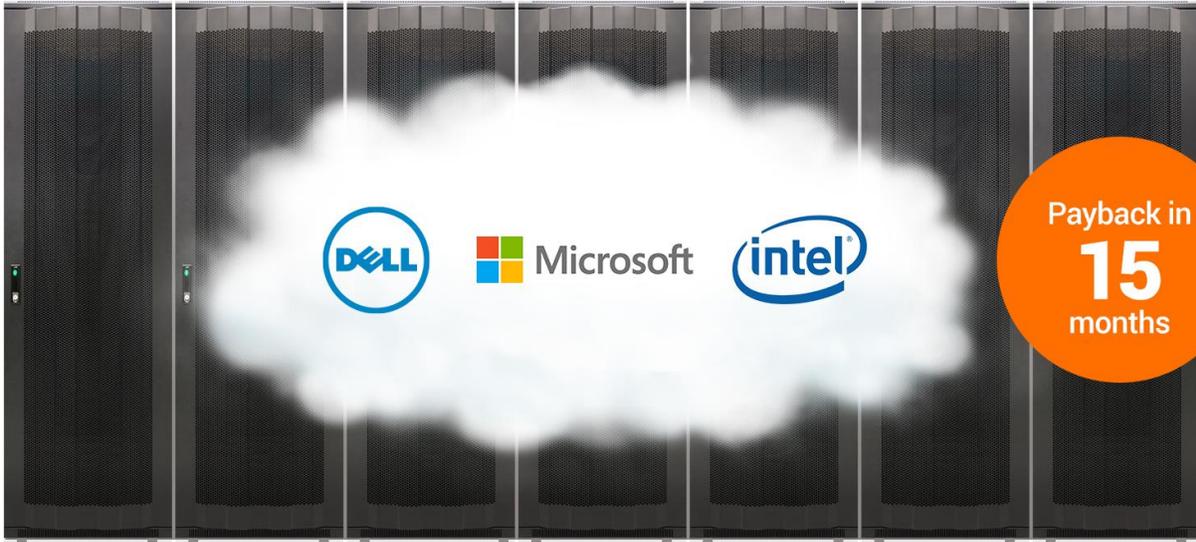


CLOUD COMPARISON: MICROSOFT PRIVATE CLOUD ON THE INTEL-POWERED DELL SOLUTION VS. A LEADING PUBLIC CLOUD PROVIDER

Up to **62.6% lower five-year TCO**

Intel® processor-based Dell™ PowerEdge™ M620 server with Microsoft® Private Cloud



Up to \$600,301.00 in five-year savings versus a leading public cloud solution

Advances and trends in technology mean more IT choices. Instead of purchasing hardware for a specific application as was typical in the past, many businesses are considering running on-demand cloud applications solely from public cloud providers. However, this outsourced solution comes at a price, with the potential for greater long-term costs, unexpected outages, and performance degradation during peak times. The Microsoft private cloud solution, running on Dell hardware and powered by Intel Xeon® processors E5-2660, can provide your business with the flexibility of a private cloud, while delivering performance and a lower total cost of ownership (TCO) over time.

In the Principled Technologies labs, we compared the performance and TCO for a leading public cloud service provider against the Intel processor-powered Dell solution with Microsoft private cloud. We found that the Dell solution provided better value, costing up to a projected 62.6 percent less over five years, and performed on par with the more expensive public cloud provider. In addition, we found that the Dell solution could deliver payback in 15 months.¹

¹ Based on publicly available pricing as of August 21, 2014.



CLOUD FEATURES WITH ON PREMISES BENEFITS

Cloud computing appeals to businesses because of the flexibility and scalability it can bring to datacenters. IT staff can spin up or downsize additional virtualized resources on the fly.

In the cost models of public clouds, they are typically priced as a recurring monthly cost and don't require up-front hardware and licensing costs. Some providers offer discounts but only when reserving resources for the long term.

Public cloud solutions present challenges though. They can be a constant expense and can exceed the cost of purchasing on-premises hardware within a relatively short period. Users must relinquish control over where data resides with public cloud solutions, and peak-hour usage can bring potential service outages and performance degradation.

The Intel processor-powered Dell solution, running Microsoft private cloud, offers a private cloud alternative. The Dell solution not only meets current performance demands, it also provides a path to expand your private cloud as your business continues to grow. It does this in two ways. First, it provides additional bays for extra compute power through Dell PowerEdge M-series servers. Second, the modular design Dell EqualLogic storage allows you to add storage nodes as I/O and capacity needs grow. Combined with Dell, Microsoft private cloud provides cloud-like management tools via System Center 2012 R2 and steady performance from Windows Server 2012 R2, with the added benefits of yielding significant savings over time and the ability to control and run your applications locally.

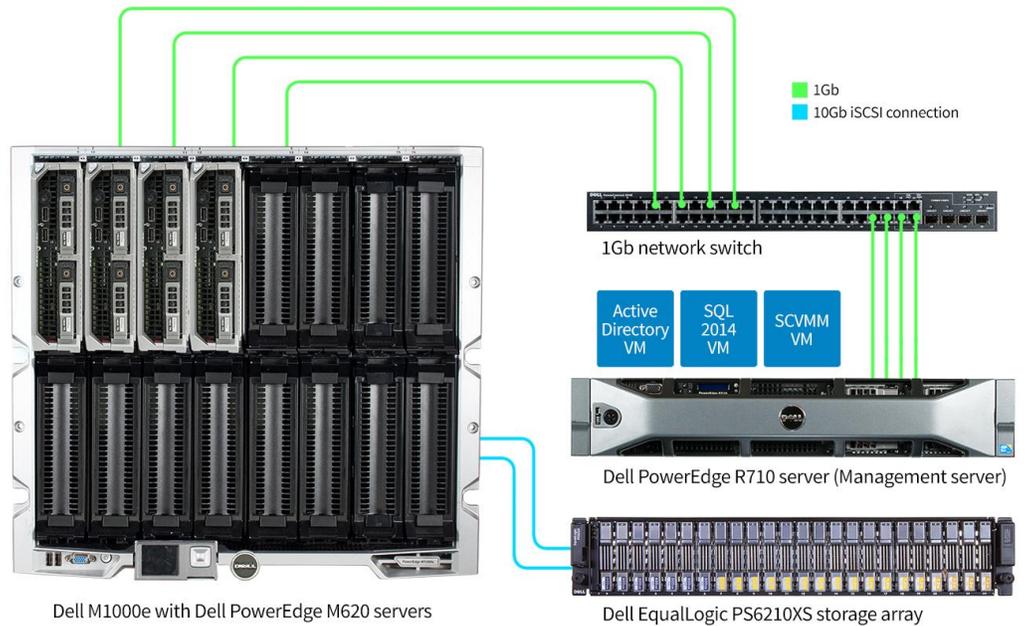
HOW WE TESTED

On both the private cloud hardware in our lab, and the public cloud provider, we tested virtual machines using a database workload as an example application. To determine an acceptable performance threshold for each VM in both solutions, we established the baseline performance for each virtual machine instance running a transactional workload as 3,500 orders per minute (OPM). This represented 350 simulated database users generating approximately 10 orders per minute on each of the VMs. We configured a single instance (VM) on a leading public cloud service with SQL Server 2014 and Windows Server 2012 R2, and ran our test workload on it to ensure that it achieved the requisite OPM.

We then determined the number of similarly configured VMs the Dell PowerEdge M620 and Dell EqualLogic PS6210XS storage array could support while running the same workload in a Microsoft private cloud environment. We used Windows Server 2012 R2 for the host and guest operating systems, SQL Server 2014 for the database software, and System Center Virtual Machine Virtual Manager for cloud management. We scaled out the number of VMs until they no longer achieved the

requisite OPM, which we determined to be 24 VMs. We found the 24 VMs on our Dell powered private cloud all achieved 3,500 OPM as well as the public cloud provider VM. Figure 1 shows our test configuration.

Figure 1: The Dell solution network diagram.

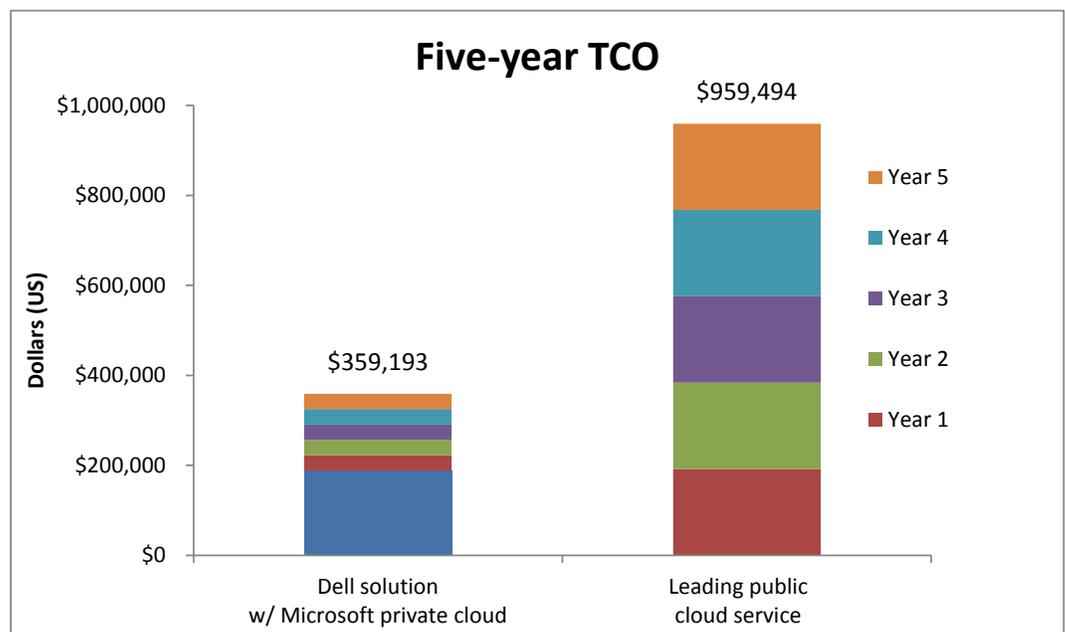


To create our database workload, we used the DVD Store Version 2.1 (DS2) benchmarking tool, which models an online DVD store and its database. For detailed system information, see [Appendix A](#). For complete details on what we tested, see [Appendix B](#). For complete details on how we tested, see [Appendix C](#).

LOWER TCO WITH THE DELL SOLUTION AND MICROSOFT PRIVATE CLOUD

After configuring the 24 VMs on four Dell PowerEdge M620 servers to provide the same performance as the public cloud provider VMs, we analyzed the five-year cost of each solution. While choosing to host VMs in the public cloud may seem convenient and cost-effective, we found that purchasing and running the Microsoft private cloud solution on Dell hardware could deliver as much as \$600,301.01 in savings, or a 62.6 percent lower projected five-year TCO, than using a leading public cloud service for the 24 virtualized SQL Server 2014 instances (see Figure 2). Numbers for the leading public cloud service are based on costs for a single instance multiplied by 24 instances.

Figure 2: The five-year TCO for the Intel processor-powered Dell solution running Microsoft private cloud and a leading public cloud service to host 24 VMs or instances. Lower numbers are better.



Although the Dell solution has an up-front acquisition cost, its monthly cost is significantly lower than that of the leading public cloud service. After five years, the Dell solution is \$600,301.01 less expensive, saving 62.6 percent (see Figure 3).

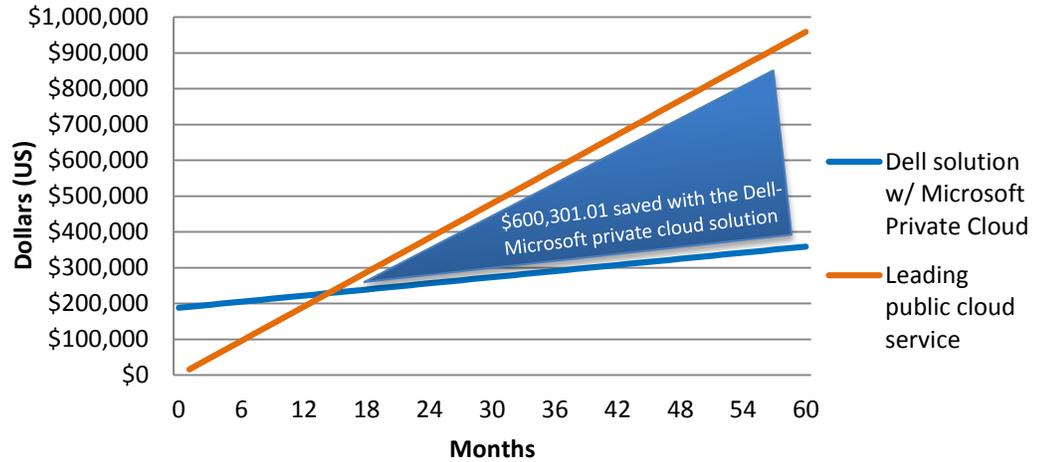
	Dell solution	Leading public cloud service
Acquisition cost	\$188,096.12	\$0
Year 1 costs	\$34,219.45	\$191,898.88
Year 2 costs	\$34,219.45	\$191,898.88
Year 3 costs	\$34,219.45	\$191,898.88
Year 4 costs	\$34,219.45	\$191,898.88
Year 5 costs	\$34,219.45	\$191,898.88
Total	\$359,193.39	\$959,494.40

Figure 3: In our 24-VM or 24-instance scenario, the Dell solution cost up to \$600,301.01 less than the leading public cloud service after five years.

With the Dell solution, we found that you could achieve payback, or a return on your investment (ROI), in as little as 15 months (see Figures 4 and 5).

Compounded monthly costs

Figure 4: The compounding monthly costs of the Dell solution with Microsoft private cloud and a leading public cloud service supporting 24 VMs and instances. Lower numbers are better.



Payback category	Dell solution	Leading public cloud service	Difference
One-time initial investment	\$188,096.12	\$0.00	(\$188,096.12)
Monthly cost	\$2,851.62	\$15,991.57	\$13,139.95
Payback period	(\$188,096.12/\$13,139.95=14.31 months)		

Figure 5: Information for determining the payback point of the Dell solution with Microsoft private cloud 24 VMs. Payback period accounts for the monthly cost of the Dell solution.

Microsoft private cloud on the Dell solution was able to deliver a lower TCO and less time to reach ROI compared to the leading public cloud service due to lower yearly operating costs.

Our cost analysis included up-front costs from hardware, software, and support as well as recurring expenses from management, power and cooling for the Dell solution. For the leading public cloud provider, we included any reservation costs as well as monthly subscriptions. For complete details of our TCO analysis, see [Appendix D](#).

AGILITY FOR FUTURE GROWTH

In addition to the lower TCO when compared to a leading public cloud provider, the Dell solution running Microsoft private cloud establishes the necessary infrastructure to expand into a larger configuration as your business grows. The Dell OpenManage portfolio, including the Integration Suite for Microsoft System Center, provides tools designed by Dell that aim to centralize management and simplify server, storage, and network resource provisioning. The Dell PowerEdge M1000e enclosure we tested had an additional 12 bays (16 total) for added compute nodes, and according to Dell, is built to support future generations of blade servers in addition to its current offerings. Dell EqualLogic management features are also designed to allow the deployment and integration of additional EqualLogic storage arrays into the existing environment. This means the potential for even greater savings through lower cost per VM as your private cloud expands into the existing infrastructure.

CONCLUSION

Combined with Microsoft private cloud software, the Dell solution featuring Intel Xeon processor-powered Dell PowerEdge M620 servers in a Dell M1000e chassis with Dell EqualLogic PS6210XS storage array delivered application performance equivalent to that of VMs from a leading public cloud provider in our tests, at a much lower project cost over five years. In our tests, the Dell solution would deliver 62.6 percent lower TCO over five years, a savings of \$600,301.01, with an ROI beginning after just 15 months. These savings could be reallocated toward other costs that could provide a leading edge to your business, such as investing in the newest end-user technologies for employees or hiring additional expertise in your field. The Dell solution provides agility through the shared infrastructure, allowing for expansion as your IT demands grow, and potentially leading toward even more savings as the number of VMs increase within the existing infrastructure. This private cloud agility, performance equality, and cost savings are all benefits for your organization, making the Dell solution running Microsoft private cloud software a great choice when evaluating your IT infrastructure strategies.

APPENDIX A – SYSTEM CONFIGURATION INFORMATION

Figure 6 provides detailed configuration information for the Dell PowerEdge M1000e Blade Enclosure.

System	Dell PowerEdge M1000e Blade Enclosure
Enclosure	
Compute node enclosure	Dell PowerEdge M1000e Blade Enclosure
Power supplies	
Total number	6
Vendor and model number	Dell E2700P-00
Wattage of each (W)	2,700
Cooling fans	
Total number	9
Vendor and model number	Dell YK776
Volts	12

Figure 6: Detailed configuration information for the Dell PowerEdge M1000e Blade Enclosure.

Figure 7 provides detailed configuration information for the Dell PowerEdge M620 server nodes.

System	Dell PowerEdge M620
Platform	
Number of server nodes	4
Vendor and model number	Dell PowerEdge M620
Motherboard model number	0GVN4C
Motherboard chipset	Intel C600
BIOS name and version	Dell BIOS 2.2.10
BIOS settings	Default
General	
Number of processor packages	2
Number of cores per processor	8
Number of hardware threads per core	2
System power management policy	Performance
CPU	
Vendor	Intel
Name	Xeon E5-2660
Socket type	Socket 2011 LGA
Core frequency (GHz)	2.20
L1 cache	32 KB (per core)
L2 cache	256 KB (per core)
L3 cache	20 MB (shared)
Memory modules (per node)	
Total RAM in system (GB)	128
Vendor and model number	Hynix Semiconductor HMT42GR7MFR4C-PB
Type	DDR3-12800
Speed (MHz)	1,600
Speed in the system currently running @ (MHz)	1,333

System	Dell PowerEdge M620
Timing/latency (tCL-tRCD-iRP-tRASmin)	11-11-11-35
Size (GB)	16
Number of RAM modules	8
Chip organization	Double-sided
RAID controller	
Vendor and model number	Dell PERC H310 mini
Firmware version	20.10.1-0084
Cache size (GB)	0
Hard drive	
Vendor and model number	Dell Seagate ST91000640NS
Number of drives	2
Size (TB)	1
RPM	7.2K
Type	SATA
Network adapter	
Vendor and model number	Intel X520 Ethernet Adapter
Type	Embedded
Number of ports	2
I/O card for Fabric B	
Vendor and model number	Intel X520 Ethernet Adapter
Type	Mezz card
Number of ports	2
I/O card for Fabric C	
Vendor and model number	N/A
Type	N/A
Number of ports	N/A
USB ports (per node)	
Number	2
Type	2.0

Figure 7: Detailed configuration information for the Dell PowerEdge M620 server nodes.

Figure 8 provides detailed configuration information for the Dell EqualLogic PS6210XS. The configuration as tested provided 9.07 TB of total available storage space. We created a 5TB volume for testing.

System	Dell EqualLogic PS6210XS
Storage	
Storage enclosure	Dell EqualLogic PS6210XS
Power supplies	
Total number	2
Vendor and model number	Dell 0R0C2G
Wattage of each (W)	700
Firmware version	01.01.12
Controller	
Model number	70-0425 (Type 15)
Number of controllers	2
Firmware version	V7.0.5
Hard drive	
First drive type	
Vendor and model number	SanDisk LB406M
Number of drives	7
Size (GB)	400
RPM	N/A
Type	SSD
Second drive type	
Vendor and model number	Seagate ST9600205SS
Number of drives	17
Size (GB)	600
RPM	10k
Type	SAS

Figure 8: Detailed configuration information for the EqualLogic PS6210XS.

APPENDIX B – WHAT WE TESTED

About the Dell PowerEdge M620 server nodes

The Dell PowerEdge M620 server node has features optimized for performance, density, and energy efficiency.

- **Processors.** The Dell PowerEdge M620 is powered by two Intel Xeon® E5-2600-series processors, which incorporate the very latest in processor technology from Intel. The powerful processors provide the performance you need for your essential mainstream tasks. The Intel Xeon E5-2600-series processor gives you up to eight cores per processor, or up to 16 cores per server.
- **Memory.** The Dell PowerEdge M620 holds up to 768GB DDR3 RAM (up to 1600 MHz) across 24 DIMM slots per compute node.
- **Management.** The Dell PowerEdge M620, like all late-model Dell servers, comes with the Dell iDRAC with Lifecycle Controller. This tool simplifies server management by providing a single interface that is OS and hypervisor-agnostic for deploying, updating, monitoring, and maintaining your Dell PowerEdge server. Additionally, Dell iDRAC with Lifecycle Controller allows for remote management features and does not require external media, such as CDs or USB keys for keeping server drivers and firmware up to date.

About the Dell PowerEdge M1000e Blade Enclosure

The Dell PowerEdge M1000e blade chassis and its supported fabric interconnects are designed for dense computing situations. According to Dell, features of the PowerEdge M1000e include:

- **Management.** The Dell PowerEdge M1000e reduces administrative demand by providing a secure centralized management interface for the chassis and blades within, using proven Web (SSL-encrypted) and CLI (SSH/Telnet) technologies.
- **Simplified configuration.** The Chassis Management Controller allows administrators to control up to nine enclosures and 144 server blades, including BIOS/firmware change management and updates, thermal monitoring, and power threshold configuration.
- **Flexible I/O.** The PowerEdge Dell M1000e has six interconnect sockets with the capability to support three fully-redundant fabrics, a passive midplane with more than 8Tbps in I/O bandwidth capacity, and FlexIO support to provide a number of connectivity options for your servers.
- **Reliability and efficiency.** The Dell PowerEdge M1000e has six power supplies and nine fans, all hot-swappable, allowing for no-downtime maintenance of key chassis components. All components are tuned for maximum power efficiency to reduce data center power consumption.

For more information about the Dell PowerEdge M1000e Blade Enclosure, visit

www.dell.com/us/enterprise/p/poweredge-m1000e/pd.

About the Dell EqualLogic PS6210XS Array

The Dell EqualLogic PS6210XS Array is designed to leverage the speed of SSDs along with the capacity of HDDs within a single array. The array uses automated data tiering between the SSD and HDD layer to keep the most-frequently accessed data on the SSD tier. The Dell EqualLogic PS6210XS features 7 hot-pluggable SSDs, and up to 17 7.2K NL-SAS, 10K SAS, or 15K SAS drives (24 total drives) for a total capacity of up to 26TB. The PS6210XS array also feature dual controllers with 16GB memory each, and 10GbE connectivity. For more information on the Dell EqualLogic PS6210XS Array, see www.dell.com/us/business/p/equallogic-ps6210-series/pd

About Microsoft private cloud

Microsoft private cloud solution consists of two components: Microsoft Windows Server 2012 R2 and Microsoft System Center 2012 R2. The Microsoft solution provides the advanced virtualization technology of Windows Server while also delivering the deployment and management features of System Center. The private cloud computing model offers resources dedicated to an organization. A private cloud shares many of the characteristics of a public cloud computing including resource and service level pooling, self-service, workload templates, and elasticity delivered in a consistent manner while supplying additional control and customization from the dedicated resources.

For more information on Microsoft private cloud, see www.microsoft.com/en-us/server-cloud/solutions/virtualization-private-cloud.aspx

About DVD Store 2

DVD Store 2 (DS2) models an online DVD store, where customers log in, search for movies, and make purchases. DS2 reports these actions in OPM that the system could handle, to show what kind of performance you could expect for your customers. The DS2 workload also performs other actions, such as adding new customers, to exercise the wide range of database functions you would need to run your ecommerce environment. For more information about the DS2 tool, see www.delltechcenter.com/page/DVD+Store.

APPENDIX C - HOW WE TESTED

Setting up the infrastructure

We used a Dell PowerEdge R710, representative of a previous-generation server that would be likely to already exist as an infrastructure or be repurposed as such, running Windows Server 2012 R2 with Hyper-V for management infrastructure and configured Active Directory, SQL Server 2014, and System Center Virtual Machine Manager (SCVMM) VMs on it. We configured four M620 blades in a Windows Server 2012 R2 cluster with a Dell EqualLogic PS6210XS storage array connected via iSCSI for the Private Cloud.

We connected four 1GB connections from the Dell PowerEdge R710 to the network switch. One connection for each of the following: Hyper-V host, Active Directory, SQL Server 2014, and SCVMM. We connected the M620 blades to the network switch through an M1000e 1GB pass through module to the network switch. All four M620s had a 10GB mezzanine card installed in fabric B. We installed two Dell PowerConnect M8024-k switches in slot B of the M1000e chassis and configured two 10GB connections from each blade for iSCSI traffic and cluster communication between the blades.

The steps below detail how we configured the test bed. In all cases, we began with a fresh installation of Windows Server 2012 R2 with the latest software updates.

Setting up the Hyper-V host

We performed the following steps to set up the management infrastructure. We checked for and applied all updates on software installations through Windows Update.

Installing Windows Server 2012 R2

1. Boot the server or VM from the Windows Server 2012 R2 DVD or ISO image.
2. Choose the language, time and currency, and keyboard input. Click Next.
3. Click Install Now.
4. Enter product key, and click Next.
5. Choose Windows Server 2012 R2 Datacenter (Server with a GUI), and click Next.
6. Accept the license terms, and click Next.
7. Click Custom, and select Install Windows Only.
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.
11. Enter the administrator password twice, and click OK.
12. Connect the machine to the Internet and install all available Windows updates. Restart as necessary.

Installing Hyper-V role

1. Open Server Manager and select Local Server in left hand column.
2. From tasks drop-down menu, select Add Roles and Features.
3. At the Before You Begin in wizard window, click Next.
4. At Installation Type select Role-Based, and click Next.
5. Select the local server in Server Pool, and click Next.
6. On the Server Roles page, select Hyper-V.
7. On the popup windows, click Add Features.
8. Click Next.
9. On the Features windows, leave defaults and click Next.

10. On Hyper-V page, click Next.
11. Select the appropriate NIC on Virtual Switches page, and click Next.
12. On Migration window, leave default settings, and click Next.
13. On Default Stores page, select appropriate folder, and click Next.
14. On Confirmation page, click Install.
15. After installation, close wizard.

Installing Active Directory server VM

We configured one VM as an Active Directory on the Dell PowerEdge R710. We began with a fresh Windows Server 2012 R2 image.

Configuring the Active Directory VM on the VMs

Modify the Active Directory VM to contain the following settings:

- Memory: 4 GB
- Virtual Processors: 2
- Virtual disks: 30 GB

Installing Active Directory role

1. Open Server Manager, and select Local Server in left column.
2. From tasks drop-down menu, select Add Roles and Features.
3. At the Before You Begin in wizard window, click Next.
4. At Installation Type select Role-Based, and click Next.
5. Select the local server in Server Pool, and click Next.
6. On the Server Roles page, select Active Directory Domain Services.
7. On the popup windows, click Add Features.
8. Click Next.
9. On the Features windows, leave default settings, and click Next.
10. On AD DS page, click Next.
11. On Confirmation page, click Install.
12. After installation, close wizard.

Configuring Active Directory

1. After the installation completes, a screen should pop up with configuration options. If not, click the Tasks flag in the upper-right section of Server Manager.
2. Click Promote this server to a Domain Controller.
3. At the Deployment Configuration screen, select Add a new forest. In the Root domain name field, type test.lan, and click Next.
4. At the Domain Controller Options screen, leave the default values, and enter a password twice.
5. Click Next four times to accept default settings for DNS, NetBIOS, and directory paths.
6. At the Review Options screen, click Next.
7. At the Prerequisites Check dialog, allow the check to complete. If there are no relevant errors, check Restart the destination server automatically if required, and click Install.
8. When the server restarts, log on using test\Administrator and the specified password.

Installing Microsoft SQL Server 2014 VM

We installed Microsoft SQL Server 2014 Standard Edition on the VM residing on the Dell PowerEdge M620. We began with a fresh Windows Server 2012 R2 image.

Configuring the SQL Server 2014 VM

Modify the SQL VM to contain the following settings:

- Memory: 8 GB
- Virtual Processors: 2
- Virtual disks: 100 GB

Joining the Domain

1. Open Control Panel→System.
2. Click Change settings.
3. On the system properties, click Change.
4. On Computer name/Domain changes, select Domain.
5. Enter the domain, and click OK.
6. In Windows Security popup window, enter user name and password, and click OK.
7. On the Welcome to the domain popup, click OK.
8. On the reboot warning, click OK.
9. On the System properties window, click Close.
10. To reboot the machine, click Restart Now.

Installing SQL Server 2014 Standard Edition on the VM

1. Open the console for the VM or connect to the VM with RDP.
2. Mount the installation ISO to the VM.
3. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2014 DVD, and double-click.
4. If the installer prompts you with a .NET installation prompt, click Yes to enable the .NET Framework Core role.
5. In the left pane, click Installation.
6. Click New SQL Server stand-alone installation or add features to an existing installation.
7. Select the Specify a free edition, and from the drop-down menu, select Evaluation. Click Next.
8. Click to accept the license terms, and click Next.
9. Select Use Microsoft Update to check for updates, click Next
10. At the Setup Role screen, choose SQL Server Feature Installation.
11. At the Feature Selection screen, select Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools – Basic, and Management Tools – Complete. Click Next.
12. At the Instance configuration screen, leave the default selection of default instance, and click Next.
13. At the Server Configuration screen, check that NT AUTHORITY\SYSTEM is selected for SQL Server Agent and SQL Server Database Engine. Click Next.
14. At the Database Engine Configuration screen, select Mixed Mode.
15. Enter and confirm a password for the system administrator account.
16. Click Add Current user. This may take several seconds.

17. Click Next.
18. At the Ready to Install screen, click Install.
19. After the installation completes, click Close.

Installing the Systems Center Virtual Machine Manager VM

We configured one SCVMM VM on the Dell PowerEdge R710. We began with a fresh Windows Server 2012 R2 image.

Configuring the SCVMM VM on the VMs

Modify the SCVMM VM to contain the following settings:

- Memory: 8 GB
- Virtual Processors: 2
- Virtual disks: 100 GB

Joining the Domain

1. Open Control Panel→System.
2. Click Change settings.
3. On the system properties, click Change.
4. On Computer name/Domain changes, select Domain.
5. Enter the domain, and click OK.
6. In Windows Security popup window, enter user name and password, and click OK.
7. On the Welcome to the domain popup, click OK.
8. On the reboot warning, click OK.
9. On the System properties window, click Close.
10. To reboot the machine, click Restart Now.

Installing the Windows Assessment and Deployment Kit (Windows ADK) for Windows 8 Release Preview

We installed all options of the Windows ADK except SQL Server Express Edition.

1. Download the Windows Assessment and Deployment Kit for Windows 8.1 RP at www.microsoft.com/en-us/download/details.aspx?id=39982.
2. Run adksetup.exe.
3. Click Install the Assessment and Deployment Kit, select the install path, and click Next.
4. Select No on the Join the Customer Experience Improvement Program (CEIP) screen, and click Next.
5. Click Accept on the License Agreement screen.
6. Select to install the Deployment Tools and Windows Pre-installation Environment features.
7. When the installation completes, click Close.

Installing the Microsoft SQL Server Command Line Utilities

1. Download the Microsoft SQL Server 2012 Feature Pack at www.microsoft.com/en-us/download/details.aspx?id=29065.
2. Run SqlCmdLnUtils.msi.
3. On the Welcome screen, click Next.
4. Click to accept the terms of the EULA.
5. Click Install.
6. When the installation completes, click Finish.

Installing System Center Virtual Machine Manager 2012 R2

1. From the SCVMM install folder, run setup.exe.
2. At the Welcome screen, click Install.
3. On the Select Features to Add screen, check VMM Management Server and VMM Console boxes.
4. Enter the name, organization, and product key on the Product Registration screen, and click Next.
5. Accept the EULA terms, and click Next.
6. Select No, I am not willing to participate on the CEIP screen, and click Next.
7. Switch on Microsoft Update, and click Next.
8. To use the default location on the Installation location screen, click Next.
9. Perform any required tasks on the Prerequisites screen, and click Next.
10. On the Database Configuration screen, select the SQL server instance to use for the SCVMM install, and click Next.
11. Choose Domain account, enter the domain administrator username and password on the Configure Service Account and Distributed Key Management screen, and click Next.
12. On the Port Configuration screen, click Next.
13. On the Library Configuration screen, create a new library share, enter a Share name, and click Next.
14. On the Installation Summary screen, click Install.
15. When the install completes, click Close.
7. Run Windows Updates, and install necessary updates.

Setting up the Storage

We used the EqualLogic Web GUI to set up the storage. We set up the storage as a 23 disk RAID 6 and created two volumes: one 5TB volume for the cluster VMs and a 1GB volume for Disk Witness.

Setting up the Cluster host on the Dell PowerEdge M620s

We started with a fresh install of Server 2012 R2 and added the Hyper-V role. We used the same steps as outlined in the [Setting up the Hyper-V host](#) section of this methodology. After installing the Hyper-V role, join each host to the domain using the steps outlined in the SQL 2014 installation section labeled Join Domain. In addition, we performed the following steps on all four hosts.

Installing Dell EqualLogic Host Integration Tools

1. To begin installation, double-click setup.exe.
2. At the Welcome screen, click Next.
3. Accept the license agreement, and click Next.
4. At Destination Folder screen, keep default settings, and click Next.
5. Keep default installation type, and click Next.
6. At Ready to Install, click Install.
7. At the completion window, click Finish.
8. To reboot, click Yes.

Installing Intel Network Driver

We installed the latest NIC driver with Advanced Network Services so we could VLAN the NICs.

1. To begin installation, double-click setup.exe.
2. At the Welcome screen, click Next.
3. Accept the license agreement, and click Next.

4. At Setup Options, select Drivers, Intel PROSet for Windows Device Manager, and Advanced Network Services.
5. At Ready to install, click Install.
6. Click Finish.

Creating Network VLANs

We created VLANs on the NICs in fabric B: one for iSCSI, one for Live Migration, and one for cluster communication. We used VLAN 0 for iSCSI, 10 for Live Migration, and 15 for cluster communication.

1. Right-click the network adapter, and select Properties.
2. In NIC Properties, click Configure.
3. Select the VLANs tab.
4. Click New.
5. Enter VLAN ID and name, click OK
6. For the other two VLANs, repeat steps 4 and 5.
7. Click OK.

Setting up iSCSI initiator

1. From Windows menu select iSCSI Initiator.
2. Enter IP address in Target box and click Quick Connect.
3. In Quick Connect popup window, select initiator and click Connect.
4. Click OK.

Setting up the Cluster

We created a cluster with all four hosts. To create the cluster, we added the Failover Cluster Manager role to all four nodes and then performed the following steps to create the cluster.

Validating the cluster setup

1. On one of the hosts, open Failover Cluster Manager.
2. Click Validate Configuration.
3. At the before you begin screen, click Next.
4. Enter the host names for the four nodes.
5. On Select Servers for Cluster, click Next.
6. On Testing Options, select Run all tests, click Next.
7. On the confirmation window, click Next.
8. On the Summary window, verify everything passed, and click Finish.

Creating the cluster

1. On one of the hosts, open Failover Cluster Manager.
2. Click Create Cluster.
3. At the before you begin screen, click Next.
4. On Select Servers for Cluster, enter the host names of four nodes, and click Next.
5. Enter Cluster name, and click Next.
6. On the confirmation window, click Next.
7. On the Summary page, click Finish.

Setting up the cloud in SCVMM

After creating the cluster, we added the cluster to SCVMM and then created the private cloud. We used the following steps.

Adding a cluster to SCVMM

1. In SCVMM, right-click All Hosts, and click Add Hosts.
2. On Resource Location, accept default settings, and click Next.
3. On Credentials page, select Manually enter the credentials and enter information, and click Next.
4. At Discovery Scope, select Specify Windows Server and enter cluster name, and click Next.
5. Select cluster on Target Resources, and click Next.
6. Keep defaults on Host Settings, and click Next.
7. On Summary page, click Finish.

Creating the private cloud

We used the following steps to create our private cloud. Then we created all VMs inside this cloud for testing.

1. In SCVMM, right-click Clouds, and click create cloud.
2. On General page, enter cloud name, and click Next.
3. On resources page, select all hosts, and click Next.
4. Select logical network, and click Next.
5. On Load Balancers, accept default settings, and click Next.
6. On VIP Templates, accept default settings, and click Next.
7. On Port Classifications, accept default settings, and click Next.
8. Select storage, and click Next.
9. Select library, and click Next.
10. Review capacity, and click Next.
11. On Capacity Profiles, select Hyper-V, and click Next.
12. On Summary page, click Finish.

Testing VM configuration

We configured our test VMs with Windows Server 2012 R2 and installed SQL Server 2014 Standard Edition as previously outlined. We configured the VMs with two disks. One for the OS and SQL installation, and one for database and logs. We used the following settings for the test VMs of both private and public clouds.

- Memory: 15 GB
- Virtual Processors: 4
- OS Virtual disk: 30 GB
- Database Virtual disk: 50 GB

Configuring the database (DVD Store)

Data generation overview

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 15GB database and the database platform on which we ran SQL Server 2014. We ran the Install.pl script on a utility system running Linux. The Install.pl script also 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 15GB 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 on the VM servers between test runs. We performed this procedure once, and used the same backup file for all virtual machines.

The only modification we made to the schema creation scripts were the specified file sizes for our database. We explicitly set the file sizes higher than necessary to ensure that no file-growth activity would affect the outputs of the test. Besides this file size modification, the database schema was created and loaded according to the DVD Store documentation. Specifically, we followed these 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 15GB 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 2014.
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 IdentityInsert.
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.

DVD Store test settings

We installed the DVD Store driver on the SQL Server VM. We used the following DVD Store parameters for testing the virtual machines in this study:

```
ds2sqlserverdriver.exe --target=localhosts --ramp_rate=10 --run_time=30 --
n_threads=32 --db_size=15GB --detailed_view=Y --warmup_time=1 -think_time=0.5
```

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 general steps. For each scenario, we ran three test cycles, and chose the median outcome.

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

APPENDIX D – TCO CALCULATIONS

In this section, we analyze the costs of Microsoft private cloud on the Dell solution and the leading public cloud service over five years, detailing the assumptions and formulas we used in our calculations. We focus our analysis on hardware and software costs, hardware and software support, energy costs, and management costs. In an enterprise-specific analysis, also consider additional areas of savings and benefit, such as direct access to hardware components. Figure 9 breaks down the costs we used for our analysis. Note: we used list prices, didn't include discounts, and annualized multi-year prices. We annualize because most multi-year support and reservation costs are for three years and our TCO is for five years. That means we used list prices for hardware and software for the private cloud and annualize multi-year support costs. We ignored discounts such as the in-cart discount for the Dell server and storage. For the public cloud, we used the advertised prices for one reserved instance, which we annualized and multiplied by both the number of instances and the number of years. To calculate payback, we assumed all annual prices are divided evenly among the 12 months in the year.

	Dell solution	Leading public cloud service
Acquisition costs		
Hardware	\$132,412.12	N/A
Software	\$54,868.00	N/A
Setup	\$816.00	N/A
Total acquisition costs	\$188,096.12	N/A
Annual operational costs		
Software support	\$13,717.00	N/A
Hardware support	\$4,372.69	N/A
Space	\$2,400.00	
Energy	\$2,713.76	N/A
Hardware management	\$9,792.00	N/A
VM management	\$1,224.00	N/A
Instance reservation cost (24 instances)	N/A	\$43,198.72
Instance monthly use cost per year (24 instances)	N/A	\$148,700.16
Total annual costs	\$34,219.45	\$191,898.88
Average cost per month	\$2,851.62	\$15,991.57

Figure 9: Monthly cost savings for using 24 SQL Server 2014 instances with the Dell solution as compared to a leading public cloud service.

Key assumptions

- We calculate costs for 24 SQL instances on each solution – 24 VMs on the M620 and 24 reserved SQL Server 2014 instances on the cloud solution.
- We use current dollars for all calculations.
- We use undiscounted costs for hardware and software.

- We annualize multi-year costs for software support for the Dell solution and three-year costs for the instance reservations for the cloud solution.
- We assume a system administrator carries out all the tasks and earns the equivalent of \$51 an hour in salary and benefits, based on the average national salary for this job of \$105,053.00.²
- We include staff costs for the Dell solution that the on-premises hardware and Microsoft private cloud suite would require.
- We consider only the costs that are platform specific. We thus omit staff costs for tasks that would be common to the two solutions and would require same or similar effort and cost on the two solutions – costs of setting up and maintaining the SQL Server databases, updating the operating system versions, and updating the SQL server versions as updates become available over the five-year TCO timeframe.
- We include only server licensing in this model and omit client access license costs and other client licensing.
- For the Dell solution, we include software license costs with acquisition costs and software support costs with annual costs.
- For the cloud solution, we include the costs to reserve instances as part of the annual costs. We include one-third of the cost of the three-year instance reservation in annual costs along with 12 times the monthly costs.
- We include estimated costs to power and cool the Dell solution. We estimate cooling costs as the same as power costs.

Public cloud solution costs

We used the cloud provider’s online cost estimation tool to estimate costs for the cloud instance we used in our testing. Numbers for the leading public cloud service were based on costs for a single instance multiplied by 24 instances. We estimated costs for an instance defined as follows:

- A medium-sized Standard SQL Server 2014 Standard Edition Instance for which we estimate 100 percent average utilization per month. Please note that the public cloud instances included SQL Server 2014 Standard Edition and did not require the purchase of additional licenses.
- 50 GB of storage in a volume with 150 provisioned IOPS

The tool reported a one-time reservation cost of \$5,399.84 for three years and a monthly cost of \$516.32 for one compute instance and storage volume. We calculated an annual cost of \$7,995.79 (see Figure 10).

	Leading public cloud service
One-time cost	
Three-year reservation cost	\$5,399.84
Reservation cost per instance per year	\$1,799.95
Reservation cost per year (24 instances)	\$43,198.72
Recurring monthly use costs	
Instance cost per month	\$516.32

² Source: swz.salary.com/salarywizard/Systems-Administrator-II-Salary-Details.aspx?hdcboxbonus=off&isshowpiechart=true&isshowjobchart=false&isshowsalarydetailcharts=false&isshownextsteps=false&isshowcompanyfct=false&isshowaboutyou=false

Instance cost per year	\$6,195.84
Cost per year (24 instances)	\$148,700.16
Annual cost per instance	\$7,995.79
Annual cost (24 instances)	\$191,898.88

Figure 10: Annual cost calculations for the leading public cloud solution.

For TCO calculations, we estimate costs for 24 SQL Server cloud instances to match the 24 instances that we tested on the Dell solution. To get estimates, we multiplied the annual cost of a single cloud instance by 24 arriving at a total annual cost of \$191,898.88 and a total monthly cost of \$15,991.57.

Dell solution costs

Acquisition costs

Acquisition costs include purchase costs for the Dell hardware that we tested; license costs for the Microsoft Windows Server 2012 R2, Microsoft SQL Server 2014, and Microsoft Windows Server 2012 R2 with Hyper-V software versions that we tested with; and IT costs to setup the system. Figure 11 details the acquisition costs we included in this study. Figure 10 details acquisition costs for the Dell solution.

Dell M620	Unit	Cost per unit	Quantity description	Quantity	Total cost
Hardware					
Dell M1000E chassis	Chassis	\$16,829.84	1 chassis with 2 Ethernet switches	1	\$16,829.84
Dell PowerEdge M620 Blade Servers	Server	\$10,627.82	1 server	4	\$42,511.28
EqualLogic PS6210XS	Storage array	\$73,071.00	1 storage array	1	\$73,071.00
Software					
Windows Server 2012 Datacenter Edition with Hyper-V (processor licenses)	2 processors	\$6,033.00	Number servers (with 1 to 2 processors)	4	\$24,132.00
Microsoft SQL Server 2014 Standard	1 per VM	\$880.00	Number VMS	24	\$21,120.00
Microsoft System Center 2012 R2	2 processor pack, so 1 per server	\$2,404.00	Number servers (with 1 to 2 processors)	4	\$9,616.00
Setup	Cost per hour	\$51.00	Number hours	16	\$816.00
Total acquisition costs					\$188,096.12

Figure 11: Acquisition costs for the Dell solution.

Hardware costs

See [Appendix A](#) for system information for the Dell hardware we tested. Dell supplied the hardware prices for the chassis and storage. We calculated the price for the blades from the Dell online storefront.

Software costs

We used the Microsoft License Advisor and selected Corporate Open No Level pricing for a Microsoft Windows Server 2012 Datacenter Edition licensed for each processor and a Microsoft SQL Server 2014 Standard Edition license for each VM.³ We used prices on the Microsoft site for Microsoft private cloud costs.

Setup costs

We estimated 16 hours of staff time to unbox and setup the Dell hardware and to install the software on it. We do not include time to update the software to the latest edition or to migrate files and databases to it. IT staff would perform those tasks on either the cloud or the Dell solutions. We omit those non platform-specific tasks from this analysis.

Annual costs

Annual costs include mission critical support for the Dell platform, Microsoft Software Assurance for the Microsoft Software, staff time to maintain the hardware and support the VMs, and energy costs for powering and cooling the platform. Figure 12 details the annual costs of the Dell solution.

Annual costs	Unit	Cost per unit	Quantity description	Quantity	Total cost
Hardware and software support					
Hardware support	Chassis, blade servers, and storage array	\$2,916.51	Solutions	1	\$4,372.69
Windows Server 2012 Datacenter Edition Software Assurance	2 processors	\$1,508.25	Number servers (with 1 to 2 processors)	4	\$6,033.00
Microsoft SQL Server 2014 Standard Software Assurance	1 VM	\$220.00	Number VMS	24	\$5,280.00
Microsoft System Center 2012 R2	2 processors	\$601.00	Number servers (with 1 to 2 processors)	4	\$2,404.00
Data center costs	1 rack unit (U)	\$200.00	Number U	12	\$2,400.00
Energy for power and cooling	Chassis plus blades	\$2,713.76	Number chassis	1	\$2,713.76
Hardware management	Cost per hour	\$51.00	Number hours	192	\$9,792.00
Software management	Cost per hour	\$51.00	Number hours	24	\$1,224.00
Total annual costs					\$34,219.45
Average cost per month of the annual costs					\$2,851.62

Figure 12: Annual costs for the Dell solution.

³ mla.microsoft.com/default.aspx

Software support

We estimated Microsoft Software Assurance costs at 25 percent per year for the Microsoft server software.

Hardware support

We assume that the organization purchases Dell's ProSupport Plus: Mission Critical 4-hour 24/7 support for the Dell hardware (see Figure 13). We estimated annual costs from the three-year costs of the plans. There are no hardware support costs for the leading public cloud service.

ProSupport Plus: Three-year mission critical four-hour onsite service	Annual cost
Chassis	\$1,203.45
4 blade servers	\$1,941.57
Storage array	\$1,227.67
Total	\$4,372.69

Figure 13: Hardware support costs for the Dell solution.

Power

Figure 14 shows the calculations for the annual energy cost estimates. The leading public cloud service does not explicitly charge for power, so we considered estimates of only the Dell solution's power requirements and costs. We estimated power for the Dell solution by using the Dell Energy Smart Advisor Tool, which estimates power utilization based on hardware specifications of the solution we tested, workload type (we selected the transactional workload), and percent utilization, which we set to 80 percent. The tool estimated 1739.3 Watts of power use.

The cost per kWh was taken from the average dollars per kilowatt-hour for the commercial sector in April 2014 as reported by the US Energy Information Administration.⁴ We used 8,766 as the average number of hours in a year in calculating the costs, so we are assuming constantly powered-on hardware. Figure 14 shows our energy cost estimates.

	Dell solution
Cost per kWh	0.1047
Typical watts (W)	1739.3
Multiplier for cooling	1.7
Annual energy cost for power and cooling	\$2,713.76

Figure 14: Energy cost estimates for the PowerEdge M620 solution.

Systems management

With mission-critical Dell support for the Dell solution, our hypothetical SMB should be able to keep in-house costs for hardware maintenance low. We include costs for 16 hours a month hardware management and two hours a month VM management for the Dell solution. We use the same \$51 per hour cost that we used for setup costs. This leads to an annual cost of \$9,792.00 per year for hardware maintenance and \$1,224.00 per year for software maintenance.

⁴ www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_06_a

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