

VDI PERFORMANCE COMPARISON: SAMSUNG SOLID-STATE DRIVES VS. SAS DRIVES IN A DELL POWEREDGE R720

DELL™ POWEREDGE™ R720 SERVER SOLUTION WITH SAMSUNG® GREEN SM825 SSDs RUNNING VMWARE® VIEW™ & VSPHERE®



NEARLY

2X AS MANY VDI USERS

compared to standard SAS drives



vmware®



Today's servers are more powerful than ever and are ideally suited for your virtual desktop infrastructure (VDI). They offer the latest in processing power, memory speed, and storage technologies. The storage technologies you select, in particular, can have a profound effect on the number of users each server can support. You can use standard SAS drives in your servers or you can upgrade—for only a modest additional investment—in Samsung Green SM825 solid-state drives (SSDs).

In the Principled Technologies (PT) labs, we tested a Dell PowerEdge R720 server configured with both SAS hard drives and Samsung Green SM825 SSDs to quantify the advantage SSDs can deliver. We found that this server configured with SAS drives could support 82 virtual desktop users, while configured with Samsung Green SM825 SSDs it supported 160 virtual desktop users—95 percent more desktop users.



It is essential that your virtual desktop infrastructure can deliver the performance your employees require today and have room to grow as your business expands. Upgrading to Green SM825 SSDs in your Dell PowerEdge R720 server is an extremely cost-effective choice—you can nearly double the number of users you can support.

We tested a single Dell PowerEdge R720 server two ways—with SAS drives and with Samsung Green SM825 SSDs. The server was otherwise identical—it was preconfigured with VMware vSphere 5.1. We installed and configured VMware View 5.1 to use a VMware vCenter and VMware Composer Server. We created two automated, floating, linked clone pools. We configured the pools to use 1 GB of host cache. The SSD pool had 160 desktops and the SAS pool had 83 desktops. We chose 83 desktops for SAS because it was the smallest number of desktops needed to cause a VSI_{max} in testing; VSI_{max} indicates user responsiveness is no longer acceptable. We used the Login VSI Medium workload to generate a reproducible, real-world test case that simulated the execution of various applications including Microsoft® Internet Explorer®, Adobe® Flash® video, and Microsoft Office applications. Using Login VSI, we could determine how many virtual desktop users each solution could support.

We configured Login VSI to run a Medium workload against a pool of virtual desktops and set up the test to incrementally log in users every 6 seconds. Login VSI measures the total response time of all the applications from each session and calculates the VSI Index by taking the average response times and dropping the highest and lowest 2 percent. The average response time of the first 15 sessions determines a baseline; the VSI_{max} is baseline x 125% + 3000ms. As more sessions begin to consume system resources, response time degrades and the VSI index increases until it is above the VSI_{max}. When this condition is met, the benchmark records a Login VSI_{max}, which is the maximum number of sessions that platform could support.

SOLID-STATE DRIVES SUPPORTED NEARLY TWICE AS MANY USERS

In our tests, we found that the Dell PowerEdge R720 with Samsung Green SM825 SSDs was able to host 160 concurrent sessions while retaining a satisfactory user experience, 95 percent more users than the same server with SAS drives, which could host only 82 sessions. For an additional hardware investment of only 6 percent (see [Appendix C](#)), the Dell R720 with Samsung Green SM825 SSDs can support nearly twice the users.

Figure 1 shows the Login VSI response times, in milliseconds, for the two types of storage. SSD testing did not reach VSI_{max}. VSI_{max} represents the maximum user capacity at which performance did not degrade; therefore, not reaching VSI_{max} is a positive indicator that response time remained satisfactory. The SAS configuration did

reach VSImax, indicating the responsiveness for the 83-session test was considerably degraded.

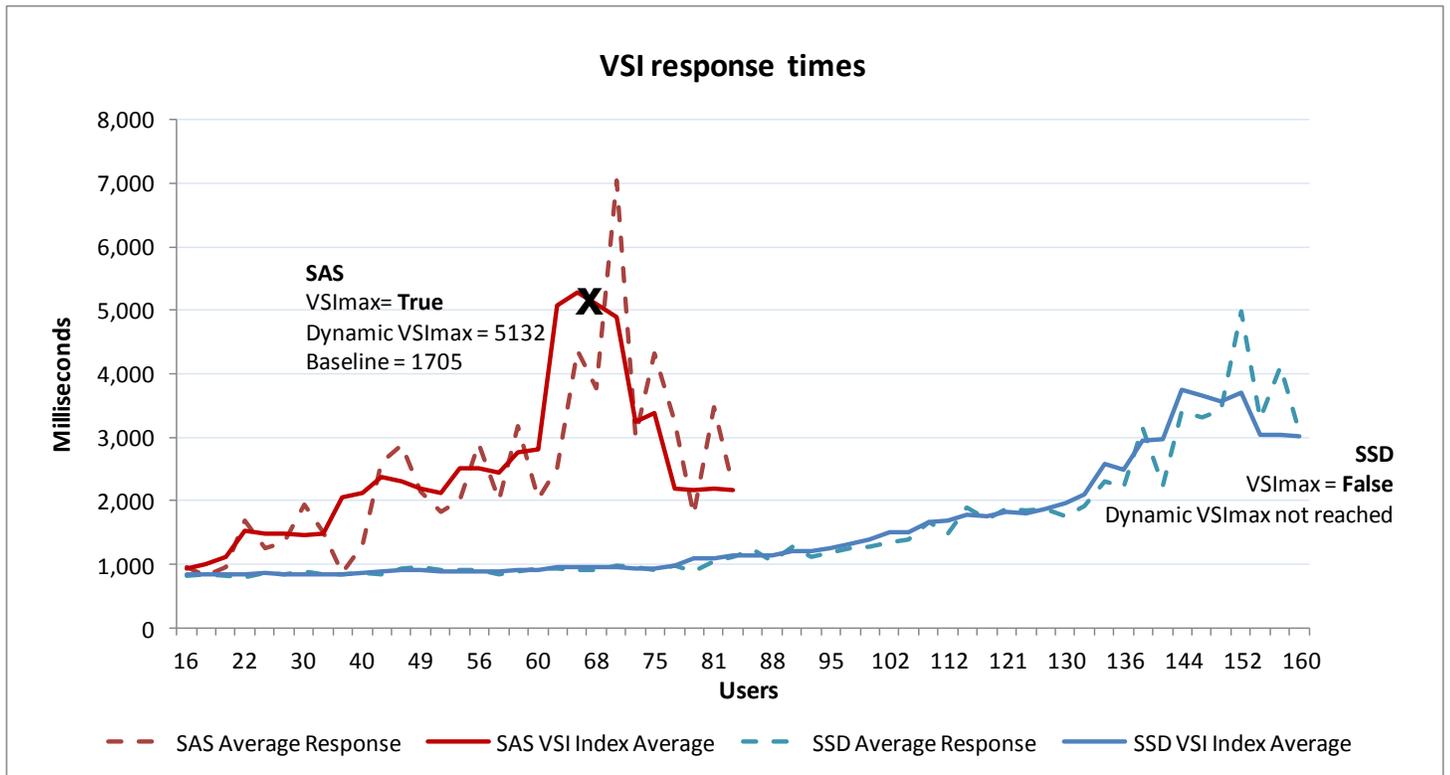


Figure 1: The Dell PowerEdge R720 with SAS drives reached VSImax with 83 users. The Dell PowerEdge R720 with Samsung Green SM825 SSDs ran 160 sessions and did not reach VSImax.

Figure 2 shows vSphere 5.1 server counters for disk latency, in milliseconds, throughout the test. Disk activity increases as users log in. The SSDs handled the 160-user workload with virtually no latency. High latency on the SAS disks prevented the server from scaling beyond 82 sessions.

Figure 2: Disk latency throughout our test period with Samsung Green SM825 SSDs averaged .036 milliseconds. Disk latency with SAS drives averaged 10.70 milliseconds.

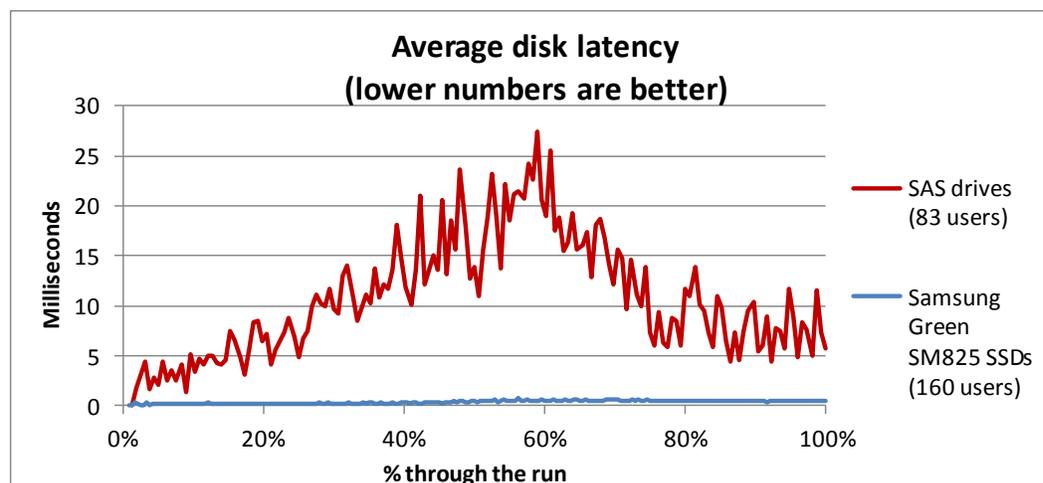


Figure 3 shows vSphere 5.1 server counters for CPU utilization throughout the test for the server with two types of storage. CPU utilization increases as more users log in. CPU limited the maximum number of users the Green SM825 SSD configuration was able to support.

Figure 3: CPU utilization throughout our test period.

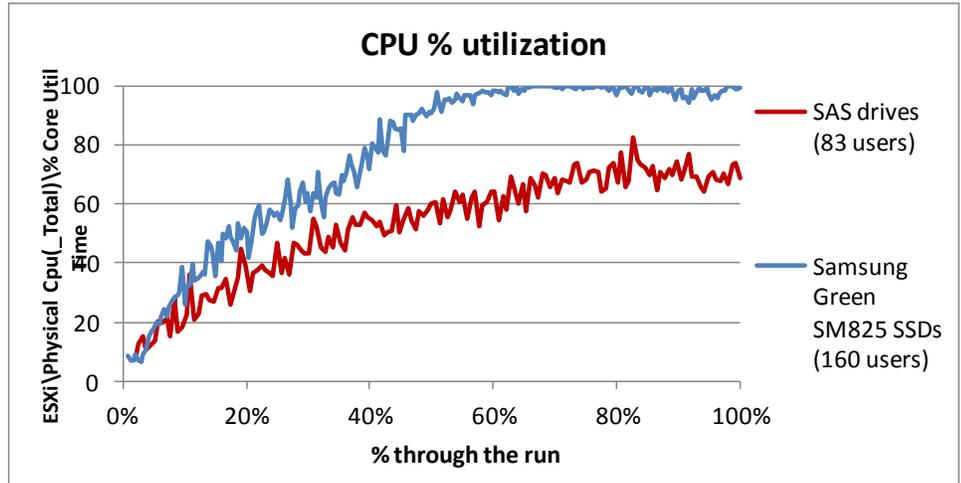
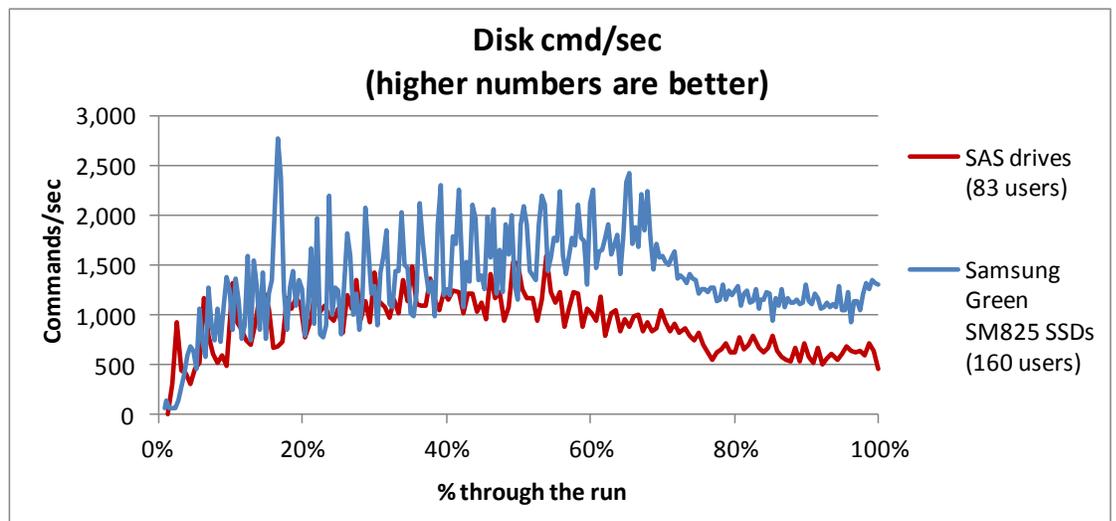


Figure 4 shows vSphere 5.1 server counters for disk commands per second. Commands per second are the sum of all storage commands. IOPS and other disk functions like SCSI reservations are included in commands per second counters. Because the SSD configuration had almost no disk latency, the SSD configuration was able to deliver more commands per second than the SAS configuration.

Figure 4: Disk cmd/s throughout our test period. With Samsung Green SM825 SSDs, the average was 1,352 commands per second. With SAS drives, the average was 908 commands per second.



ABOUT THE COMPONENTS OF OUR SOLUTION

Dell PowerEdge R720

According to Dell, the new Intel® Xeon® processor E5-2680-powered Dell PowerEdge R720 2U rack server incorporates many enhancements and features designed to improve performance, lower power consumption, and ease maintenance. Some of these features include the following:

- **Performance.** Dell engineered the PowerEdge R720 to handle complex workloads, with I/O and internal data management technologies (i.e., NSC, NPAR, CacheCade) to allow faster access to information and GPU accelerators for faster than ever computational performance.
- **Processors.** The Dell PowerEdge R720 is powered by two Intel Xeon processors E5-2680, which incorporate the very latest in technology from Intel. The powerful processors provide exceptional performance and make the PowerEdge R720 a solid virtualization platform.
- **Power efficiency.** Dell PowerEdge R720 servers implement leading industry power-efficiency standards, and are designed to optimize performance while maintaining low power consumption. Automated tracking and regulation of thermal activity, intelligent design of right-sized power options, and high efficiency fans and airflow management work to save power, saving you money in the process.
- **Management.** The Dell PowerEdge R720, like all late-model Dell servers, comes with the Dell Lifecycle Controller. This tool simplifies server management by providing a single interface for management functions and by storing critical system information in the system itself. There are no CDs or USB keys to keep track of for drivers or firmware.
- **Storage.** With impressive storage capacity for small business servers, the Dell PowerEdge R720 is available in both an 8-bay and 16-bay chassis.
- **Memory.** The Dell PowerEdge R720 holds up to 768 GB of RAM, many times the memory capacity of older small business servers, allowing for powerful flexibility with virtualized database solutions.

Samsung SATA Green SM825 SSDs

According to the Dell Web site, the addition of Samsung Green SM825 SSDs lets Dell PowerEdge servers deliver outstanding sustained read, write, and sequential speeds. The SSDs also deliver an increased level of performance and reliability with their power-loss protection. That translates into long-lasting, sustained performance for your servers.

Dell PowerEdge servers with Samsung Green SM825 SSDs also provide the ability to scale for capacities from 100 GB to 400 GB and ensure that all sensitive data is secure. They help protect your data with AES 256-bit encryption, delivering the optimal level of security.

About VMware View 5.1

VMware designed its View 5.1 desktop virtualization software to simplify IT management of virtual desktops from within the cloud. A centralized interface allows

administrators to manage thousands of end-users. An administrator can easily manage settings such as policy enforcement, performance monitoring, connection brokering, and provisioning, to name a few. The result includes improved security, less costly management, and faster provisioning and maintenance of desktop images and applications. The end-user enjoys easier access to his or her View 5.1 desktop from a variety of locations, less downtime, a customizable desktop, and robust multimedia capabilities.

To learn more about VMware View 5.1, visit <http://www.vmware.com/products/view/overview.html>.

About VMware vSphere 5.1

vSphere 5.1 is the latest virtualization operating system from VMware. vSphere 5.1 allows companies to virtualize their server, storage, and networking resources, achieving a consolidation ratio greater than 15:1. Features such as automated management and dynamic resource allocation improve efficiency. The services that vSphere 5.1 provides fall into two categories: Infrastructure services or application services. The former handle the virtualization of resources and their allocation to application when most needed, while the latter provide service-level controls to applications running on vSphere 5.1.

To learn more about VMware vSphere 5.1, visit <http://www.vmware.com/products/vsphere/overview.html>.

About Login VSI 3.6

Login Virtual Session Indexer (Login VSI) 3.6 is a tool that helps assess the virtual desktop performance, capacity, and scalability of a server.

The newest version of Login VSI, Login VSI 3.6, includes client side performance testing that test character response, large text response, mouse-click feedback, and image quality and loading times on clients to ensure good end-user performance. In our tests, we did not use the client-side testing portion of Login VSI, but instead used the tool to determine how many virtual desktops the appliance could support. For more information about Login VSI 3.6, see <http://www.loginvsi.com/product-overview>.

CONCLUSION

Choosing SSDs can dramatically boost the user count your VDI server can support because of their ability to deliver low latency I/O. In our testing, simply replacing standard SAS drives in a Dell PowerEdge R720 with Samsung Green SM825 SSDs improved overall response times making it possible to nearly double the number of VMware View 5.1 virtual desktops—increasing this number from 82 to 160. This makes Samsung Green SM825 SSDs an excellent choice for your virtual desktop infrastructure.

APPENDIX A – SYSTEM CONFIGURATION INFORMATION

Figure 5 details the configuration information for the system we tested.

System	Dell PowerEdge R720
Power supplies	
Total number	2
Vendor and model number	Dell 05NF18X02
Wattage of each (W)	750 W
Cooling fans	
Total number	6
Vendor and model number	Sanyo Denki 9GA0612P1K641
Dimensions (h x w) of each	60mm x 60mm
Volts	12
General	
Number of processor packages	2
Number of cores per processor	8
Number of hardware threads per core	2
CPU	
Vendor	Intel
Name	Xeon
Model number	E5-2680
Stepping	5
Socket type	FCLGA2011
Core frequency (GHz)	2.7
Bus frequency (GT/s)	8.0
L1 cache	256KB
L2 cache	2 MB
L3 cache (MB)	20 MB
Platform	
Vendor and model number	Dell R720
BIOS name and version	Dell Server BIOS 12G 1.2.6
Memory module(s)	
Total RAM in system (GB)	256
Vendor and model number	Kingston KVR13LL9Q4/32
Type	ECC DDR3
Speed (MHz)	1,333
Speed running in the system (MHz)	1,333
Timing/Latency (tCL-tRCD-tRP-tRASmin)	9-9-9-7
Size (GB)	32
Number of RAM module(s)	8
Chip organization	Double-sided
Rank	Quad-rank

System	Dell PowerEdge R720
Operating system	
Name	ESXi 5.1.0
Build number	914609
File system	VMFS
Service Pack	N/A
Language	English
RAID controller	
Vendor and model number	PERC H710
Firmware version	21.1.0-007
Cache size (MB)	512
Storage	
Option 1: Solid-state drives	
Vendor and model number	Samsung MZ-5EA1000-0D3
Number of drives	8
Size (GB)	100
Type	SATA SSD
Option 2: SAS drives	
Vendor and model number	Western Digital® WD3000BKHG
Number of drives	8
Size (GB)	300
RPM	10,000
Type	SAS
Network adapter	
Vendor and model number	Intel Gigabit 4P I350-t rNDC
USB ports	
Number	4 external, 1 internal
Type	2.0

Figure 5: Configuration information for the system we tested.

APPENDIX B – HOW WE TESTED

Figure 6 presents the settings we used to configure the VMware View 5.1 environment.

VM name	Hosted OS	Role (s)	Host	Memory	# vCPUs
DC1	Win 2008 R2 x64 Enterprise	AD Domain controller VSI Share, DHCP, DNS, NTP, AD roaming profiles, folder redirection	SUT	4 GB	8
SQL	Win 2008 R2 x64 Enterprise	Microsoft SQL server	Infra	4 GB	4
View	Win 2008 R2 x64 Enterprise	VMware View Connection server	Infra	4 GB	4
vCenter	Win 2008 R2 x64 Enterprise	VMware Virtual Center, Composer	Infra	4 GB	4
Master_Image	Windows 7 x 86 Enterprise	View master image	Infra	1 GB	1
X001	Windows 7 x 86 Enterprise	Login VSI master launcher	Infra	4 GB	2

Figure 6: Settings for the VMware View 5.1 environment we tested.

Configuring power performance settings on Dell PowerEdge R720 (SUT)

1. Power cycle the server under test (SUT).
2. At Dell splash screen, press F2 to Enter System Setup.
3. Select System Profile Settings.
4. Click the pull-down menu for System Profile, and select Performance.
5. Exit System Setup and restart system.

Configuring Physical Volumes for ESXi datastores on Dell PowerEdge R720 (SUT)

1. Insert eight SAS drives into slots 1 through 8 of SUT.
2. Insert eight Green SM825 SSDs into slots 9 through 16 of SUT.
3. Power on the SUT.
4. After splash screen, press Ctrl-R to enter the PERC configuration utility.
5. Select Clear all configurations.
6. Select Clear foreign configurations.
7. Create a new RAID 5 volume with all SAS drives.
8. Initialize Volume.
9. Create a new RAID 5 volume with all Green SM825 SSDs.
10. Initialize Volume.
11. Confirm two volumes exist in array controller configuration.
12. Exit the array controller configuration utility.

Installing VMware ESXi 5.1 on Dell PowerEdge R720 (SUT)

1. Insert the installation median and select boot from disk.
2. At the VMware Installer screen, press Enter.
3. At the EULA screen, press F11 to Accept and Continue.
4. Under Storage Devices, select USB storage, and press Enter.
5. Select US as the keyboard layout, and press Enter.
6. Enter Root password twice, and press Enter.
7. Press F11 to start installation.
8. After the server reboots, press F2 to configure the network settings.

Configuring ESXi datastores on Dell PowerEdge R720 (SUT)

1. Open VMware vSphere 5.1 Client and connect to management network address of SUT.
2. Click the configuration tab.

3. Under Hardware, click Storage.
4. Click Add Storage...
5. In the pop-up window, select Disk/LUN, and click Next.
6. Select the volume associated with the SAS array, and click Next.
7. Select VMFS-5, and click Next.
8. Click Next to create a partition.
9. Enter the datastore name "datastore1" and click Next.
10. Select Custom space setting, enter capacity 648.37.GB, and click Next.
11. Review the configuration information, and click Finish to define the datastore.
12. Repeat steps 3 through 11 for the Green SM825 SSD datastore.

Setting up a VM to host Microsoft Windows Active Directory® server (DC1) on (SUT)

1. Connect to SUT via the VMware vSphere client.
2. Log in as root.
3. Click the Virtual Machines tab.
4. Right-click, and choose New Virtual Machine.
5. Choose Custom, and click Next.
6. Assign the name DC1DC1 to the virtual machine, and click Next.
7. Select SUT as the host, and click Next.
8. Select the appropriate datastore for storage, and click Next.
9. Choose Virtual Machine Version 8, and click Next.
10. Choose Windows, choose Microsoft Windows Server® 2008 R2 (64-bit), and click Next.
11. For CPUs, select one virtual processor socket, and 8 cores per virtual socket, and click Next.
12. Choose 4 GB RAM, and click Next.
13. Click 1 for the number of NICs, select VMXNET3, connect to the VDI network, and click Next.
14. Leave the default virtual storage controller, and click Next.
15. Choose to create a new virtual disk, and click Next.
16. Make the OS virtual disk size 40 GB, choose thick-provisioned lazy zeroed, specify external storage, and click Next.
17. Keep the default virtual device node (0:0), and click Next.
18. Click Finish.
19. Right-click the VM, and choose Edit Settings.
20. On the Hardware tab, click Add...
21. Click Hard Disk, and click Next.
22. Click Create a new virtual disk, and click Next.
23. Specify 40 GB for the virtual disk size, choose thick-provisioned lazy zeroed, specify external storage, and click Next.
24. Choose SCSI (0:1) for the device node, and click Next.
25. On the Hardware tab, click Add...
26. Click Create a new virtual disk, and click Next.
27. Specify 40 GB for the virtual disk size, choose thick-provisioned lazy zeroed, specify external storage, and click Next.
28. Choose SCSI (0:2) for the device node, and click Next.
29. On the Hardware tab, click Add...
30. Click Create a new virtual disk, and click Next.
31. Specify 40 GB for the virtual disk size, choose thick-provisioned lazy zeroed, specify external storage, and click Next.
32. Choose SCSI (0:3) for the device node, and click Next.

33. Click Finish, and click OK.
34. Click the Resources tab, and click Memory.
35. Select Reserve all guest memory, and click OK.
36. Connect the VM virtual CD-ROM to the Microsoft Windows Server 2008 R2 installation disk.
37. Start the VM.

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

1. Choose the language, time and currency, and keyboard input. Click Next.
2. Click Install Now.
3. Choose Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
4. Accept the license terms, and click Next.
5. Click Custom.
6. Click the Disk, and click Drive options (advanced).
7. Click New→Apply→Format, and click Next.
8. After the installation completes, click OK to set the Administrator password.
9. Enter the administrator password twice, and click OK.
10. Install VMware Tools. For more information, see http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=340.
11. Reboot the server.
12. Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.
13. Enable remote desktop access.
14. Change the hostname to DC1 and reboot when the installation prompts you.
15. Run diskmgmt.msc.
16. Select a 40 GB volume, name it `profiles` format it NTFS, and assign it drive letter E
17. Select another 40 GB volume, name it `share` format it NTFS, and assign it drive letter F
18. Select the last 40 GB volume, name it `folderredirect` format it NTFS, and assign it drive letter G
19. 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 as `172.1.0.10/255.255.0.0`

Installing Active Directory and DNS services on DC1

1. Click Start→Run, type `dcpromo` and click OK.
2. At the Active Directory Domain Services Installation Wizard welcome screen, check the Use advanced mode installation option, 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 `vdi.test` and click Next.
5. At the NetBIOS name prompt, leave the name VDI, 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. At the System Folder Location screen, change to `E:\` leave the default options, and click Next.
9. Assign a Directory Services Restore Mode Administrator account password, and click Next.
10. At the Summary screen, review your selections, and click Next.
11. Once Active Directory Domain Services finishes installing, click Finish, and restart the system.
12. Run `dnsmgmt.msc`.
13. Create a reverse lookup zone for DC1.

14. Create static entries for the launcher server and all four nodes.

Configuring the Windows time service on DC1

To ensure reliable time, we pointed our Active Directory server to a physical NTP server.

1. Open a command prompt.
2. Type the following:

```
W32tm /config /syncfromflags:manual /manualpeerlist:"<ip address of a NTP server>"
W32tm /config /reliable:yes
W32tm /config /update
W32tm /resync
Net stop w32time
Net start w32time
```

Setting up DHCP services on DC1

1. Click Start→Administrative Tools→Server Manager→Add Roles.
2. Select DHCP Server, and click Next.
3. At the Introduction to DHCP Server screen, click Next.
4. At the Specify IPv4 DNS Settings screen, type `vdi.testvdi.testvdi.test` for the parent domain.
5. Enter the preferred DNS server IPv4 address, and click Next.
6. At the Specify IPv4 WINS Server Settings screen, select WINS is not required for applications on the network, and click Next.
7. At the Add or Edit DHCP Scopes screen, click Add.
8. At the Add Scope screen, enter the Name DHCP Scope name.
9. In the next box, set the following values, and click OK.
 - Start IP address=172.1.1.0
 - End IP address=172.1.5.0
 - Subnet mask=255.255.0.0
10. Check the Activate This Scope box.
11. At the Add or Edit DHCP Scopes screen, click Next.
12. Click the Enable DHCP v6 Stateless Mode radio button, and click Next.
13. Leave the default IPv6 DNS Settings, and click Next.
14. At the Authorize DHCP server dialog box, select Use current credentials.
15. At the Confirm Installation Selections screen, click Next. If the installation is set up correctly, a screen displays saying that DHCP server install succeeded.
16. Click Close.

Setting up the Login VSI share and Active Directory users

For Login VSI to work correctly, you must create a CIFS share, Active Directory OU, and Active directory. For more information on Login VSI, see <http://www.loginvsi.com/en/admin-guide/installation.html>. Open Windows Explorer, and create the following folders: `f:\share`, `e:\profiles` and `g:\folderredirect`

1. Assign permissions of read/write to the `vdi/everyone` group.
2. Right-click the `f:\share`, `e:\profiles` and `g:\folderredirect` folders, and select Properties.
3. Click the Sharing tab, and click Share...
4. Add everyone, system and administrators to the Read/Write group, and click Share.
5. Right-click the `g:\folderredirect` folder and select Properties→Sharing→Advanced Sharing→Caching, and select No files or programs from the Share Folder are available offline.
6. Click OK, Apply, OK, and Close.

7. From the Login VSI 3.6 media, run the Login VSI AD Setup.
8. Keep the default settings, and click Start.

Setting up roaming profiles for users

1. Open Active Directory Users and Computers.
2. Browse to vdi.test→Login_VSI→Users→Target.
3. Select all Login VSI users, and right-click Properties.
4. Click the Profiles tab.
5. Check box Profile path, and type `e:\profiles\%username%`
6. Click OK.

Configuring folder redirection

1. Log into DC1 as administrator
2. Open the Group Policy Editor.
3. Open Forest→Domains→vdi.test, right-click Group Policy Objects, and select New.
4. Type `folder_redirection` leave source starter GPO as None, and click OK.
5. Right-click the folder redirection GPO, and click Edit.
6. Browse User Configuration→Policies→Windows Settings→Folder Redirection, and right-click AppData (roaming).
7. In the AppData (roaming) Properties, target-tab select the following:
 - Setting= select Basic= Redirect everyone's folders to the same location
 - Target folder location= Create a folder for each user under the root path
 - Root Path= `\\DC1\folderredirection`
8. In the AppData (roaming) Properties→Setting tab, remove the checkbox for Grant the user exclusive right to AppData (Roaming), and click OK.
9. Repeat steps 6 through 8 for all subfolders in the folder redirection tree.
10. Close the Folder Redirection group policy.
11. In the Group Policy Editor, right-click the folder redirection policy, and select →GPO status→Computer Configuration Settings Disabled.
12. In the Group Policy Editor, drag the folder redirect GPO to Forest→Domains→vdi.test→Login_VSI→Users→Target.

Setting up a VM to host the SQL server (SQL)

1. Connect to Infra via the VMware vSphere 5.1 client.
2. Log in as root.
3. Click the Virtual Machines tab.
4. Right-click, and choose New Virtual Machine.
5. Choose Custom, and click Next.
6. Assign the name `SQL` to the virtual machine, and click Next.
7. Select SUT as the host, and click Next.
8. Select the appropriate datastore for storage, and click Next.
9. Choose Virtual Machine Version 8, and click Next.
10. Choose Windows, choose Microsoft Windows Server® 2008 R2 (64-bit), and click Next.
11. For CPUs, select one virtual processor socket, and 4 cores per virtual socket, and click Next.
12. Choose 4 GB RAM, and click Next.
13. Click 1 for the number of NICs, select VMXNET3, connect to the VDI network, and click Next.
14. Leave the default virtual storage controller, and click Next.
15. Choose to create a new virtual disk, and click Next.
16. Make the OS virtual disk size 80 GB, choose thin-provision, specify external storage, and click Next.

17. Keep the default virtual device node (0:0), and click Next.
18. Click Finish.

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

1. Choose the language, time and currency, and keyboard input. Click Next.
2. Click Install Now.
3. Choose Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
4. Accept the license terms, and click Next.
5. Click Custom.
6. Click the Disk, and click Drive options (advanced).
7. Click New→Apply→Format, and click Next.
8. After the installation completes, click OK to set the Administrator password.
9. Enter the administrator password twice, and click OK.
10. Install VMware Tools. For more information, see http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=340.
11. Reboot the server.
12. Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.
13. Enable remote desktop access.
14. Change the hostname to SQL and reboot when the installation prompts you.
15. Set up networking for the data network:
 - f. Click Start→Control Panel, right-click Network Connections, and choose Open.
 - g. Right-click the VM traffic NIC, and choose Properties.
 - h. Uncheck TCP/IP (v6).
 - i. Select TCP/IP (v4), and choose Properties.
 - j. Set the IP address as 172.1.0.20/255.255.0.0
 - k. Set the default gateway as 172.1.0.1
 - l. Set the Preferred DNS Server address as 172.1.0.10
16. Click Start and right-click on Computer. Select Properties
17. Click Change Settings to add the server to the VDI.TEST domain
18. Close and reboot the computer when prompted
19. Login as VDI\Administrator and install all available updates and security patches.

Installing Microsoft SQL Server 2008 R2 on the SQL server VM (SQL)

1. Right-click on the SQL VM in vCenter and select Edit Settings.
2. In the pop-up window, select CD/DVD drive 1.
3. Select the Datastore ISO File radio button and click Browse.
4. Browse the datastores for the SQL Server 2008 R2 ISO and click OK.
5. Click OK.
6. Login to the SQL VM as VDI\Administrator.
7. Click Start, click Computer, and double-click DVD Drive (D:).
8. Click OK to install the .NET Framework and begin installation of SQL server.
9. Wait for the SQL Installer to launch. On the left menu, click Installation.
10. Click New installation or add features to an existing installation.
11. Click OK.
12. Enter the Product Key, and click Next.
13. Click the I accept the license terms checkbox, and click Next.
14. Click Install to install the Setup Support Files (required).
15. Resolve any issues displayed in the setup wizard and click Next.
16. Click Next.
17. Install Database Engine Services and Management Tools (Basic and Complete), and click Next.

18. Click Next.
19. Accept instance configuration defaults and click Next.
20. Accept defaults for disk space requirements and click Next.
21. Click Use the same account for all SQL Server services, select NT Authority\System, and click OK. Click Next.
22. Select Mixed Mode and enter a password for the SA account. Click Add Current User, and click Next.
23. Accept defaults for error reporting, and click Next.
24. Review installation configuration rules check and click Next.
25. To begin installation, click Install.
26. At completion screen, click Close.
27. Run Windows Update to receive all updates and security patches.

Setting up a VM to host the vCenter server (vCenter)

1. Log into INFRA with the VMware vSphere 5.1 client.
2. Click the Virtual Machines tab.
3. Right-click, and choose New Virtual Machine.
4. Choose Custom, and click Next.
5. Assign the name `vCenter` to the virtual machine, and click Next.
6. Select INFRA for the host, and click Next.
7. Select the appropriate storage, and click Next.
8. Choose Virtual Machine Version 8, and click Next.
9. Choose Windows, choose Microsoft Windows Server 2008 R2 (64-bit), and click Next.
10. For CPUs, select one virtual processor socket, and 8 cores per virtual socket, and click Next.
11. Choose 4GB RAM, and click Next.
12. Click 1 for the number of NICs, select VMXNET3, connect to the VDI port group, and click Next.
13. Leave the default virtual storage controller, and click Next.
14. Keep the default virtual device node (0:0), and click Next.
15. Connect the VM virtual CD-ROM to the Microsoft Windows 2008 R2 installation disk.
16. Click Finish.
17. Right-click the vCenter VM, and click Edit settings.
18. Click the Resources tab, click Memory, check the Reserve all guest memory checkbox, and click OK.
19. Start the VM.

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

1. Choose the language, time and currency, and keyboard input. Click Next.
2. Click Install Now.
3. Choose Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
4. Accept the license terms, and click Next.
5. Click Custom.
6. Click the Disk, and click Drive options (advanced).
7. Click New→Apply→Format, and click Next.
8. After the installation completes, click OK to set the Administrator password.
9. Enter the administrator password twice, and click OK.
10. Install VMware Tools. For more information, see http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=340.
11. Reboot.
12. Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.
13. Enable remote desktop access.
14. Change the hostname to `vCenter` and reboot when the installation prompts you.
15. 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.
16. Join the VDI domain.
 17. Reboot the system.

Setting up a database and ODBC DSN for vCenter

1. Open a remote desktop session to the SQL server and log in.
2. From the SQL server desktop, open Start→All Programs→Microsoft SQL Server 2008 R2→Configuration Tools→SQL Server Configuration Manager.
3. Click SQL Server Network Configuration→Protocols for MSSQLSERVER.
4. Right-click TCP/IP, and select Enabled.
5. Click SQL Services→right-click SQL Server Browser, and select Properties.
6. In the SQL Server Browser Properties, select the Services tab, change the Start mode to Automatic, and click OK. Repeat this step for the SQL Server Agent service.
7. Start the SQL Server browser service and the SQL Server Agent service.
8. From the SQL server desktop, open Start→All Programs→Microsoft SQL Server 2008 R2→Configuration Tools→SQL Server Management Studio
9. Click Connect.
10. Select the Databases folder, right-click, and select New Database
11. Provide the name vcenter for the new database.
12. Click Options and change the recovery model from full to simple, and click OK.
13. From the desktop of the vCenter server, select Start→Run→odbcad32.exe.
14. Click the system DSN tab.
15. Click Add.
16. Click SQL Server Native Client 10.0, and click Finish.
17. In the Create a New Data Source to SQL Server text box, enter the connection name type: vCenter
18. For Server, select SQL, and click Next.
19. Change authentication to With SQL Server authentication using a login ID and password entered by the user, enter sa as the Login ID, use the password you defined in SQL server setup for the SA account, and click Next.
20. Select the Change the default database to: checkbox, choose vcenter from the pull-down menu, and click Next.
21. Click Finish.
22. Click Test Data Source... to confirm correct configuration.
23. Click OK to create the vCenter ODBC connection.

Installing VMware vCenter 5.1

1. Log onto the vCenter as VDI\administrator
2. From the VMware vCenter 5.1 install media, click Autorun.
3. Click Run to start the install wizard.
4. Click the Install button on the VMware vSphere 5.1 Simple Install wizard.
5. Select the Install wizard language as English, and click OK.
6. At the Install wizard welcome screen, click Next.
7. At the End User Patent Agreement, click Next.
8. Agree to the license agreement, 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 Install a local Microsoft SQL Server 2008 R2 Express Instance and click Next.

11. Enter and confirm the passwords for the DBA and SQL user accounts and click Next.
12. Confirm the Fully Qualified Domain Name or IP address is correct and click Next.
13. Check "Use network service account" checkbox and click Next.
14. Accept the default installation path and click Next.
15. Accept the default https port and click Next.
16. Click Install.
17. After Single Sign On completes, and vCenter Server installation begins, enter user information and a license key, and click Next.
18. Select "Use an existing supported database" and select the Data Source Name (DSN) for the connection to the SQL Server: `vcenter`
19. Enter `sa` as the database username, provide the password for the `sa` account, and click Next.
20. Select the system account for the vCenter Server service account, and click Next.
21. Keep the vCenter default ports, and click Next.
22. Select 1024 MB for the JVM memory, and click Next.
23. Click Install to finish the vCenter server installation.
24. Click Finish to exit the wizard.
25. Click OK to confirm completion.
26. Click Exit on the installer.
27. Restart the server when complete.
28. Using the vSphere 5.1 client, log into vCenter5 as `VDI\administrator`
29. Right-click the root of vCenter, and click New Data center.
30. Name the New datacenter `vdi`
31. Add the ESX server named `Infrastructure` to the datacenter.
32. Add the ESX server `SUT` to the datacenter.

Setting up a database and ODBC DSN for Composer

1. Open an RDP session to the SQL server.
2. From the SQL server desktop, open Start→All Programs→Microsoft SQL Server 2008 R2→Configuration Tools→SQL Server Management Studio
3. Click Connect.
4. Select the Databases folder, right-click, and select New Database
5. Provide the name `composer` for the new database.
6. Click Options and change the recovery model from full to simple and click OK.
7. From the desktop of the vCenter server, select Start→Run→`odbcad32.exe`.
8. Click the system DSN tab.
9. Click Add.
10. Click SQL Server Native Client 10.0, and click Finish.
11. In the Create a New Data Source to SQL Server text box, enter the connection name: `Composer`
12. For Server, select SQL, and click Next.
13. Change authentication to With SQL Server authentication using a login ID and password entered by the user, enter `sa` as the Login ID, use the password you defined in SQL server setup for the SA account, and click Next.
14. Select the Change the default database to: checkbox, choose `composer` from the pull-down menu, and click Next.
15. Click Finish.
16. Click Test Data Source... to confirm correct configuration.
17. Click OK to create the vCenter ODBC connection.

Setting up VMware View Composer

1. Open the View5 media folder, and run the file names VMware-viewcomposer.exe.
2. At the Welcome screen and the Patents screen, click Next.
3. Accept the VMware end user license agreement, and click Next.
4. Leave the Destination folder as default, and click Next.
5. In the Database information box, type `composer` as the source name and `VDI\Administrator` as the user name. Enter the password, and click Next.
6. Leave the default SOAP port, and click Next.
7. Click Install, and click Finish.

Setting up a VM to host the VMware View 5.1 connection server

1. Log into vCenter with the VMware vSphere 5.1 client.
2. In the vSphere 5.1 client, browse to the ESXi host named INFRA.
3. Click the Virtual Machines tab.
4. Right-click, and choose New Virtual Machine.
5. Choose Custom, and click Next.
6. Assign the name View5 to the virtual machine, and click Next.
7. Select INFRA for the host, and click Next.
8. Select the appropriate storage, and click Next.
9. Choose Virtual Machine Version 8, and click Next.
10. Choose Windows, choose Microsoft Windows Server 2008 R2 (64-bit), and click Next.
11. For CPUs, select one virtual processor socket, and 2 cores per virtual socket, and click Next.
12. Choose 4GB RAM, and click Next.
13. Click 1 for the number of NICs, select VMXNET 3, connect to the VDI port group, and click Next.
13. Leave the default virtual storage controller, and click Next.
14. Choose to create a new virtual disk, and click Next.
14. Make the OS virtual disk size 40 GB, choose thick-provisioned lazy zeroed, specify the OS datastore on the external storage, and click Next.
15. Keep the default virtual device node (0:0), and click Next.
16. Connect the VM virtual CD-ROM to the Microsoft Windows Server 2008 R2 installation disk.
17. Right-click the View5 VM, and click Edit settings.
18. Click the Resources tab, click Memory, check the Reserve all guest memory checkbox, and click OK.
19. Click Finish.
20. Start the VM.

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

1. Choose the language, time and currency, and keyboard input. Click Next.
2. Click Install Now.
3. Choose Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
4. Accept the license terms, and click Next.
5. Click Custom.
6. Click the Disk, and click Drive options (advanced).
7. Click New→Apply→Format, and click Next.
8. After the installation completes, click OK to set the Administrator password.
9. Enter the administrator password twice, and click OK.
10. Install VMware Tools. For more information, see http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=340.
11. Reboot.
12. Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.

13. Enable remote desktop access.
14. Change the hostname to `ViewConnection` and reboot when the installation prompts you.
15. 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.
16. Join the VDI domain.
17. Reboot the system.

Installing the VMware View 5.1 Connection Server

1. Log into the server named VMW-View.
2. Browse to VMware View 5.1 installation media, and click View Connection Server x86_64-5.1.0.exe.
3. To begin the install wizard, click Next.
4. Agree to the license agreement, and click Next.
5. Keep the destination directory as `C:\Program Files\VMware View\Server\`, and click Next.
6. Select View Standard Server, and click Next.
7. Allow View Server to configure the firewall, and click Next.
8. Authorize the local administrator to administer View 5.1, and click Next.
9. Choose whether to participate in the customer experience improvement program.
10. Complete the installation wizard to finish installing View Connection Server.
11. Click Finish.
12. Reboot server.

Configuring the VMware View 5.1 Connection Server

1. Open a Web browser to `<view server ip address>/admin`
2. Log in as administrator
3. Open View Configuration → Servers.
4. In the vCenter Servers tab, click Add...
5. In the Add vCenter Servers settings, add the vCenter server, and enable View Composer. Click OK.
6. Set the Host Cache setting to 1024 MB.
7. Open View Configuration → Product Licensing and Usage.
8. Click Edit license...
9. Enter a valid license serial number, and click OK.
10. Close the View Administrator.

Setting up a Windows 7 Enterprise x86 image template

Using the vSphere 5.1 client, we created a Windows Enterprise X86 VMs base image and converted it into a template. Using our template, we deployed a View 5.1 gold image and a Login VSI launcher.

On the gold image, we installed Microsoft Office 2010, installed the Login VSI target software, added them to the vdi domain, added them to the Login VSI OU, and installed the respective VMware View 5.1 agents.

For the Login VSI launcher VM, we installed the VMware View 5.1 client, added it to the vdi domain/Login VSI OU in Active Directory, and installed the Login VSI Launcher software.

Installing the Windows 7 Enterprise (x86) base image VM

1. In the vSphere 5.1 client, connect to the vCenter Server, and browse to the INFRA host.
2. Click the Virtual Machines tab.
3. Right-click, and choose New Virtual Machine.

4. Choose Custom, and click Next.
5. Assign the name as `win7-temp` and click Next.
6. Select INFRA for the host, and click Next.
7. Select the appropriate storage.
8. Choose Virtual Machine Version 8, and click Next.
9. Choose Windows, choose Microsoft Windows 7 (32-bit), and click Next.
10. For CPUs, select one virtual processor socket and one core per virtual socket, and click Next.
11. Choose 1GB RAM, and click Next.
12. Click 1 for the number of NICs, select VMX, and click Next.
13. Leave the default virtual storage controller, and click Next.
14. Choose to create a new virtual disk, and click Next.
15. Make the OS virtual disk size 20 GB, choose thin-provisioned, specify the OS datastore on the external storage, and click Next.
16. Keep the default virtual device node (0:0), and click Next.
17. Click Finish.
18. Click Finish, and click OK.
19. Right-click the `win7-temp` VM, and click Edit settings.
20. Click the Resources tab, click Memory, and check the Reserve all guest memory checkbox.
21. Click the Hardware tab, CD/DVD Drive, and Connect the VM virtual CD-ROM to the Microsoft Windows 7 x86 installation disk.
22. Click OK.

Installing the Windows 7 Enterprise (X86) on the base image VM

1. When the installation prompts you, press any key to begin setup.
2. Enter your language preferences, and click Next.
3. Click Install.
4. Accept the license terms, and click Next.
5. Select Custom, and select the drive that will contain the OS.
6. Click Install.
7. Type `user` for the username, and click Next.
8. Enter no password, and click Next.
9. At the system protection screen, select Use recommended settings, and click Next.
10. Enter your time zone, and click Next.
11. Select the Work Network setting, and click Next.
12. Install VMware Tools. For more information, see http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=340.
13. Reboot.
14. Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.
15. Join the domain and restart the VM.

Optimizing Windows 7

Adjusting page file

1. Log in as `administrator`
2. Right-click Computer→Properties→Change settings→Advanced→Performance→Settings.
3. In Performance Settings, select the Advanced tab, and select Change for Virtual Memory.
4. Deselect Automatically manage page file.
5. Select Custom size, type `1024` for both values, and select Set.

Enabling ClearType fonts

1. Click Start→Run, and type `cttune.exe`
2. Check the Turn on ClearType checkbox, and click Next.
3. Follow the wizard to enable ClearType fonts.

Converting the base image VM to a template

1. In vSphere 5.1 Client, right-click `win7-temp` VM and select Template→Convert to Template.

Deploying the view_gold VM from base template

2. In vSphere 5.1 Client, browse to Home→VMs and Templates.
3. Right-click `Gold_Image` to deploy a virtual machine from template.
4. Type `Master_Image` as the new VM name, and click Next.
5. Click Datacenter, and click Next.
6. Click INFRA, and click Next.
7. Select the appropriate storage, and click Next.
8. Select customization using existing customization specifications, select the appropriate file, and click Next.
9. Click Finish to deploy the `Master_Image` VM.
10. Repeat steps 1 through 8 to deploy a `launcher` VM to launcher server.

Preparing view_gold for deployment

Installing Office 2010 Professional

1. From the Office 2010 media, run Setup.
2. Enter the product key for Office 2010, and click Continue.
3. Accept the licensing agreement.
4. Select Install Now.
5. Reboot the system.

Installing Login VSI target software

1. Log into the `Master_Image` VM as `VDI\administrator`
2. Browse to `\vsi-install\Target setup`.
3. Run the `setup.exe`.
4. In the Target Setup wizard, specify the VSI share `\\DC1\share`.
5. Click Start.
6. At the security warnings, click OK.
7. When the installation is complete, reboot the system.

Installing the View 5.1 agent

1. Browse to the VMware View 5.1 media, and run the `VMware-viewagent-x86_64.exe` file.
2. Click Run.
3. At the Welcome screen, click Next.
4. Accept the VMware end user license agreement, and click Next.
5. Select defaults, and click Next.
6. Enter the server name of the View Connection Server, and click Next.
7. Click Install.

Optimizing Windows 7 for VMware View 5.1

We executed the `CommandsNoPersonaManagement` script to prepare the `view_gold` VM as recommended by VMware. This script is included as part of the VMware View Optimization Guide for Windows 7.

For more information, visit <http://www.vmware.com/files/pdf/VMware-View-OptimizationGuideWindows7-EN.pdf>.

Configuring Regedit for Quick prep (kb.vmware.com/kb/1026556)

1. Click Start→Run, and type `regedit`
2. Browse to `HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\vmware-viewcomposer-ga`.
3. Right-click `SkipLicenseActivation`, and click `Modify...`
4. Change the value from 0 to 1.

Preparing Launcher_1 for testing

We installed Login VSI target software and View 5.1 client on our launcher. Once all the necessary software was installed, we converted the launcher VM into another template that was used to deploy multiple launchers required for testing.

Installing the Login VSI launcher

1. Log into the `launcher` VM as `VDI\administrator`
2. Browse to `\vsi-install\Launcher setup`.
3. Run the `setup.exe`.
4. In the Target Setup wizard, specify the VSI share `\\DC1\share`.

Installing the VMware View 5.1 client

1. Browse to the VMware View 5.1 media, and run the `VMware-viewclient-x86_64.exe` file.
2. Click `Run`.
3. At the welcome screen, click `Next`.
4. At the Patents screen, click `Next`.
5. Accept the VMware end user license agreement, and click `Next`.
6. Select defaults, and click `Next`.
7. Click `Install`.

Converting the launcher VM to a template

1. In vSphere 5.1 Client, right-click `launcher` VM and select `Template→Convert to Template`.

Deploying the launchers VM from launcher template

1. In vSphere 5.1 Client, browse to `Home→VMs and Templates`.
2. Right-click `launcher` to deploy a virtual machine from template.
3. Type `X001` as the new VM name and click `Next`.
4. Click `Datacenter`, and click `Next`.
5. Click the launcher server, and click `Next`.
6. Select the appropriate storage LUN, and click `Next`.
7. Select customization using existing customization specifications, select the appropriate file, and click `Next`.
8. Click `Finish` to deploy the new VM.
9. Repeat steps 1 through 8 to deploy more launcher VMs to launcher server.

Configuring View 5.1 - creating a pool and adding entitlements for Login VSI users

1. Open `vCenter→Datacenter→INFRA`, and right-click the `Master_Image` VM, select `Snapshot→Take Snapshot`.
2. Name the snapshot `Master_Image`
3. Open the View Administrator.
4. Log in as `administrator`

5. Click Pools, and in the right window, click Add...
6. Select Automatic Pool, and click Next.
7. Select Floating, and click Next.
8. Select View Composer linked clones, and click Next.
9. Type pool for the pool ID and display name, and click Next.
10. Leave the pool settings as defaults, and click Next.
11. Under Naming Pattern, use View-{n:fixed=003}
12. Under Pool Sizing, enter 200 for Max number of desktops and number of spare (power on) desktops.
13. Select provision all desktops up-front, and click Next.
14. Select Redirect disposable files to a non-persistent disk, type 4096 MB for Disk Size, and click Next.
15. Under Storage Optimization, click Next.
16. Under vCenter Settings, use:
 - Parent VM: /vdi/vm/Master_Image
 - VM folder: /vdi/vm/Pool
 - Host or cluster: /vdi/host/SUT
 - Resource pool: /vdi/host/SUT/Resources
 - Datastore=select the appropriate storage (linked clone, replica, VAAI, etc.)
Overcommit: Conservative
17. Under Advanced Storage Options select Use host caching, OS disk, 7 days, and click Next.
18. Under Guest customization, select the following:
 - Domain: vdi.test
 - AD container: OU=Users,OU=Login_VSI
 - Select Use Quick Prep, and click Next.
19. Click Finish.
20. Click Pool, and click Entitlements...
21. Click Add, type Login_VSI_TS and click OK.
22. Click Desktops, and wait for the virtual desktops to report as ready.

Configuring the Login VSI Management Console

For VMware View 5.1 testing we used the following Settings:

- Connection Type: Custom Commandline with CSV
- Specify Custom Commandline:


```
c:\program files\VMware\VMware View\Client\bin\wswc.exe -serverURL
http://viewconnection.vdi.test -username: %view_user% -password Password1 -
domainname vdi -desktopname View -Standalone -LoginAsCurrentUser False -
ConnectUSBonStartup False
```
- Specify CSV file:


```
\\DC1\Share\csv\view_user.csv
```
- Connection Settings session:
 - Connect: Specify User
 - Formatting Length: Set to 1
 - Server Name: Leave blank
 - User Name: Leave blank
 - Password: Leave blank
 - Domain: Leave blank

APPENDIX C – PRICING

Dell PowerEdge R720 with SAS disks	
2 x Intel Xeon E5-2680	
8 x 32GB 4R 1333 (256GB total)	
PERC H710 RAID Controller	
8 x 300GB 10K 2.5" SAS HDDs	
Intel Gigabit 4P I350-t rNDC	
2 x Dell 05NF18X02 750W Power Supplies	
Cost	\$19,422

Dell PowerEdge with Green SM825 SSDs	
2 x Intel Xeon E5-2680	
8 x 32GB 4R 1333 (256GB total)	
PERC H710 RAID Controller	
8 x 100GB 2.5" SATA SSDs	
Intel Gigabit 4P I350-t rNDC	
2 x Dell 05NF18X02 750W Power Supplies	
Cost	\$20,622

Figure 7: System pricing as of February 27, 2013.

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1007 Slater Road, Suite 300
Durham, NC, 27703
www.principledtechnologies.com

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