGURATION OVERVIEW

We used 20 client machines for the 20-VM test on each server, with each client targeting one VM on the servers under test. We first tested the VMs on the HP ProLiant BL680c G7, and then on the Dell PowerEdge M915. We used the same storage connected to each server: three trays of Dell EqualLogic iSCSI storage, each filled with 15K SAS drives. Each client machine ran Windows Server 2003 R2 SP1 with the .NET framework 3.5 SP1 installed. We initiated and controlled all testing sessions from a separate controller machine.

## APPENDIX C – CONFIGURING STORAGE

### Dell PowerEdge M915, HP ProLiant BL680c G7, and Dell EqualLogic PS5000XV storage configuration overview

Our complete storage infrastructure consisted of the following:

- Dell
  - Two internal 15K 146GB drives
  - A Dell PERC H200 internal RAID controller
  - Two onboard Broadcom® NICs dedicated to iSCSI traffic
- HP
  - Two internal 15K 146GB drives
  - An HP Smart Array P410i RAID controller
  - Two onboard HP NC553i 10Gb FlexFabric NICs dedicated to iSCSI traffic
- Common elements
  - A Dell PowerConnect 6248 switch dedicated to iSCSI traffic
  - Three Dell EqualLogic™ PS5000XV storage arrays

We configured the internal drives on the server in a RAID 1 volume, with each volume containing two physical disks. On the HP ProLiant BL680c G7 server, we installed VMware vSphere 5, and on the Dell PowerEdge M915 we installed Microsoft® Windows Server® 2008 R2 SP1.

For external storage, we used three Dell EqualLogic PS5000XV arrays, each containing 16 drives. We cabled each Dell EqualLogic PS5000XV to a Dell PowerConnect 6248 switch via their three available ports, and we mapped the two iSCSI-dedicated blade server NICs to their respective blade modules: on the Dell we used a Dell PowerConnect M6220 switch and on the HP we used an HP 1/10Gb Virtual Connect Ethernet blade module. From each blade module, we cabled to the PowerConnect 6248 dedicated to iSCSI traffic. For specifics on multipathing drivers used on each platform, see the sections below specific to each server setup.

We enabled jumbo frames on each server's two iSCSI-dedicated NICs. To do this in Windows, we adjusted the MTU to 9,000 via the NIC Properties window, while in vSphere we adjusted the MTU for the relevant vSwitches and the bound VMkernel ports. We also enabled jumbo frames on the Dell PowerConnect 6248 switch, the Dell PowerConnect M6220 switch, and on each NIC on the Dell EqualLogic PS5000XV storage. The HP Virtual Connect blade module passed our jumbo frame traffic successfully with no further configuration. For specific configurations on the Dell PowerConnect 6248 and Dell PowerConnect M6220, see the recommended settings from the document titled *Dell EqualLogic Configuration Guide, Appendix E: PowerConnect 62xx Switch Configuration*.

Each Dell EqualLogic PS5000XV contained 16 drives. We configured each Dell EqualLogic PS5000XV in RAID 10 mode. We created a large storage pool in the group and created volumes for each platform in the pool. We created six volumes, each sized at 210 GB to hold VM virtual disk files for each hypervisor.

## Setting up the internal storage for host operating system installation

On each server, using the RAID BIOS for each server's respective RAID controller, configure a RAID 1 volume for the host operating system.

## Setting up the external storage

1. Using the command-line console, via serial cable, reset the first Dell EqualLogic PS5000XV by using the reset command.
2. Supply a group name, group IP address, and IP address for eth0 on the first of three arrays.
3. Reset the remaining two arrays in the same manner, supply the group name to join and IP address created in Step 2, and supply an IP address in the same subnet for eth0 on each remaining tray.
4. After group creation, using a computer connected to the same subnet as the storage, use the Dell EqualLogic Web interface to do the following:
  - a. Assign IP addresses on the remaining NICs (eth1 and eth2) on each array. Enable the NICs.
  - b. Verify matching firmware levels on each array and MTU size of 9,000 on each NIC on each array.
  - c. Click each member (array), and choose Yes when prompted to configure the member. Choose RAID 10 for each array.
  - d. Create twelve 210GB volumes for VM virtual disk storage – six for VMware vSphere 5.0 usage and six for Microsoft Hyper-V R2 SP1 usage.
  - e. Enable shared access to the iSCSI target from multiple initiators on the volume.
  - f. Create an access control record for the volume without specifying any limitations.
  - g. During testing, offline the volumes not in use by the current hypervisor.

# APPENDIX D – SETTING UP THE MICROSOFT WINDOWS ENVIRONMENT

## Adjusting BIOS settings

We used the latest released BIOS updates on the Dell PowerEdge M915, ensured that Virtualization was enabled, and enabled the Maximum Performance power profile.

## Setting up the Hyper-V R2 SP1 host server

### Installing Windows Server 2008 R2 SP1

1. Log into the iDRAC console for the Dell PowerEdge M1000e blade server enclosure.
2. Launch the console for the PowerEdge M915.
3. In the iDRAC console, mount the installation DVD ISO for Windows Server 2008 R2 SP1 to the PowerEdge M915.
4. Choose the language, time and currency, and keyboard input. Click Next.
5. Click Install Now.
6. Choose Windows Server 2008 R2 Datacenter (Full Installation), and click Next.
7. Accept the license terms, and click Next.
8. Click Custom.
9. Click the Disk, and click Drive options (advanced).
10. Click New→Apply→Format, and click Next.
11. After the installation completes, click OK to set the Administrator password.
12. Enter the administrator password twice, and click OK.
13. Connect the machine to the Internet and install all available Windows updates. Restart as necessary.
14. Disable all firewall settings.
15. Enable remote desktop access.
16. Change the hostname, and reboot when prompted.
17. Create a shared folder to store test script files. Set permissions as needed.
18. Set up networking for the VM network that DVD Store traffic will use:
  - a. Click Start→Control Panel, right-click Network Connections, and choose Open.
  - b. Right-click the VM traffic NIC, and choose Properties.
  - c. Select TCP/IP (v4), and choose Properties.
  - d. Set the IP address for this NIC, which will handle management traffic. Click OK, and click Close.
  - e. Repeat steps b through d for the two onboard NICs to be used for iSCSI traffic.
    - i. For the iSCSI NICs, assign IP addresses on the same subnet as the storage configuration you configured on the Dell EqualLogic arrays. Open the Connection properties, and click Configure for each respective NIC. Modify the advanced properties of each NIC, setting the MTU to 9000.
19. Install hotfix numbers KB2568088 and KB2645594.

### Adding the Hyper-V R2 SP1 role

1. Open Server Manager, and click Roles.
2. Click Add Roles.
3. On the Before You Begin page, check the Skip this page by default box, and click Next.
4. Select Hyper-V, and click Next.
5. On the Hyper-V Introduction page, click Next.
6. On the Create Virtual Networks page, click Next.
7. Confirm installation selections, and click Install.
8. Once the installation is complete, click Close.
9. When the system prompts a restart, click Yes.

10. Allow the system to fully reboot, and log in using the administrator credentials.
11. Once the desktop loads, the Hyper-V Installation Results window will finish the installation.
12. Click Close. The Hyper-V role will now be available in Server Manager under Roles.

### Installing Dell EqualLogic Host Integration Tools for MPIO

1. Log into Windows, and start the Dell EqualLogic Host Integration Tools installer.
2. At the Welcome screen, click Next.
3. At the License Agreement screen, click Next.
4. At the Installation Type screen, select Typical (Requires reboot on Windows Server platforms), and click Next.
5. In the Microsoft iSCSI Initiator service is not running window, click Yes to start the service and enable iSCSI traffic through the firewall.
6. In the Microsoft iSCSI service window, click Yes.
7. When the iSCSI Initiator Properties window pops up, accept the defaults, and click OK.
8. If a Windows Firewall Detected window appears, click Yes to enable echo requests.
9. At the Ready to install the components screen, click Install.
10. In the Microsoft Multipath I/O feature is not detected window, click Yes to install the feature.
11. At the Installation Complete screen, click Finish.
12. In the System Restart Required window, select Yes, I want to restart my computer now, and click OK.
13. After reboot, open the Dell EqualLogic Host Integration Toolkit remote setup wizard, and click configure MPIO. Under Subnets included for MPIO, ensure that only the iSCSI subnet is included in the “include” section.

### Connecting to the volumes with Microsoft iSCSI Initiator

1. Using the Dell EqualLogic Web UI, ensure the Hyper-V-specific volumes are online and the VMware-specific volumes are offline.
2. On the server, click Start→Administrative Tools→iSCSI Initiator.
3. Select the Discovery Tab, and click Discover Portal.
4. Enter the IP address for the Dell EqualLogic Storage Group, and click OK.
5. Select the Targets tab, and click Refresh.
6. Select the first Inactive Target listed, and click Connect.
7. Ensure that Add this connection to the list of Favorite Targets is selected, check the Enable multi-path check box, and click OK.
8. Repeat until you have connected to all six volumes, and click OK.

### Configuring the external volumes in Windows Server 2008 R2 SP1

1. On the server, click the Server Manager icon in the taskbar.
2. In the left pane, expand Storage, and click Disk Management.
3. Right-click the first external volume, and choose Initialize Disk.
4. In the right pane, right-click the volume, and choose New Simple Volume.
5. At the Welcome window, click Next.
6. At the Specify Volume Size window, leave the default selection, and click Next.
7. At the Assign Drive Letter or Path window, choose a drive letter, and click Next.
8. At the Format Partition window, choose NTFS and 64K allocation unit size, and click Next.
9. At the Completing the New Simple Volume Wizard window, click Finish.
10. Repeat steps 3 through 9 for the remaining external volumes.

### Configuring the virtual network

1. In Hyper-V Manager, right-click the server name in the list on the left side of Hyper-V, and choose Virtual Network Manager...

2. Choose External, and click Add.
3. Name the Virtual Network, and choose the appropriate NIC for your VM network from the drop-down menu.
4. Click OK.

### Configuring the first Hyper-V VM

1. On the Hyper-V host, click Action→New→Virtual Machine.
2. On the Before You Begin window, click Next.
3. Enter the name of the VM, and click Next.
4. Assign 5,632MB of memory, and click Next.
5. Choose the virtual network you created from the drop-down menu, and click Next.
6. Choose to attach a virtual hard drive later.
7. Click Finish.
8. Create the following fixed size VHDs by choosing Action→New→Virtual Hard Drive:
  - a. 20GB VHD for the VM OS
  - b. 13GB VHD for SQL Server data
  - c. 11GB VHD for SQL Server logs
  - d. 2GB VHD for the backup files
9. Right-click the VM, and choose Settings.
10. Add the VM OS VHD to the IDE controller.
11. Add the VM SQL VHD, the VM backup VHD, and the SQL log VHD to the SCSI controller.
12. Click Processors, and adjust the number of virtual processors to 2.
13. Start the VM.
14. Attach the Windows Server 2008 R2 SP1 ISO image to the VM and install Windows Server 2008 R2 on your VM. See [Appendix E](#) for VM-related setup.

# APPENDIX E – SETTING UP THE VMWARE VSPHERE 5 ENVIRONMENT

## Adjusting BIOS settings

We used the latest released BIOS updates on the HP ProLiant BL680c G7, ensured that Virtualization was enabled, and enabled the Maximum Performance power profile.

## Installing VMware vSphere 5 (ESXi) on the HP ProLiant BL680c G7

1. Log into the HP iLO console, and connect to the HP ProLiant BL680c G7.
2. Mount the VMware vSphere ISO disk.
3. Insert the disk, and select Boot from disk.
4. On the Welcome screen, press Enter.
5. On the End User License Agreement (EULA) screen, press F11.
6. On the Select a Disk to Install or Upgrade Screen, select the relevant volume to install ESXi on, and press Enter.
7. On the Please Select a Keyboard Layout screen, press Enter.
8. On the Enter a Root Password Screen, assign a root password, and confirm it by entering it again. Press Enter to continue.
9. On the Confirm Install Screen, press F11 to install.
10. On the Installation complete screen, press Enter to reboot.

## Configuring ESXi after installation

1. On the 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 if you want to apply the changes, type `Y`.

## Configuring iSCSI networking on ESXi

1. Using the vSphere client from another machine, connect to host server then browse to the server.
2. Add the necessary vSwitches:
  - a. Click the host, click the Configuration tab, and click Networking.
  - b. Click Add Networking.
  - c. Choose VMkernel, and click Next.
  - d. Choose create a vSphere standard switch.
  - e. Choose the first onboard NIC associated with iSCSI traffic.
  - f. Assign the network label, and assign IP settings.
  - g. Click Finish.
  - h. Repeat steps b through g for the remaining NIC assigned to iSCSI traffic.
3. Add the iSCSI software storage adapter:
  - a. Click the host, click the Configuration tab, and click Storage adapters.
  - b. Click Add.
  - c. Click Add software iSCSI adapter.
  - d. Click OK.

4. Configure the iSCSI software storage adapter:
  - a. Right-click the iSCSI adapter that was just added to the system, choose Properties, and ensure it is enabled.
  - b. Inside the iSCSI adapter Properties window, click the Network Configuration tab.
  - c. Under VMkernel port bindings, click Add, and add each VMkernel adapter to the VMkernel port bindings list.
5. Enable jumbo frames in ESXi:
  - a. Click the host, click the Configuration tab, and click Networking.
  - b. On the first vSwitch used for iSCSI, click Properties.
  - c. Select the vSwitch.
  - d. Click Edit.
  - e. Modify the MTU to 9,000.
  - f. Click OK.
  - g. In the vSwitch Properties window, choose the VMkernel port.
  - h. Click Edit.
  - i. Modify the MTU to 9,000.
  - j. Click OK.
  - k. Click Yes if warned about datastore access.
  - l. Click Close.
  - m. Repeat steps b through l for the remaining NIC dedicated to iSCSI traffic.
6. Access provisioned Dell EqualLogic storage:
  - a. Using the Dell EqualLogic Web UI, ensure the VMware-specific volumes are online and the Hyper-V-specific volumes are offline.
  - b. In the vSphere client, click the host, click the Configuration tab, and click Storage adapters.
  - c. Right-click the iSCSI software storage adapter.
  - d. Click Dynamic discovery.
  - e. Click Add.
  - f. Enter the Dell EqualLogic group IP address.
  - g. Click Close.
  - h. When prompted to rescan the HBA, click Yes.

### Installing the Dell EqualLogic Multipathing Extension Module (MEM) version 1.1 on the ESXi server

1. Using a file transfer utility, copy the MEM installation ZIP file to the ESXi server.
2. Use the following command to install the Dell EqualLogic MEM beta. Consult the installation and user guide for more details on the VMware MEM integration.
 

```
esxcli software vib install -d membundlename.zip --no-sig-check
```
3. Using the Dell EqualLogic Multipathing Extension Module Installation and User Guide, verify that the MEM is functional on the host server.

### Configuring the external volumes in VMware vSphere 5

1. In the vSphere client, select the host.
2. Click the Configuration tab.
3. Click Storage, and click Add Storage...
4. Choose Disk/LUN.
5. Select the disk, and click Next.
6. Accept the default of VMFS-5 for the file system.
7. Review the disk layout, and click Next.
8. Enter the datastore name, and click Next.
9. Accept the default of using maximum capacity, and click Next.

10. Click Finish.
11. Repeat steps 3 through 10 for the remaining LUNs.

### Configuring the first vSphere VM

1. In the vSphere client, connect to the vSphere host.
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 datastore on the external storage, and click Next.
7. Choose Virtual Machine Version 8, and click Next.
8. Choose Windows, choose Microsoft Windows Server 2008 R2 (64-bit), and click Next.
9. Choose two virtual processors, and click Next.
10. Choose 5632MB 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 20 GB, choose thick-provisioned lazy zeroed, specify the 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 13GB for the virtual disk size, choose thick-provisioned lazy zeroed, and specify the datastore on the external storage.
22. Choose SCSI(1:0) for the device node, and click Next.
23. On the Hardware tab, click Add...
24. Click Hard Disk, and click Next.
25. Click Create a new virtual disk, and click Next.
26. Specify 11GB for the virtual disk size, choose thick-provisioned lazy zeroed, and specify the datastore on the external storage.
27. Choose SCSI(1:1) for the device node, and click Next.
28. On the Hardware tab, click Add...
29. Click Hard Disk, and click Next.
30. Click Create a new virtual disk, and click Next.
31. Specify 2GB for the virtual disk size, choose thick-provisioned lazy zeroed, and specify the datastore on the external storage.
32. Choose SCSI(1:2) for the device node, and click Next.
33. Click SCSI Controller 1, and choose Change Type.
34. Choose VMware Paravirtual, and click OK.
35. Click Finish, and click OK.
36. Click the Resources tab, and click Memory.
37. Adjust the memory reservation for the VM to 5,632MB, to match Hyper-V's static guarantee of 5,632MB.
38. Start the VM.
39. Attach the Windows Server 2008 R2 SP1 ISO image to the VM and install Windows Server 2008 R2 on your VM. See [Appendix E](#) for VM-related setup.

## APPENDIX F – CONFIGURING THE VMS ON EACH HYPERVISOR

See the previous appendixes regarding the initial creation of the virtual machines on each hypervisor. We provide steps below for installing the operating system, Microsoft SQL Server, and configuring the VMs.

### Installing the VM operating system on the first VM

1. Use an ISO image for the OS installation and connect to the VM console on either vSphere or Hyper-V.
2. Open the VM console on vSphere or Hyper-V.
3. At the Language Selection Screen, click Next.
4. Click Install Now.
5. Select Windows Server 2008 R2 Standard (Full Installation), and click Next.
6. Click the I accept the license terms check box, and click Next.
7. Click Custom.
8. Click Next.
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. \*VMware only\* - Install the latest VMware tools package on the VM. Restart as necessary. Windows Server 2008 R2 SP1 already includes Hyper-V integration tools.
13. Connect the VM to the Internet, and install all available Windows updates. Restart as necessary.
14. Enable remote desktop access, and disable all firewall settings.
15. Change the hostname, and reboot when prompted.
16. Create a shared folder to store test script files. Set permissions as needed.
17. Set up networking:
  - a. Click Start→Control Panel, right-click Network Connections, and choose Open.
  - b. Right-click the VM traffic NIC, and choose Properties.
  - c. Select TCP/IP (v4), and choose Properties.
  - d. Set the IP address, subnet, gateway, and DNS server for the virtual NIC, which will handle outgoing server traffic. Click OK, and click Close.
18. In the VM, configure the VM storage:
  - a. Click the Server Manager icon in the taskbar.
  - 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.
19. Copy the pre-created 5GB DVD Store backup file to the backup virtual disk inside the first VM.

### Installing SQL Server 2008 R2 SP1 on the first VM

1. Open the Hyper-V or vSphere console for the VM.
2. Log into the virtual machine.
3. Mount the DVD ISO file for SQL Server 2008 R2 to the appropriate Hyper-V or vSphere VM.
4. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2008 R2 DVD, and double-click.

5. If the installer prompts you with a .NET installation prompt, click Yes to enable the .NET Framework Core role.
6. In the left pane, click Installation.
7. Click New installation or add features to an existing installation.
8. At the Setup Support Rules screen, wait for the check to complete. If there are no failures or relevant warnings, click OK.
9. Select the Enter the product key radio button, and enter the product key. Click Next.
10. Click the checkbox to accept the license terms, and click Next.
11. Click Install to install the setup support files.
12. If no failures are displayed, click Next. If you see a Computer domain controller warning and a Windows Firewall warning, ignore them for now.
13. At the Setup Role screen, choose SQL Server Feature Installation.
14. 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.
15. At the Installation Rules screen, click Next when the check completes.
16. At the Instance configuration screen, leave the default selection of default instance, and click Next.
17. At the Disk space requirements screen, click Next.
18. 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.
19. At the Database Engine Configuration screen, select Mixed Mode.
20. Enter and confirm a password for the system administrator account.
21. Click Add Current user. This may take several seconds.
22. Click Next.
23. At the Error and usage reporting screen, click Next.
24. At the Installation Configuration rules screen, check that there are no failures or relevant warnings, and click Next.
25. At the Ready to Install screen, click Install.
26. After installation completes, click Next.
27. Click Close.
28. Create a SQL Server login for the ds2user (see the [Configuring the database \(DVD Store\) section](#) for the specific script to use).
29. Click Start→All Programs→Microsoft SQL Server 2008 R2→Configuration Tools, and click SQL Server Configuration Manager.
30. Expand SQL Server Network Configuration, and click Protocols for MSSQLSERVER.
31. Right-click TCP/IP, and select Enable.
32. Close the SQL Server Configuration Manager.
33. Click Start→All Programs→Microsoft SQL Server 2008 R2→SQL Server Management Studio. Choose to connect to the instance.
34. Right-click the instance and choose Properties.
35. Click Database Settings.
36. Assign a high value, such as 2,000, to the Recovery Interval setting to prevent checkpoints during test runs.
37. Close the SQL Server Management Studio.
38. Restart the SQL Server service.
39. Download and install Microsoft SQL Server 2008 R2 SP1.

## Configuring additional VMs on Microsoft Hyper-V R2 SP1

### Copying the VMs

1. Right-click the first VM, and choose Settings.
2. Remove all VHDs from the first VM.
3. Create additional “shell” VMs as necessary with the same settings as the first.
4. Copy all four VHD files from the first VM’s LUNs to each additional VM’s respective LUNs. We used a round-robin approach to spread our VM files to the six hypervisor-specific LUNs. For example, VM 1 files were placed on LUN 1, VM 2 files were placed on LUN 2, etc.
5. Reattach all newly copied VHDs to their respective VMs.
6. Start each VM, rename the computer name of each VM, and reboot each VM.
7. Assign IP addresses as needed for each VM.
8. Modify the SQL Server hostname of each VM using the instructions provided by Microsoft (<http://msdn.microsoft.com/en-us/library/ms143799.aspx>).
9. Bring each VHD online in each VM, using the Server Management utility.

### Configuring additional VMs on VMware vSphere 5

1. Add the vSphere host to a vCenter Server datacenter for cloning purposes. vCenter Server setup is outside the scope of this report.
2. Right-click the first VM, and choose Clone.
3. Name the new VM.
4. Choose the datacenter, and select the host.
5. For the storage screen, select the proper datastore. Again, we used a round-robin approach to spread our VM files to the six hypervisor-specific LUNs. For example, VM 1 files were placed on LUN 1, VM 2 files were placed on LUN 2, etc.
6. Choose to customize using the customization wizard. Save the clone details as a new customization specification.
7. Continue cloning each VM, modifying the customization specification as necessary for IP addressing and so on.
8. Ensure in each VM that the necessary virtual disks are all online, the hostname is renamed, and the IP addressing was properly assigned by the customization wizard.
9. Modify the SQL Server hostname of each VM using the instructions provided by Microsoft (<http://msdn.microsoft.com/en-us/library/ms143799.aspx>).

## APPENDIX G - CONFIGURING THE DATABASE (DVD STORE)

### Data generation overview

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 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 schemas were 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 2008 R2 SP1. We built the database in SQL Server 2008 R2 SP1, performed a full backup of the 5GB database, and moved that backup files to all VMs. We used that backup file to restore on all VMs between test runs. We performed this data-generation and schema-creation procedure once, and used the same SQL Server backup files for both VMware vSphere 5 and Hyper-V R2 SP1 virtual machines.

The only modification we made to the schema-creation scripts were the specified file sizes for our database, which we note in Figure 9. We explicitly set the file sizes higher than necessary to ensure that no file-growth activity would affect the outputs of the test. In addition, as we note in the above setup steps, we extended the recovery interval setting for SQL Server to avoid heavy disk I/O activity during the test run. Besides these changes, we created and loaded the database schema 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 5GB 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.

Figure 15 shows our initial file size modifications.

Logical name	Filegroup	Initial size (MB)
<b>Database files</b>		
primary	PRIMARY	3
cust1	DS_CUST_FG	2,560
cust2	DS_CUST_FG	2,560
ind1	DS_IND_FG	1,536
ind2	DS_IND_FG	1,536
ds_misc	DS_MISC_FG	1,536
orders1	DS_ORDERS	1,536
orders2	DS_ORDERS	1,536
<b>Log files</b>		
ds_log	Not applicable	10,240

**Figure 15. Our initial file size modifications.**

### Editing the workload script – ds2xdriver.cs module

We used the default downloaded ds2sqlserverdriver.exe application from the DVD Store page and made no modifications for this testing.

### 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 only the difference between the two solutions, which was 4.4%.

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 driver 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 20 minutes.
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=10 --db_size=5GB --think_time=0
```

## APPENDIX H – SERVER AND STORAGE CONFIGURATION INFORMATION

Figure 16 provides detailed configuration information for the Dell PowerEdge M915 and the HP ProLiant BL680c G7 servers we tested, Figure 17 provides configuration information for the Dell EqualLogic PS5000 storage array, and Figure 18 provides detailed configuration information for the blade enclosures.

System	Dell PowerEdge M915	HP ProLiant BL680c G7
<b>General</b>		
Number of processor packages	4	4
Number of cores per processor	16	10
Number of hardware threads per core	16	20
<b>CPU</b>		
Vendor	AMD	Intel
Name	Opteron	Xeon
Model number	6276	E7-8867L
Socket type	G34	LGA1567
Core frequency (GHz)	2.30	2.13
Bus frequency	6.4 GT/s	6.4 GT/s
L1 cache	48 KB	480 KB
L2 cache	1,000 KB	2.5 MB
L3 cache	16 MB	30 MB
<b>Platform</b>		
Vendor and model number	Dell PowerEdge M915	HP ProLiant BL680c G7
Motherboard model number	OJ4N6F	USE147LDB0
BIOS name and version	Dell Inc. 2.3.0 (10/18/2011)	HP BIOS I25 (05/23/2011)
BIOS settings	Maximum Performance	Maximum Performance
<b>Memory module(s)</b>		
Total RAM in system (GB)	128	128
Vendor and model number	Samsung M393B5273CH0-YH9	Micron MT36JSZF51272PZ-1G4F1DD
Type	PC3L-10600R	PC3-10600R
Speed (MHz)	1,333	1,333
Speed running in the system (MHz)	1,333	1,333
Timing/Latency (tCL-tRCD-tRP-tRASmin)	9-9-9-24	9-9-9-20
Size (GB)	4	4
Number of RAM module(s)	32	32
Chip organization	Double-sided	Double-sided
Rank	Dual	Dual
<b>OS/Hypervisor</b>		
Name	Windows Server 2008 R2 SP1 Datacenter	VMware vSphere 5.0.0
Build number	7601	469512
File system	NTFS	VMFS
Kernel	ACPI x64-based PC	5.0.0
Language	English	English

System	Dell PowerEdge M915	HP ProLiant BL680c G7
<b>RAID controller</b>		
Vendor and model number	Dell PERC H200	HP Smart Array P410i
Firmware version	7.03.05.00	5.14
Cache size (MB)	0	0
<b>Hard Drives</b>		
Vendor and model number	Dell ST9146852SS	HP EH0146FARWD
Number of drives	2	2
Size (GB)	146	146
RPM	15,000	15,000
Type	SAS	SAS
<b>Ethernet adapter</b>		
Vendor and model number	Broadcom BCM5709S NetXtreme II GigE Adapters	HP NC553i 10Gb FlexFabric Adapters
Number of ports	4	6
Type	Integrated	Integrated
<b>USB ports</b>		
Number	2	N/A
Type	2.0	N/A

Figure 16: Detailed configuration information for the servers under test.

Storage array	Dell EqualLogic PS5000 storage array
Arrays	3
Number of active storage controllers	1
Number of active storage ports	3
Firmware revision	5.1.2
Switch number/type/model	Dell PowerConnect 6248
Disk vendor and model number	Dell ST3146855SS / Maxtor Atlas 15K2_147SAS
Disk size (GB)	147 / 147
Disk buffer size (MB)	16
Disk RPM	15,000
Disk type	3.0 Gbps SAS/ 3.0 Gbps SAS
EqualLogic Host Software for Windows	Dell EqualLogic Host Integration Tools 3.5.5
EqualLogic Host Software for VMware	Dell EqualLogic Multipathing Extension Module (MEM) 1.1

Figure 17: Detailed configuration information for the storage array.

Enclosure	Dell PowerEdge M1000e	HP BladeSystem c7000
Number of blades	1	1
<b>Power supplies</b>		
Total number	2	6
Wattage of each	2,360	2,450
<b>Cooling fans</b>		
Total number	9	10
Voltage	12	12
Amps	7.0	16.5
<b>Network modules</b>		
Total number	2	2
Vendor and model	Dell PowerConnect M6220	HP 1/10Gb VC-Enet Module
Firmware version	3.1.3.9	3.51

Figure 18: Detailed configuration information for the blade enclosures.

## ABOUT PRINCIPLED TECHNOLOGIES



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We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.

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