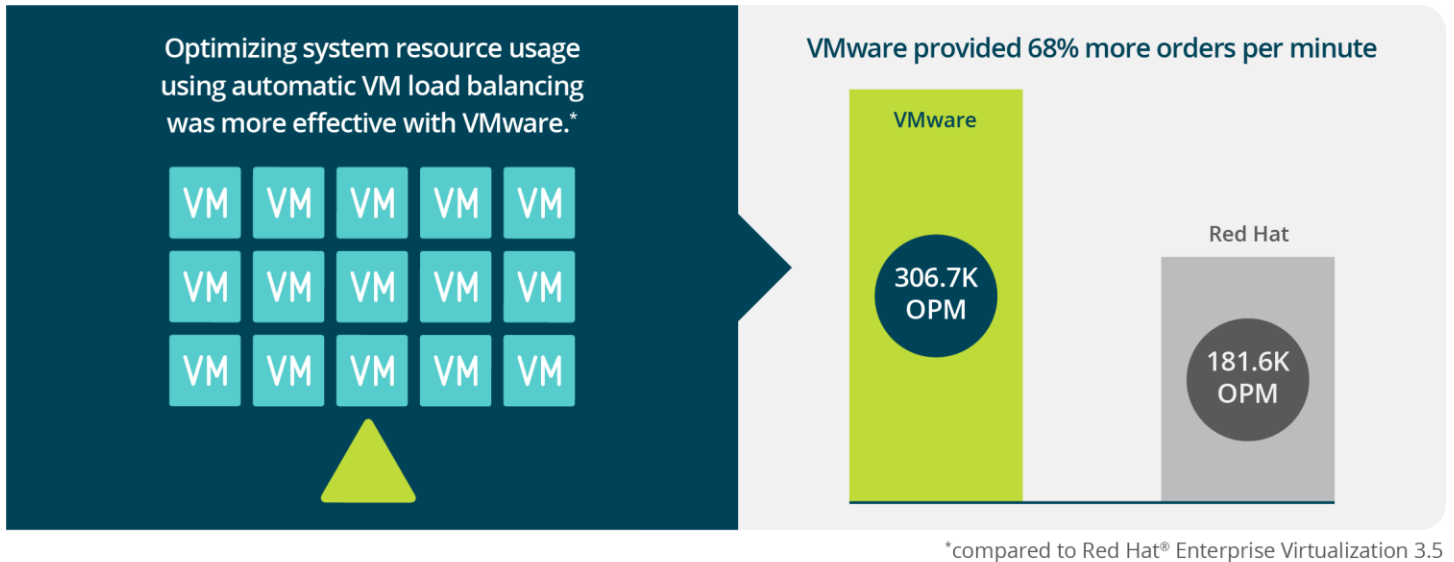


# RESOURCE BALANCING COMPARISON: VMWARE VSPHERE 6 VS. RED HAT ENTERPRISE VIRTUALIZATION 3.5

VMware® vSphere® 6

## More efficient automatic load balancing



Load balancing, the practice of evenly delivering system resources across a cluster as user demand fluctuates, helps ensure applications don't perform poorly due to resource contention. This ultimately means that users have a better application experience because they aren't left waiting for servers to handle their requests. Modern virtualization platforms can manage load balancing for you, so it's critical to choose the one that best mitigates contention by most efficiently and automatically balancing resources in your virtualization cluster.

In the Principled Technologies datacenter, we first tested a three-node cluster with just one active server running 15 VMs. We tested two hypervisors: VMware vSphere 6 and Red Hat Enterprise Virtualization 3.5 (RHEV). VMware vSphere 6 slightly outperformed the RHEV platform in this baseline scenario. Next, we powered on the other two servers in the cluster and used each hypervisor's built-in resource-management tools to automatically balance resources. When using load-balancing features, the VMware vSphere 6 cluster delivered 68.9 percent greater performance than the cluster running RHEV 3.5 (see Figure 1).

By more effectively balancing workloads across a cluster to make sure that resources are evenly allocated, we found in our test case that VMware vSphere 6 could process more database orders, which means that in configurations such as ours, you could get more out of your environment and ensure an optimal user experience.

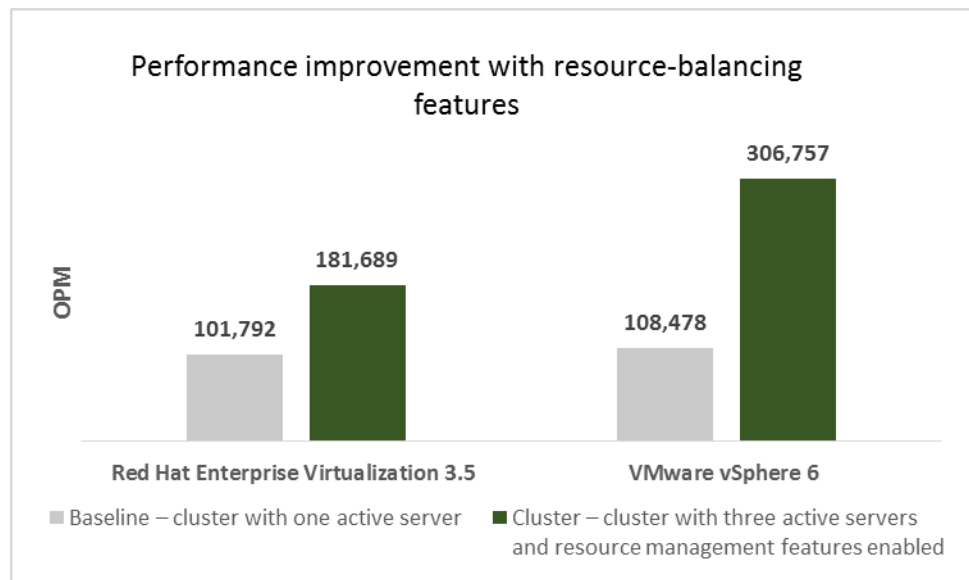


## EFFECTIVE RESOURCE BALANCING BOOSTS PERFORMANCE

Virtualization has become the new normal in today's datacenters. Servers are hosting more and more VMs, each having varied CPU, memory, and storage requirements. When server clusters host dozens, hundreds, or even thousands of VMs, managing the physical and virtual resources in an environment can be a daunting task for a system administrator. However, today's enterprise level virtualization platforms, including VMware vSphere 6 and Red Hat Enterprise Virtualization 3.5, offer resource management features to automatically monitor and adjust resource usage to maximize application performance. Which solution can provide the greatest performance advantage?

Specifically, we looked at how VMware Distributed Resource Scheduler (DRS) and Storage DRS features improved performance compared to the load balancing, memory ballooning, memory page sharing, and quota features of Red Hat Enterprise Virtualization. The two baseline configurations—using no resource management and only a single active server in the cluster—delivered a comparable number of database OPM, with the VMware vSphere solution delivering slightly more. However, when we powered on the other two servers in the cluster and used the available resource management features in VMware vSphere 6, the cluster saw a 183 percent performance boost over the single server configuration running 15 VMs. However, clustering servers with RHEV 3.5 and using its resource management features provided only a 79 percent boost over its single active server configuration. In total, when using load balancing features, the VMware vSphere 6 cluster delivered 68.9 percent greater performance than the cluster running RHEV 3.5 (see Figure 1).

**Figure 1: Using resource management features, RHEV 3.5 delivered 1.79 times the baseline performance while VMware vSphere 6 delivered 2.83 times its baseline.**



## WHAT HAPPENED?

VMware vSphere balances computing capacity by cluster to optimize performance for hosts and virtual machines. We used two particular vSphere features to help balance load: DRS and Storage DRS.

One of the key reasons why RHEV 3.5 did not see as large a boost in performance as VMware vSphere may be due to its load-balancing limitations. RHEV allows two different forms of load balancing:

- **Evenly Distributed.** This approach balances the load based on the CPU utilization of the virtual machines on the hosts, a policy that may have little impact when VMs run applications that are storage-bound, such as database applications.
- **VM Evenly Distributed.** This approach balances the load based solely on the number of virtual machines running in the cluster. In other words, if one server has more VMs than another server has, regardless of the total load on each server, RHEV will try to put more VMs on the server with fewer VMs.

Despite the limitations of the VM Evenly Distributed policy, it still worked better in our testing than the Evenly Distributed policy. The intelligence of VMware vSphere and vCenter with DRS and Storage DRS, in contrast, correctly identified the storage bottleneck and moved the virtual machines to new hosts and new datastores in a more balanced manner, which allowed the VMware cluster to drive the overall better performance gains.

## How VMware balances load

### VMware vSphere DRS

VMware vSphere Distributed Resource Scheduler is included in the vSphere Enterprise and Enterprise Plus editions. According to VMware, “DRS dynamically balances computing capacity across a collection of hardware resources aggregated into logical resource pools, continuously monitoring utilization across resource pools and intelligently allocating available resources among the virtual machines based on pre-defined rules that reflect business needs and changing priorities. When a virtual machine experiences an increased load, VMware DRS automatically allocates additional resources by redistributing virtual machines among the physical servers in the resource pool. VMware DRS allows IT organizations to:

- Prioritize resources to the highest value applications in order to align resources with business goals
- Optimize hardware utilization automatically and continuously to respond to changing conditions

- Provide dedicated resources to business units while still profiting from higher hardware utilization through resource pooling
- Conduct zero-downtime server maintenance”

Learn more about DRS at

<https://www.vmware.com/products/vsphere/features/drs-dpm>.

## VMware vSphere Storage DRS

According to VMware, “VMware vSphere Storage DRS continuously balances storage space usage and storage I/O load while avoiding resource bottlenecks to meet application service levels.

- Deploy and integrate additional storage capacity into a storage pool.
- Take advantage of new capacity.
- Improve service levels for all applications.
- Increase VMware vSphere administrator productivity by allowing them to monitor and manage additional infrastructure.”

Learn more about VMware vSphere Storage DRS at

[www.vmware.com/products/vsphere/features/storage-drs](http://www.vmware.com/products/vsphere/features/storage-drs).

## CONCLUSION

Having ample resources to handle user requests is a necessity of modern virtualization solutions. Allocating and distributing those resources evenly, however, is imperative to the success of your business’s virtualized environment. In our tests, after powering on the other two servers in our three-node cluster and adding resource management features, VMware vSphere 6 improved performance by 183 percent over its baseline configuration of one active server and no resource management features. RHEV 3.5, in contrast, delivered only a 79 percent increase over its baseline. As you design your business’s infrastructure and applications, improvements such as those offered by VMware vSphere 6 DRS and Storage DRS can play a critical role by offering your users better application experiences. Optimized and modern resource management provided by VMware DRS can also help to lower your IT purchase and maintenance costs by reducing the number of servers necessary to run your applications.

## APPENDIX A – TEST CONFIGURATION OVERVIEW

We configured a three-node cluster with Dell PowerEdge R730s using each virtualization solution running a set of Windows Server 2012 R2 with SQL Server 2014. We ran a workload—DVD Store 2—that targets the SQL Server 2014 VMs and reports a score in terms of OPM.

We ran the workload first with all VMs on one active server and no resource management features enabled for a baseline OPM score. Next, we powered on the other two servers and experimented with the different automated resource-management features each environment offered to distribute the workloads across the servers for maximum optimization. We again measured database performance to see how increasing servers and using the resource-management tools increased the number of OPM each cluster could handle. For each solution, we ran each test three times and reported the median results.

For our testing, we configured a test bed with three Dell PowerEdge R730 servers as our systems under test servers. We added an additional server used to host management virtual machines and DVD store clients (see Figure 2). For our management and test traffic on the servers under test, we used one port on the onboard Intel Gigabit 4P I350-t NIC and attached it to a 1 gigabit management switch. We also attached the management and client server to the 1 gigabit management switch. For our NFS storage connection and migration/vMotion traffic, we configured each Dell R730 with one dual-port Intel X520 NIC and attached both ports to a Dell Networking S4810. To allow for easy switching between RHEV and VMware environments, we configured two RAID 1 pairs and switched the PERC boot drive between the two installations.

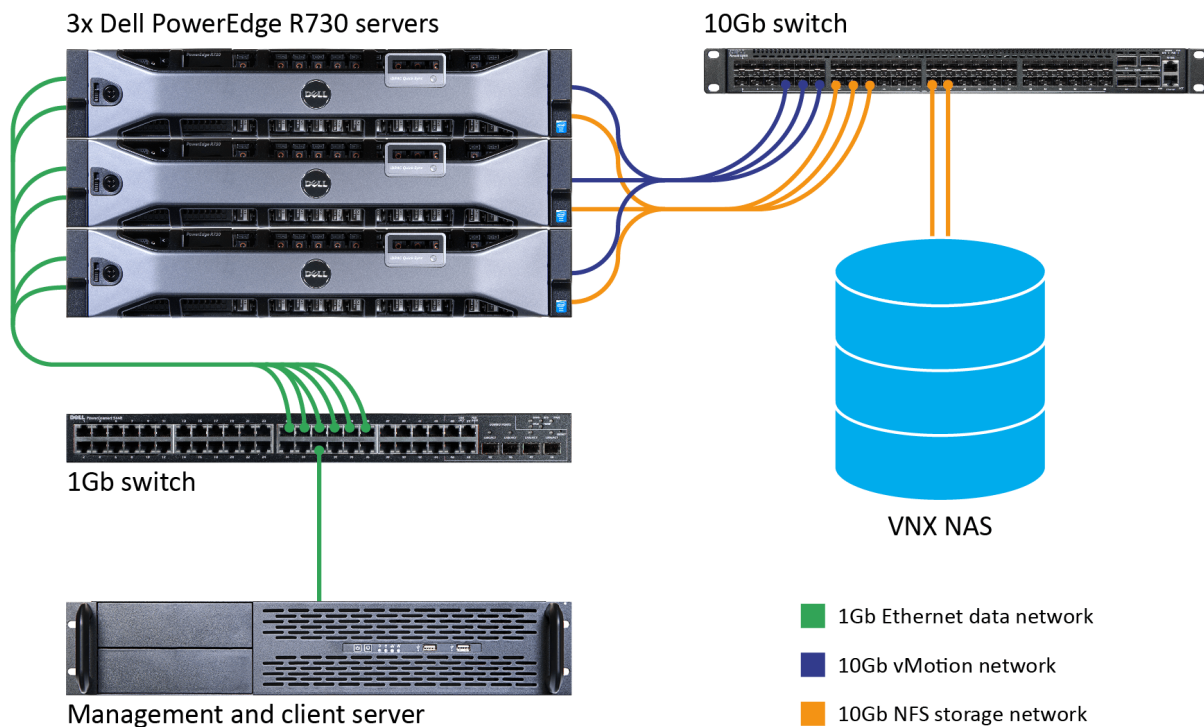


Figure 2: The production test bed and networking.

For our storage, we configured three NFS shares on an EMC VNX 5700 storage array and connected it to the S4810 switch via two 10Gb copper ports. Figure 3 presents the detailed storage configuration. In it, we specify the storage we used before the upgrade and the storage we added in the second scenario.

| Volume name                      | No. of drives | Drive type | Drive size | Drive RPM | RAID configuration |
|----------------------------------|---------------|------------|------------|-----------|--------------------|
| <b>Disks used before upgrade</b> |               |            |            |           |                    |
| FAST                             | 80            | HDD        | 300 GB     | 15,000    | RAID 10            |
| <b>Disks added with upgrade</b>  |               |            |            |           |                    |
| FLASH                            | 9             | SSD        | 200 GB     | N/A       | RAID 5             |
| SLOW                             | 8             | HDD        | 300 GB     | 15,000    | RAID 10            |

Figure 3: The storage we used during our testing.

## APPENDIX B – ISSUES WE ENCOUNTERED WITH RHEV-H DURING TESTING

As we noted in the body of this report, RHEV as it stands has issues with load balancing that we observed during our testing. As workloads become increasingly storage-based, balancing based on CPU utilization is less useful. An alternative to CPU based load balancing that RHEV supports is to load balance based solely on the number of VMs powered on per server. This approach has limited usefulness because it assumes all of your VMs are running with the same amount of stress on their hosts.

An additional problem with manual load balancing in RHEV is that it does not include a unified tool comparable to esxtop in VMware. Without such a tool, it is difficult to ascertain bottlenecks and other problems quickly. RHEV does include the standard suite of stat-tracking programs, but they are not optimized for virtualization in the same way as VMware's tools.

Finally, in our testing we settled on using Red Hat Enterprise Linux 6.6 because of the compatibility issues we were encountering with RHEV-H 7 and RHEV-M 3.5. In particular, RHEV-H 7 had problems with mounting multiple NFS mounts and presenting them properly. Even after we changed to RHEV-H 6, we continued to have problems with V2V transfers from ESX to RHEV.

## APPENDIX C – SETTING UP THE VIRTUAL ENVIRONMENT FOR RED HAT ENTERPRISE VIRTUALIZATION 3.5

We installed RHEL 6.6 on a VM host on a separate management server, and installed and configured RHEV-M using a subscription to RHEV. We installed RHEV-H 6 for RHEV 3.5 on one RAID pair for each Dell R730. For our testing, we configured our environment to use the Default datacenter and cluster. We then modified the settings of each as needed.

### Installing Red Hat Enterprise Linux 6.6 and RHEV-M

1. SSH into the RHEL VM.
2. Register the VM with subscription manager:  

```
# subscription-manager register
```
3. List the available subscription pools for your Red Hat account:  

```
# subscription-manager list --available | grep -A8 "Red Hat Enterprise Linux Server"
# subscription-manager list --available | grep -A8 "Red Hat Enterprise Virtualization"
```
4. Attach the entitlements for RHEL and RHEV:  

```
# subscription-manager attach --pool=PROPER_POOL_ID_FOR_EACH
```
5. Enable the following repositories:  

```
# subscription-manager repos --enable=rhel-6-server-rpms
# subscription-manager repos --enable=rhel-6-server-supplementary-rpms
# subscription-manager repos --enable=rhel-6-server-rhev-3.5-rpms
# subscription-manager repos --enable=jb-eap-6-for-rhel-6-server-rpms
```
6. Run updates and install the rhevm package:  

```
# yum update; yum install rhevm
```
7. To configure RHEVM, run the following:  

```
# engine-setup
```
8. At the Configure Engine on this host prompt, press enter.
9. At the Configure WebSocket Proxy on this machine prompt, type No.
10. At the Do you want Setup to configure the firewall prompt, press enter.
11. At the Host fully qualified DNS name of this server prompt, press enter.
12. At the Where is the Engine database located prompt, press enter.
13. On the next prompt, select Automatic to allow the installer to configure a local Postgresql database for RHEV-M automatically.
14. Enter a password twice for the admin user.
15. Enter both admin name and password for the Application mode.
16. At the Organization name for certificate prompt, press enter.
17. To accept the RHEV console as the default web page for the server, press enter.
18. To configure apache to use a certificate from an internal CA automatically, press enter.
19. Type No at the Configure NFS prompt.



20. At the Red Hat Access Plugin prompt, press enter.
21. Confirm the settings, and allow setup to complete.

### Installing and configuring Red Hat Enterprise Virtualization Hypervisor 6 for RHEV 3.5

1. Boot to the RHEV-H installation disk.
2. At the installation menu, select Install or Upgrade.
3. At the Keyboard Layout Selection, select U.S. English, and click Continue.
4. Select the proper virtual disk to install the hypervisor, and click Continue.
5. Leave the defaults for the disk layout, and click Continue.
6. Enter a password twice for the admin user, and click Install.
7. Once the installation completes, reboot the server.
8. Once the server reboots, log in as admin.
9. Navigate to the Network section.
10. Enter a hostname for the server, and click Save.
11. Select the desired network device for the private management network connection, and click Enter.
12. Enter the desired network IP information, and click OK.
13. Click Save.
14. Navigate to the Security section, check Enable SSH password authentication, and click Save.
15. Navigate to the RHEV-M section.
16. Enter the IP address for the RHEV-M server, and click Save & Register.
17. For each Dell R730, complete steps 1 through 16.

### Configuring the Red Hat Enterprise Virtualization 3.5 cluster

1. From a client system, open a web browser, navigate to RHEV-M server's IP, and log into the console as admin.
2. Navigate to Hosts.
3. Verify that each R730 is listed and is awaiting approval.
4. Select each host, and click Approve. This should assign each host to the Default cluster.

### Configuring RHEV cluster features

1. For testing using the Cluster policy features, navigate to Clusters.
2. Right-click the Default cluster, and click Edit.
3. Select Cluster Policy.
4. Select the `vm_evenly_distributed` policy.
5. Type 5 for HighVmCount, MigrationThreshold, and SpmVmGrace.
6. Click OK.

### Configuring the RHEV host networking

1. On the left side in the RHEV-M web console, click Networks.
2. Click New.
3. Enter a name for the new network, and click OK.
4. Complete steps 1 through 3 for the NFS and migration networks, changing the MTU setting to 9000.
5. Navigate to Hosts.

6. Select the first host, and click Network Interfaces.
7. Click Setup Host Networks.
8. Assign each new network to the desired physical network ports.
9. For each network, click the edit icon, and assign the desired IP addresses.
10. Complete steps 6 through 9 for each host.
11. To configure the migration network, navigate to Clusters, and select the Default cluster.
12. Click Logical Networks, and click Manage Networks.
13. On the previously configured desired migration virtual network, select migration.

### Configuring the NFS storage domains

1. On the left side in the RHEV-M web console, click Storage.
2. Click New domain.
3. Enter a name for the domain, and select Data/NFS for the storage type.
4. Enter the NFS export remote path, and click OK.
5. Complete steps 1 through 4 for the second NFS share. We also configured an ISO NFS share for our Windows and SQL ISOs used during VM creation.

### Creating and cloning the test VM

1. In the RHEV-M web console, navigate to virtual machines.
2. Click New VM.
3. For the Operating System, select Windows 2012 x64.
4. Enter a name for the new VM.
5. Select the private management network connection.
6. Click System.
7. Enter a memory size of 10 GB.
8. Type 8 for the number of Virtual CPUs.
9. Click Resource Allocation.
10. Enter 1 GB for the Physical Memory Guarantee.
11. Under boot options, attach the Windows installer ISO.
12. Click OK.
13. Click Configure Virtual Disks.
14. Enter 60 GB for the virtual disk size.
15. Select Preallocated for the allocation policy.
16. Select the desired Storage Domain, and click OK.
17. Click Add another disk, and configure the same settings above for a 50GB disk.
18. Complete step 17 for a 40GB disk.
19. Prior to installation of the Windows OS, ensure that the latest VirtIO drivers, virtual floppy disk, ISO, and RHEV tools are uploaded to the ISO share.
20. Right-click the new VM, and click Run Once.
21. Under boot options, attach the VirtIO disk and the Windows install ISO.

22. Click OK.
23. During the Windows installation, select and install the VirtIO drivers.
24. For the installation and OS configuration steps, see [the section below titled Configuring the SQL Server VM](#).
25. To clone the VM, right-click the VM, and click Make template.
26. Enter a name for the template, and click OK.
27. Once the template is created, click New VM.
28. Under Based on Template, select the new template.
29. Enter a name for the new VM, and click OK.
30. Complete steps 27 through 29 for to have 15 VMs.
31. After cloning the VMs, power on each one, and reconfigure the network IP and hostname.

## APPENDIX D – SETTING UP THE VIRTUAL ENVIRONMENT FOR VMWARE VSPHERE 6

We configured a management server running ESX to host our management VMs for testing. For VMware vCenter, we configured a VM running Windows Server 2012 R2. We installed VMware vSphere 6 hypervisor on one RAID pair for each Dell R730. While we used a Microsoft Windows Server-based vCenter installation in our testbed, VMware also offers a simplified vCenter appliance virtual machine. You can find more information on how to deploy the vCenter appliance here: <https://pubs.vmware.com/vsphere-60/index.jsp?topic=%2Fcom.vmware.vsphere.install.doc%2FGUID-F06BA415-66D8-42CD-9151-701BBBCE8D65.html>

### Installing VMware vSphere 6 hypervisor

1. Boot the server to the vSphere 6.0 hypervisor installation disk.
2. At the VMware Installer screen, press Enter.
3. At the EULA screen, press F11.
4. Under Storage Devices, select the appropriate virtual disk, and press Enter.
5. Select US as the keyboard layout, and press Enter.
6. Enter the root password twice, and press Enter.
7. To start installation, press F11.
8. After the installation completes, reboot the server.
9. After the server boots into vSphere, press F2, and enter root credentials.
10. Select Configure Management Network, and press Enter.
11. Select the appropriate network adapter, and select OK.
12. Using the VMware vSphere client, log into the server.
13. Select Configuration, and click Networking.
14. Click Add Networking...
15. Create the management network.
16. Click Configuration, and select Time configuration.
17. Click DNS and Routing, and confirm the settings.
18. Complete steps 1 through 17 for each server.

### Setting up a VM to host the vCenter server

1. Log into the infra1 server with the VMware vSphere client.
2. Under Basic Tasks in the VMware vSphere client, select Create a new virtual machine.
3. Choose Custom, and click Next.
4. Assign the name vCenter to the VM, and click Next.
5. Select infra1 as the host, and click Next.
6. Select the appropriate 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. For CPUs, select one virtual processor socket and four cores per virtual socket, and click Next.
10. Choose 8GB RAM, and click Next.
11. Click 1 for the number of NICs, select VMXNET3, connect to the PRIV-NET port group, and click Next.

12. Leave the default virtual storage controller, and click Next.
13. Keep the default virtual device node (0:0), and click Next.
14. Connect the VM virtual CD-ROM to the Microsoft Windows 2008 R2 installation disk.
15. Click Finish.
16. Right-click the vCenter VM, and click Edit settings.
17. Click Resources, click Memory, check Reserve all guest memory, and click OK.
18. Start the VM.

### Installing the Microsoft Windows Server 2008 R2 operating system on the VM

1. Open a VM console on vCenter.
2. Choose the language, time and currency, and keyboard input. Click Next.
3. Click Install Now.
4. Choose Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
5. Accept the license terms, and click Next.
6. Click Custom.
7. Click the Disk, and click Drive options (advanced).
8. Click New→Apply→Format, and click Next.
9. After the installation completes, click OK to set the Administrator password.
10. Enter the administrator password twice, and click OK.
11. Install VMware Tools. For more information, see [kb.vmware.com/selfservice/microsites/search.do?language=en\\_US&cmd=displayKC&externalId=340](http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=340).
12. Reboot.
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 to vCenter, and reboot when the installation prompts you.
16. Set up networking for the data network:
  - a. Click Start, Control Panel, right-click Network Connections, and choose Open.
  - b. Right-click the VM traffic NIC, and choose Properties.
  - c. Uncheck TCP/IP (v6).
  - d. Select TCP/IP (v4), and choose Properties.
  - e. Set the IP address, subnet, gateway, and DNS server.
17. Join the domain.local domain.
18. Reboot the system.

### Installing Active Directory and DNS services

1. Click Start→Run, type `dcpromo`, and click OK.
2. At the Active Directory Domain Services Installation Wizard welcome screen, check Use advanced mode installation, and click Next.
3. In the Choose a Deployment Configuration dialog box, select Create a new domain in a new forest, and click Next.
4. At the FQDN page, type `vsphere.local`, and click Next.
5. At the NetBIOS name prompt, leave the name `domain`, and click Next.
6. At the Forest Functionality level, select Windows Server 2008 R2, and click Next.

7. At the additional Domain Controller Options, leave DNS server selected, and click Next.
8. Assign a Directory Services Restore Mode Administrator account password, and click Next.
9. At the Summary screen, review your selections, and click Next.
10. Once Active Directory Domain Services finishes installing, click Finish, and restart the system.
11. Click Start→Run, and type `dnsmgmt.msc`
12. Create a reverse lookup zone for DC1.
13. Create static entries for the three infrastructure servers and the five servers under test.

### Installing VMware vCenter 6.0

1. Log into vCenter VM.
2. Attach the VMware vCenter 6 install media, and click Autorun.
3. Click Run to start the install wizard.
4. Select vCenter Server for Windows, and click Install.
5. At the Install wizard welcome screen, click Next.
6. Accept the End User License Agreement, and click Next.
7. Select embedded deployment and the deployment type, and click Next.
8. Verify the system name, and click Next.
9. Enter and confirm the password you wish to use with the Administrator account for vCenter Single Sign On, and click Next.
10. Select Use Windows Local System Account and the service account, and click Next.
11. Select Use an embedded database, and click Next.
12. At the Configure Ports screen, click Next.
13. Accept the default installation path, and click Next.
14. Click Install.
15. Using the vSphere web client, log into the vCenter server with the Single Sign-On credentials.
16. Right-click the root of vCenter, and click New Data center.
17. Name the new datacenter.

### Configuring VMware vSphere 6 cluster

1. Right-click the datacenter, and click New Cluster.
2. Enter a name for the cluster, and click OK.
3. Right-click the cluster, and click Add Host....
4. Enter the IP for the host, and click Next.
5. Enter the username and password, and click Next.
6. Accept the default setting for the remaining sections, and click Finish.
7. Complete steps 3 through 6 for the additional hosts.
8. Right-click the datacenter, and click Add Host....
9. Enter the IP for the host, and click Next.
10. Enter the username and password, and click Next.
11. Accept the default setting for the remaining sections, and click Finish.

## Configuring the host networking

When configuring our host networking for our private, NFS, and vMotion networks, we changed the advanced settings on the NFS and vMotion distributed switches and VMkernel to use 9000 MTUs.

1. From the vCenter web console, select Networking.
2. Right-click the datacenter, and click Distributed Switch→New Distributed Switch.
3. Enter a name for the switch, and click Next.
4. Select Distributed switch: 6.0.0, and click Next.
5. Enter the number of uplinks.
6. Uncheck the Create a default port group box, and click Next.
7. Click Finish.
8. Right-click the new distributed switch, and click Distributed port group→New distributed port group.
9. Enter a name for the new port group, and click Next.
10. Leave the default configuration settings, and click Next.
11. Click Finish.
12. Right-click the distributed virtual switch, and click Add and Manage Hosts.
13. Select Add hosts, and click Next.
14. Select all three hosts in the cluster.
15. If each host is cabled the same, check Configure identical network settings, and click Next.
16. Select the first host to be the template, and click next.
17. Check Manage physical adapters and VMkernel adapters, and click Next.
18. Select the desired physical uplink on host one, and click Assign uplink.
19. Select the desired uplink, and click OK.
20. Click Apply to all, and click Next.
21. In the top section, click New adapter.
22. Under Select an existing network, click Browse.
23. Select the desired port group on the distributed switch, and click OK.
24. Click Next.
25. Select the desired services for the VMkernel, and click Next.
26. Enter the desired IP address for the network on host one, and click next.
27. Click Finish.
28. Click Apply to all.
29. Enter the desired IP addresses for the remaining two hosts, and click OK.
30. Click Next.
31. If there are no warnings, click Next.
32. Click Finish.
33. Complete steps 1 through 32 to configure networks for NFS, private VM network, and vMotion.

## Configuring the NFS datastores

1. Log into vCenter via the VMWare Web client.
2. Select Storage.
3. Right-click the datacenter, hover over Storage, and choose New Datastore.
4. Click Next.
5. Select NFS as the datastore type, and click Next.
6. Select NFS 3 as the NFS version, and click Next.
7. Enter the mount point folder name and server IP, and click Next.
8. Select the hosts that will mount the datastore, and click Next.
9. Click Finish.
10. Complete steps 3 through 9 for any additional datastores.
11. Right-click the data center, hover over Storage, and choose New Datastore Cluster.
12. Name the datastore cluster, unselect Turn ON Storage DRS, and click Next.
13. Click Next.
14. Click Next.
15. Select the previously created cluster, and click Next.
16. Select all previously added NFS datastores, and click Next.
17. Click Finish.

## Creating the first test VM

1. Log into vCenter via the VMWare Web client.
2. Select VMs and Templates.
3. Right-click the datacenter, hover over New Virtual Machine, and choose New Virtual Machine.
4. Select Create a new virtual machine.
5. Name the VM, and click Next.
6. Select the cluster, and click Next.
7. Select the appropriate storage, and click Next.
8. Select ESXi 6.0 and later, and click Next.
9. Select Windows, select Microsoft Windows Server 2012 (x64), and click Next.
10. Select 8 CPUs, enter 10 GB for Memory, and enter 60 GB for New Hard disk.
11. Expand Memory, and enter 1 GB for Reservation.
12. Expand New Network, and select VMXNET 3 for Adapter Type.
13. Click Next.
14. Click Finish.
15. For the installation and OS configuration steps, see [the section below titled Configuring the SQL Server VM](#).
16. Right-click the VM, hover over Clone, and select Clone Virtual Machine to Template.
17. Enter a name for the template, and click Next.
18. Select the cluster, and click Next.
19. Select the appropriate storage, and click Next.



20. Click Finish.
21. Right-click the new template, and click New VM from this Template....
22. Name the VM, select the datacenter, and click Next.
23. Select the cluster, and click Next.
24. Select the appropriate storage, and click Next.
25. Click Next.
26. Click Finish.
27. Complete steps 21 through 26 to have 15 VMs.

### Configuring vSphere DRS and Storage DRS

1. Log into the vCenter via the VMWare Web client.
2. Select Hosts and Clusters.
3. Expand the datacenter, and select the cluster.
4. Select Manage.
5. Under Settings→Services→vSphere DRS, click Edit....
6. Click Turn ON vSphere DRS.
7. Select Fully Automated for DRS Automation, and click OK.
8. Click Storage.
9. Expand the datacenter, and click the datastore cluster.
10. Select Manage.
11. Under Settings→Services→Storage DRS, click Edit....
12. Click Turn ON vSphere Storage DRS.
13. Expand Advanced options.
14. Enable Keep VMDKs together by default for Default VM affinity.
15. Choose 1 hour for frequency to check imbalances.
16. Click OK.

## APPENDIX E – CONFIGURING THE VMS ON EACH HYPERVISOR

### Configuring the SQL Server VM

Modify the SQL VM to contain the following settings:

- Memory: 10GB
- Virtual Processors: 8
- Additional virtual disks:
  - 50GB virtual disks for SQL database data (Thick provisioned)
  - 40GB virtual disk for SQL log data (Thick provisioned)

### Installing Microsoft Windows Server 2012 R2

1. Mount the ISO for Windows Server 2012 R2.
2. Connect to the virtual machine console.
3. Choose the language, time and currency, and keyboard input. Click Next.
4. Click Install Now.
5. Choose Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
6. Accept the license terms, and click Next.
7. Click Custom.
8. Click the Disk, and click Drive options (advanced).
9. Click New→Apply→Format, and click Next.
10. After the installation completes, click OK to set the Administrator password.

### Configuring the VM storage

1. In the taskbar, click Server Manager.
2. In the left pane, expand Storage, and click Disk Management.
3. Right-click the first volume, and choose Initialize Disk.
4. In the right pane, right-click the volume, and choose New Simple Volume...
5. At the welcome screen, click Next.
6. At the Specify Volume Size screen, leave the default selection, and click Next.
7. At the Assign Drive Letter or Path screen, choose a drive letter, and click Next.
8. At the Format Partition screen, choose NTFS, and click Next.
9. At the Completing the New Simple Volume Wizard screen, click Finish.

### Installing .Net Framework 3.5

1. Click Start→Server Manager→Manage→Add Roles and Features.
2. Select Role-based or feature-based installation, and click Next.
3. Under Server Pool, select the local server, and click Next twice.
4. Under Features, select .NET Framework 3.5 Features, and click Next.
5. Click Install.
6. Click Close.

### Installing Microsoft SQL Server 2014

1. Attach the installation media to the server.
2. Launch setup.exe.

3. Choose the Installation section on the left, and click New SQL Server stand-alone installation or add features to an existing installation.
4. At the Product Key screen, enter the product key, and click Next.
5. At the License Terms screen, check I accept the license terms, and click Next.
6. At the Global Rules screen, allow the Global Rules check to finish, and click Next.
7. At the Microsoft Update screen, check Use Microsoft Update to check for updates (recommended), and click Next.
8. Once the updates have been downloaded and installed, click Next.
9. At the Install Setup Files screen, allow the setup files to install, and click Next.
10. At the Install Rules screen, allow the Install Rules check to run, and click Next.
11. At the Setup Role screen, select the SQL Server Feature Installation radio button, and click Next.
12. At the Feature Selection screen, select the features required for your installation. We selected Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, Client Tool Backwards Compatibility, Management Tools - Basic, and Management Tools - Complete.
13. At the Feature Rules screen, allow the Feature Rules check to run, and click Next.
14. At the Instance Configuration screen, click Next to use the default instance named MSSQLSERVER.
15. At the Server Configuration screen, click Next.
16. At the Database Engine Configuration screen, select Mixed Mode (SQL Server authentication and Windows authentication), and enter a password for the SQL Server system administrator (sa) account.
17. Click Add Current User.
18. In the Data Directories tab, enter the directories to be used for SQL data and logs. We used E:\ and F:\, respectively, to place the data and logs on their appropriate virtual disks. Click Next.
19. At the Feature Configuration Rules screen, allow the Feature Configuration Rules check to finish, and click Next.
20. At the Ready to Install screen, click Install.
21. After the installation has completed, close the wizard.

## Configuring the database workload client

For our testing, we used a virtual client for the Microsoft SQL Server client. To create this client, we installed Windows Server 2008 R2, assigned a static IP address, and installed .NET 3.5.

## APPENDIX F – CONFIGURING THE DATABASE (DVD STORE)

### Configuring the database

#### 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 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 Install.pl script generated the database schema.

After processing the data generation, we transferred the data files and schema creation files to a Windows-based system running SQL Server 2014. We built the 20GB database in SQL Server 2014, and then performed a full backup, storing the backup file on the C: drive for quick access. We used that backup file to restore the server between test runs.

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 following steps:

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.

Figure 4 shows our initial file size modifications.

| Logical name          | Filegroup      | Initial size (MB) |
|-----------------------|----------------|-------------------|
| <b>Database files</b> |                |                   |
| primary               | PRIMARY        | 5                 |
| cust1                 | DS_CUST_FG     | 6,144             |
| cust2                 | DS_CUST_FG     | 6,144             |
| cust3                 | DS_CUST_FG     | 6,144             |
| cust4                 | DS_CUST_FG     | 6,144             |
| ind1                  | DS_IND_FG      | 2,891             |
| ind2                  | DS_IND_FG      | 2,891             |
| ind3                  | DS_IND_FG      | 2,891             |
| ind4                  | DS_IND_FG      | 2,891             |
| ds_misc               | DS_MISC_FG     | 200               |
| orders1               | DS_ORDERS      | 3,072             |
| orders2               | DS_ORDERS      | 3,072             |
| orders3               | DS_ORDERS      | 3,072             |
| orders4               | DS_ORDERS      | 3,072             |
| <b>Log files</b>      |                |                   |
| ds_log                | Not applicable | 18,141            |

Figure 4: Our initial file size modifications.

## Running the DVD Store tests

### Test start and run times

We ran all workloads concurrently to start and record all performance counters for this report. The specific testing parameters we used are included in the setup section, and the following section describes specifics for launching the test.

### About 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 following steps:

1. Move all VMs to the first host and the initial datastore.
2. Clean up prior outputs from the target system and the client driver system.
3. Drop the database from the target.
4. Restore the database on the target.
5. Shut down the target.
6. Reboot the host and client system.

7. Wait for a ping response from the server under test (the hypervisor system), the client system, and the target.
8. Let the test server idle for 10 minutes.
9. Start the DVD Store driver on the client. We used the following DVD Store parameters for testing.
10. For the first three VMs:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30 --n_threads=64 --db_size=20GB --think_time=0 --detailed_view=Y --warmup_time=5 --report_rate=1 --pct_newcustomers=20 --csv_output=<drive path>
```

11. For the next three VMs:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30 --n_threads=32 --db_size=20GB --think_time=0.1 --detailed_view=Y --warmup_time=5 --report_rate=1 --pct_newcustomers=5 --csv_output=<drive path>
```

12. For the remaining VMs:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30 --n_threads=64 --db_size=20GB --think_time=0.05 --detailed_view=Y --warmup_time=5 --report_rate=1 --pct_newcustomers=20 --csv_output=<drive path>
```

13. Enable DRS features for the cluster:

- For VMware, see section “Configuring vSphere DRS and Storage DRS”
- For RHEV, see section “Configuring RHEV cluster features”

14. Complete steps 2 through 9 using a longer run time (`--run_time=60`) to ensure the hypervisors have sufficient information to automatically distribute cluster resources.

15. Verify all automatic actions based on DRS recommendations are completed.

- For VMware:
  - a. Log into the vCenter via the vSphere client.
  - b. Select Hosts and Clusters.
  - c. Expand the data center, and select the cluster.
  - d. Select the Tasks & Events tab.
  - e. Change View to Events.
  - f. Verify there are no outstanding migrations and all recent tasks are complete.
- For RHEV:
  - a. Log into the Red Hat Enterprise Virtualization web client.
  - b. Expand System → Data Centers, and select your data center.
  - c. Select Virtual Machines.
  - d. Boot the SQL VMs.
  - e. Watch the Event pane on the bottom of the console.
  - f. When there have not been any migrations for 15 minutes, the cluster is balanced.

## APPENDIX G – SERVER CONFIGURATION INFORMATION

Figure 5 provides detailed configuration information for the test systems.

| System                                | 3 x Dell PowerEdge R730  |
|---------------------------------------|--------------------------|
| <b>Power supplies</b>                 |                          |
| Total number                          | 1                        |
| Vendor and model number               | Dell 0G6W6               |
| Wattage of each (W)                   | 750                      |
| <b>Cooling fans</b>                   |                          |
| Total number                          | 6                        |
| Vendor and model number               | NMB 06038DA-12S-EWH      |
| Dimensions (h × w) of each            | 2.5" x 2.5"              |
| Volts                                 | 12                       |
| Amps                                  | 1.80                     |
| <b>General</b>                        |                          |
| Number of processor packages          | 2                        |
| Number of cores per processor         | 10                       |
| Number of hardware threads per core   | 2                        |
| System power management policy        | Balanced                 |
| <b>CPU</b>                            |                          |
| Vendor                                | Intel                    |
| Name                                  | Xeon                     |
| Model number                          | E5-2650 v3               |
| Socket type                           | LGA2011-3                |
| Core frequency (GHz)                  | 2.3                      |
| Bus frequency                         | 9.6 GT/s                 |
| L1 cache                              | 32 KB + 32 KB (per core) |
| L2 cache                              | 256 KB (per core)        |
| L3 cache                              | 25 MB                    |
| <b>Platform</b>                       |                          |
| Vendor and model number               | Dell PowerEdge R730      |
| Motherboard model number              | 0599V5                   |
| BIOS name and version                 | 1.2.10                   |
| BIOS settings                         | Default                  |
| <b>Memory module(s)</b>               |                          |
| Total RAM in system (GB)              | 128                      |
| Vendor and model number               | Hynix                    |
| Type                                  | HMA42GR7MFR4N-TF         |
| Speed (MHz)                           | 2,133                    |
| Speed running in the system (MHz)     | 2,133                    |
| Timing/Latency (tCL-tRCD-tRP-tRASmin) | 15-15-15-33              |
| Size (GB)                             | 16                       |
| Number of RAM module(s)               | 8                        |
| Chip organization                     | Double-sided             |
| Rank                                  | Dual                     |

|                            |  |
|----------------------------|--|
| <b>System</b>              | <b>3 x Dell PowerEdge R730</b>                 |
| <b>Hypervisor #1</b>       |  |
| Name                       | VMware ESXi 6.0.0                              |
| Build number               | 2715440  |
| File system                | VMFS   |
| Language                   | English  |
| <b>Hypervisor #2</b>       |  |
| Name                       | Red Hat Enterprise Virtualization Hypervisor 6 |
| Build number               | RHEV 3.5                                       |
| File system                | ext4   |
| Language                   | English  |
| <b>RAID controller</b>     |  |
| Vendor and model number    | Dell PERC H730P Mini                           |
| Firmware version           | 25.2.2-0004                                    |
| Cache size (MB)            | 2048   |
| <b>Hard drives #1</b>      |  |
| Vendor and model number    | Seagate ST300MM0006                            |
| Number of drives           | 2  |
| Size (GB)                  | 300  |
| RPM                        | 10k  |
| Type                       | SAS  |
| <b>Hard drives #2</b>      |  |
| Vendor and model number    | Seagate ST300MM0006                            |
| Number of drives           | 2  |
| Size (GB)                  | 300  |
| RPM                        | 10k  |
| Type                       | SAS  |
| <b>Ethernet adapter #1</b> |  |
| Vendor and model number    | Intel Gigabit 4P I350-t                        |
| Type                       | Integrated                                     |
| <b>Ethernet adapter #2</b> |  |
| Vendor and model number    | Intel X520 10Gb Adapter                        |
| Type                       | PCI-E  |

Figure 5: System configuration information for the test systems.



## ABOUT PRINCIPLED TECHNOLOGIES



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