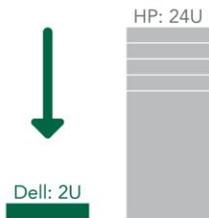


INCREASED DATABASE PERFORMANCE AND REDUCED COSTS WITH DELL POWEREDGE FX2 & VMWARE VIRTUAL SAN

GET MORE WITH LESS USING A DELL™ POWEREDGE™ FX2 SOLUTION

8.3%
of the rack space



2.8X
the orders per minute



Dell: 530,817

HP: 184,446

9.7%
more cost efficient



Dell: \$0.31 per order per minute

HP: \$0.34 per order per minute

6.5X
the performance per watt



Dell: 573 OPM per watt

HP: 88 OPM per watt

Powered by
Intel® Xeon®
E5-2640 v3
processors



Dell PowerEdge FC430 server

Dell PowerEdge FD332 storage node

Featuring
VMware Virtual SAN™
and Intel SSDs

vs. four legacy HP servers and traditional storage array

If the time has come to refresh your aging legacy servers and SAN, moving to a customizable, converged solution to meet your exact needs can give your organization the agility to meet fluctuating demands and help you move with flexibility into the future.

The Dell PowerEdge FX2 converged architecture solution combines compute, networking, and storage into a single chassis, bringing components closer together for improved density and energy efficiency. At Principled Technologies, we set up a Dell PowerEdge FX2 solution featuring

- Two Dell PowerEdge FD332 storages nodes
- Four Dell PowerEdge FC430 servers powered by Intel Xeon E5-2640 v3 processors
- 400GB and 800GB solid-state drives (SSDs) from the Intel SSD DC S3700 and S3500 Series
- An all-flash VMware Virtual SAN 6 architecture

When we compared the Dell PowerEdge FX2 solution to four legacy HP ProLiant DL380 Gen7 servers (released in 2010) and an external traditional storage array, it delivered 2.8 times the database orders per minute (OPM) and used 8.3 percent of the rack space due to its sleek 2U chassis and converged infrastructure approach.



Based on its database performance versus the HP legacy solution, our Dell PowerEdge FX2 solution showed it could deliver a greater value per dollar with a 9.7 percent reduction in cost per OPM and greater energy efficiency by offering 6.5 times the database performance per watt.

UNIFYING RESOURCES TO GET A HOST OF BENEFITS

At first glance, the Dell PowerEdge FX2 doesn't seem like a traditional rack or blade server—how is it different? It takes a converged infrastructure approach to bring datacenter resources into one unified component, which administrators can manage from a single console like a blade, or from the individual nodes like a rack.

In addition, the Dell PowerEdge FX2 features a number of server, networking, and storage components to choose from, so your FX2 solution can be tailor-made for your workload needs. For example, the Dell PowerEdge FX2 converged, 2U rack chassis allows you to incrementally add or swap compact, modular IT building blocks, including servers, storage, and IO, to fit many of your enterprise computing demands. This may be an ideal alternative to overhauling your infrastructure and invaluable for organizations that need agility in the datacenter. The software-defined datacenter approach that the Dell PowerEdge FX2 follows can ensure that you maximize the efficiency of each piece of hardware you run, reducing or eliminating waste while ensuring workloads run comfortably.

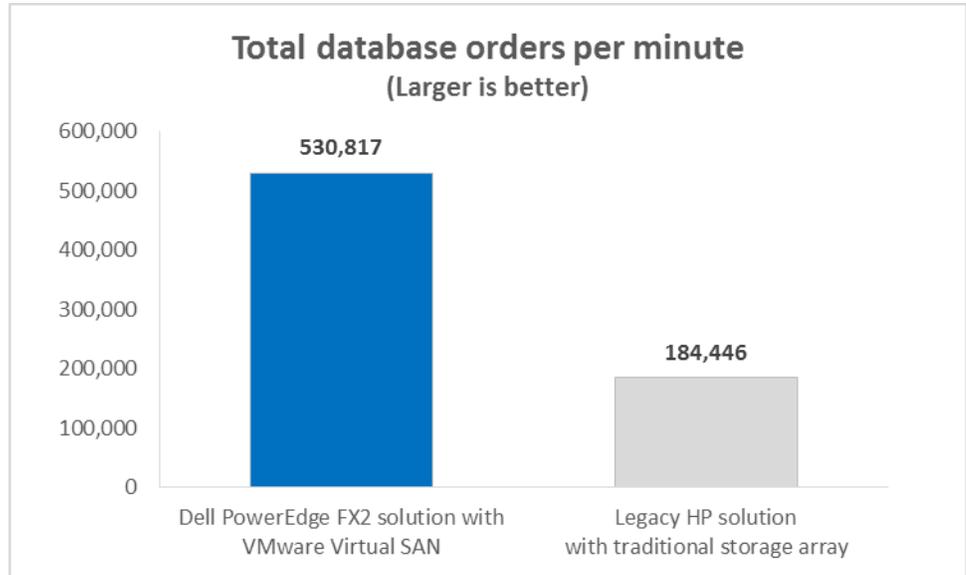
WHAT WE FOUND

Handle more database operations

Your legacy hardware may be a great fit for your current or former workloads, but different workloads tax different datacenter resources, so your legacy hardware might not deliver peak database performance compared to today's high standards. Combining Dell PowerEdge FC430 servers with Intel Xeon processors, Intel SSDs, and VMware Virtual SAN into the Dell PowerEdge FX2 chassis delivered 2.8 times the database orders per minute (OPM) of the legacy HP solution with a traditional storage array (see Figure 1).¹ The FX2 solution delivered over 345,000 more OPM from the same number of servers as the legacy HP solution.

¹ See [Appendix A](#) for more about our solution, [Appendix B](#) for configuration information, [Appendix C](#) for step-by-step testing details, and [Appendix D](#) for detailed results and pricing information.

Figure 1: The Dell PowerEdge FX2 solution delivered 2.8 times the OPM of the legacy HP solution with a traditional storage array.



Handling more OPM can mean applications and users that rely on your databases aren't held back by resource contention—instead, they're working efficiently and doing more.

If your legacy solution components are at or near end-of-life, tweaking your legacy solution by adding more disk trays or faster drives to your external storage array may not be a sensible option. You may end up swapping one bottleneck for another. For example, your storage performance may improve, but your older servers may be too slow to keep up with your updated storage. The resulting solution might not be as fast or as cost efficient as the converged Dell PowerEdge FX2 solution with VMware Virtual SAN for storage.

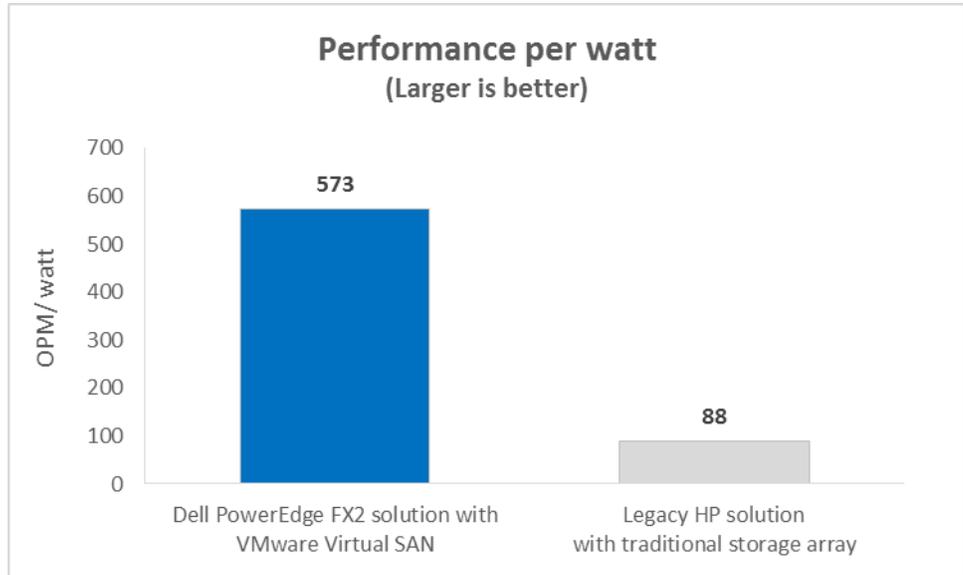
Power efficiency keeps costs down

Datacenters often face power constraints as they grow. This is what makes energy-efficient converged solutions so appealing: they save ongoing costs. The legacy HP solution used older power-hungry servers with a separate traditional storage array, so it used more power than the compact Dell PowerEdge FX2 solution did. We found that the Dell PowerEdge FX2 solution used 55.9 percent less power and was able to deliver 6.5 times the performance per watt (see Figure 2).

More power efficiency yields lower energy costs. The Dell PowerEdge FX2 solution could deliver a savings of more than \$7,000 over three years in power and cooling costs compared to the legacy HP solution.²

² See [Appendix D](#) for details.

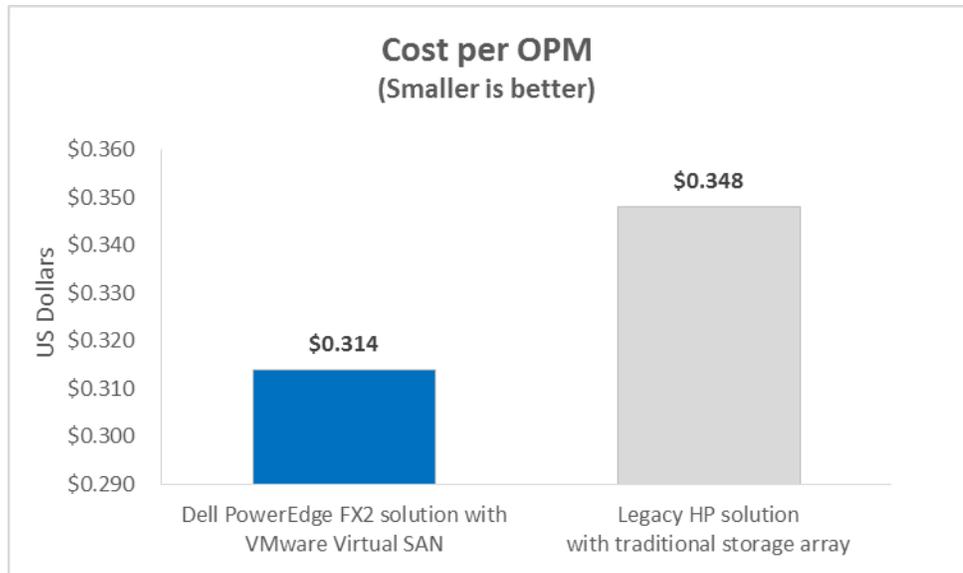
Figure 2: The Dell PowerEdge FX2 solution delivered 6.5 times the performance per watt of the legacy HP solution.



Get more for your dollar

What good is better performance if you can't afford it? Based on our findings, the Dell PowerEdge FX2 solution cost only \$.314 per OPM compared to \$.348 per OPM for the legacy HP solution (see Figure 3).³ Improved performance can help alleviate the costs of refreshing legacy systems.

Figure 3: Our Dell PowerEdge FX2 solution was 9.7 percent more cost efficient than our legacy HP solution.

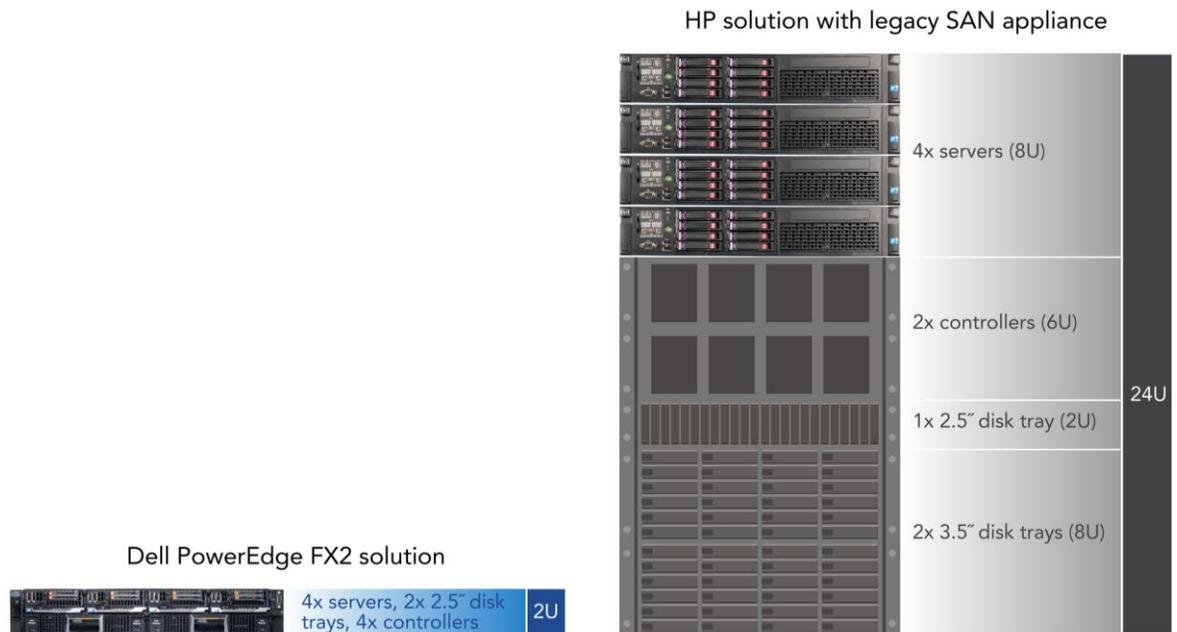


³ See [Appendix E](#) for pricing details.

All-in-one 2U chassis saves on space

Cutting costs can sometimes be as simple as cutting down the size of your infrastructure. Converged solutions can pack more performance into less space—they're designed to use fewer ports and less physical space than traditional architectures, thereby reducing potential future costs as your business grows. As Figure 4 shows, the Dell PowerEdge FX2 solution takes up only 2U—8.3 percent of the rack space that the legacy HP solution occupied (see Figure 4).

Figure 4: The Dell PowerEdge FX2 solution occupied 22 fewer U than the legacy HP solution.



CONCLUSION

Holding onto legacy servers and storage can limit database performance and infrastructure agility along with wasting space and power. The Dell PowerEdge FX2 with VMware Virtual SAN can provide more value for your business, while setting up your datacenter to adapt to changing workloads as business needs fluctuate. In our tests, the PowerEdge FX2 solution outperformed four legacy HP servers and a traditional storage array. It offered 2.8 times the database OPM of the legacy solution while saving over half a rack of datacenter space. It also improved energy efficiency by delivering 6.5 times the performance per watt. Finally, the PowerEdge FX2 solution was more cost efficient, offering a cost per OPM that was 9.7 percent less than the legacy HP solution. The Dell PowerEdge FX2 solution is designed to provide a converged, flexible, and cost-efficient database modernization platform.

APPENDIX A – ABOUT THE COMPONENTS

About the Dell PowerEdge FX2 enclosure

The shared infrastructure approach of the Dell PowerEdge FX2 enclosure is scalable and can help you make the most of your datacenter space while reducing rack space. The Dell PowerEdge FX2 enclosure has a standard 2U footprint and features a modular design that can hold different combinations of compute and storage nodes to meet your specific goals. The PowerEdge FX2 fits four half-width or eight quarter-width compute nodes to increase the compute density in your rack and optimize the space in your datacenter. You can deploy the FX2 solution like a traditional rack-mounted server while gaining the benefits and features that more expensive dense blade solutions provide. Important features of the FX2 enclosure include the following:

- Up to eight low-profile PCIe® expansion slots
- Two networking FN I/O Aggregator modules
- Embedded network adapters within the server nodes
- Offers both chassis-based management through the Chassis Management Controller and rack-based management through Integrated Dell Remote Access (iDRAC) with Lifecycle Controller on each compute node

The Dell PowerEdge FX2 enclosure fits a number of server and storage options, including the PowerEdge FM120, FC430, FC630, and FC830 servers, and PowerEdge FD332 storage node—all powered by Intel Xeon processors. For more information about the Dell PowerEdge FX2 solution, visit www.dell.com/us/business/p/poweredge-fx/pd.

About the Intel Xeon processor E5-2600 v3 product family

According to Intel, the Intel Xeon processor E5-2600 v3 product family “helps IT address the growing demands placed on infrastructure, from supporting business growth to enabling new services faster, delivering new applications in the enterprise, technical computing, communications, storage, and cloud.” It also delivers benefits in performance, power efficiency, virtualization, and security.

The E5-2600 v3 product family has up to 50 percent more cores and cache than processors from the previous generation. Other features include the following:

- Intel Advanced Vector Extensions 2 (AVX2)
- Intel Quick Path Interconnect link
- Up to 18 cores and 36 threads per socket
- Up to 45 MB of last level cache
- Next-generation DDR4 memory support
- Intel Integrated I/O providing up to 80 PCIe lanes per two-socket server
- Intel AES-NI data encryption/decryption

The Intel Xeon processor E5-2600 v3 product family also uses Intel Intelligent Power technology and Per-core P states to maximize energy efficiency. Learn more at www.intel.com/content/www/us/en/processors/xeon/xeon-e5-brief.html.

About VMware Virtual SAN 6

Our solution also used VMware Virtual SAN 6, a software-defined shared storage solution that allows policy-based provisioning of direct-attached storage on server nodes. It automates many manual storage tasks and offers flexibility that lets companies grow their storage environments when they need to. It uses a flash pool as a read/write storage cache, improving the performance of direct-attached disks. This software-defined shared storage solution automates many manual storage tasks such as disk management, storage optimization, and failure tolerance and offers flexibility that lets companies increase storage capacity by adding more SSDs or HDDs to new or existing hosts on the fly.

With VSAN, you can maximize performance using the existing direct-attached storage without having to invest in external storage solutions. Virtual SAN's simple, easy-to-use design has the potential to increase operational efficiency, saving you both time and money. For more information about VMware Virtual SAN, visit www.vmware.com/products/virtual-san.

About the Intel SSD DC S3700 and S3500 Series

Intel designed its SSD Data Center Family to help maximize performance, reduce power consumption, and lower operating costs in the datacenter. Our solution featured 400GB and 800GB 2.5-inch SATA drives (the Intel SSD DC 3700 and DC 3500 Series respectively). According to Intel, our drives were specifically designed for read- and write-intensive storage workloads at predictable rates to deliver smooth datacenter operation.

To learn more about the Intel SSD DC 3700 Series, see www.intel.com/content/www/us/en/solid-state-drives/solid-state-drives-dc-s3700-series.html. To learn more about the Intel SSD DC 3500 Series, see www.intel.com/content/www/us/en/solid-state-drives/solid-state-drives-dc-s3500-series.html.

About our test tool, DVD Store Version 2.1

To create our real-world ecommerce workload, we used the DVD Store Version 2.1 benchmarking tool. DS2 models an online DVD store, where customers log in, search for movies, and make purchases. DS2 reports these actions in orders per minute 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 details about the DS2 tool, see www.delltechcenter.com/page/DVD+Store.

APPENDIX B – SYSTEM CONFIGURATION INFORMATION

Figure 5 provides detailed configuration information for the test systems.

System	Dell PowerEdge FX2 FC430	HP DL380 G7
Enclosure		
Blade enclosure	PowerEdge FX2	N/A
Power supplies		
Total number	2	2
Wattage of each (W)	1,600	750
Cooling fans		
Total number	8	6
General		
Number of processor packages	2	2
Number of cores per processor	12	6
Number of hardware threads per core	2	2
System power management policy	High Performance	High Performance
CPU		
Vendor	Intel	Intel
Name	Xeon	Xeon
Model number	E5-2640 v3	E5-5650
Stepping	M0	B1
Socket type	LGA2011	LGA1366
Core frequency (GHz)	2.30	2.67
Bus frequency	9.6 GT/s	6.4 GT/s
L1 cache	384 KB	192 KB
L2 cache	3 MB	1.5 MB
L3 cache	30 MB	12 MB
Platform		
Vendor and model number	Dell PowerEdge FC430	HP DL380 G7
Motherboard model number	0H05YT	589152-001
BIOS name and version	1.0.1	P67
BIOS settings	Default	Default
Memory module(s)		
Total RAM in system (GB)	128	128
Vendor and model number	Samsung® M393A2G40DB0-CPB	Samsung M393B2G70DB0-YK0
Type	DDR4-2133 PC4-17000	DDR3 PC3L-12800R
Speed (MHz)	2,133	1,600
Speed running in the system (MHz)	2,133	1,600
Size (GB)	16	16
Number of RAM module(s)	8	8
Chip organization	Double-sided	Double-sided

System	Dell PowerEdge FX2 FC430	HP DL380 G7
Operating system		
Name	VMware® vSphere® 6	VMware vSphere 6
Build number	2809209	2809209
Language	English	English
Internal Disks		
Drive Size (GB)	60	144
Drive Type	SSD	15k SAS
Number of Drives	2	2
Vendor and Model Number	LITEON IT EBT-60N9S	EH0146FARWD
RAID controller		
Vendor and model number	Dell PERC FD33xD	HP Smart Array P410i
Network adapter		
Vendor and model number	Broadcom® NetXtreme® II 10 GbE BCM57810	Intel® Ethernet Converged Network Adapter X520-DA2
Vendor and model number	Dell FN410S IO Aggregator	N/A

Figure 5: System configuration information for the test systems.

Figure 6 shows the details of our storage array.

Storage array	Dell PowerEdge FX2 solution with VMware Virtual SAN	Legacy HP solution with traditional storage array
Number of controllers	4	2
RAID level	Automatically managed by VSAN	Dual Parity
Number of 3.5" disk enclosures	0	2
Number of 2.5" disk enclosures	0	1
Number of drives, type 1	4	32
Vendor and model number	Intel® SSD DC S3700 Series	N/A
Drive size (GB)	400	600
Drive type	6Gb SAS SSD	10K, 6Gb SAS HDD
Number of drives, type 2	12	12
Vendor and model number	Intel SSD DC S3500 Series	N/A
Drive size (GB)	800	200
Drive type	6Gb SAS SSD	6Gb SAS SSD

Figure 6: Detailed storage specifications.

APPENDIX C – HOW WE TESTED

Setting up the hardware

Server name	# of servers	Model	Processors	Memory (GB)	Functional role
Infrastructure	1	Intel processor-based server	2 × Intel Xeon E5-2650 v3	128	Infrastructure/DVD Store Clients
FX2+FC430 servers	4	Dell PowerEdge FC430	2 × Intel Xeon E5-2640 v3	128	Dell SUT
HP DL380 Gen7	4	HP ProLiant DL380 Gen7	2 × Intel Xeon E5-5650 v3	128	HP SUT

Figure 7: The servers we used in our testbed.

We installed and configured the latest available version of VMware vSphere 6.0 on the Dell PowerEdge FC430 servers, HP ProLiant DL380 Gen7 servers, and infrastructure server (see Figure 7). For the Dell solution, we created an all-flash VMware Virtual SAN cluster using all four FC430 servers. Then, we configured each FC430 server to access eight disk slots on the assigned FD332 storage node. We only used four disk slots per server to create the VSAN disk groups, leaving the other four slots available for future storage expansion or adding additional VSAN disk groups. We built one VSAN local-disk group per server, and each disk group consisted of one 400GB SSD used as a caching device and three 800GB SSDs used as capacity drives. We also used the default VSAN storage policy, which uses the following settings:

1. Number of failures to tolerate = 1
2. Number of disk stripes per object = 1
3. Object space reservation = 0%
4. Flash read cache reservation = 0%
5. Force provisioning = NO

We configured the HP solution to use a legacy storage array from a leading provider in the industry, and configured one iSCSI datastore using all the available drives on the array. We also created a cache pool based on two 900GB SSDs and enabled the SSD-caching feature provided by the storage array.

On the Dell FX2 solution, we configured a single FN410S IO aggregator for internal switching, which reduced the number of switches, 10Gb ports, and cables needed to run the VSAN cluster. We also used the four physical ports on the same FN410S aggregator to connect all four Dell PowerEdge FC430 servers to a Dell Networking S4820 switch, which provided connectivity between the infrastructure server and the Dell servers under test. The FN410S IO aggregator provides the capability to consolidate the number of physical ports needed down to a single port thanks to cable aggregation technology, but we didn't use that feature. On the HP solution, we configured two Dell Networking S4820 switches—one for storage traffic and the other for test traffic—and installed one dual-port 10Gb network card on each of the four HP ProLiant DL380 Gen7 servers. One port provided connectivity between servers and storage, while the second port provided connectivity between the infrastructure servers and the HP servers under test.

The controllers on the Dell PowerEdge FD332 storage blocks were set up in pass-through/HBA mode to support the VSAN configuration. For all servers under test, we configured the BIOS power performance setting to high performance and installed the hypervisor on internal SSDs in a RAID1 configuration.

For both the Dell and HP solutions, we configured 24 SQL virtual machines, each with 8GB of memory, four vCPUs, and a single 120GB drive for OS, database files, and database logs.

Figure 8 shows the Dell PowerEdge FX2 solution test bed, while Figure 9 shows the HP solution with external legacy storage array.

Dell PowerEdge FX2 with 4x FC430 servers and 2x FC332 storage blocks

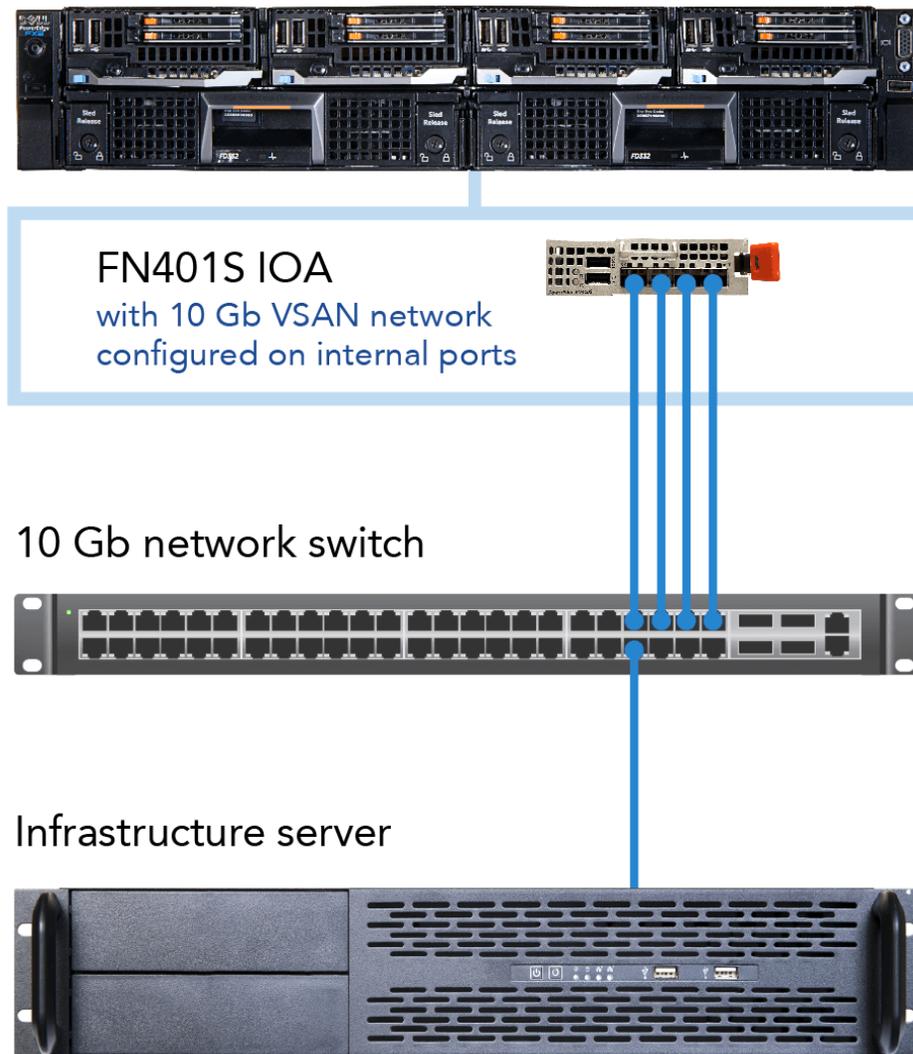


Figure 8: Our testbed for the Dell PowerEdge FX2 solution.

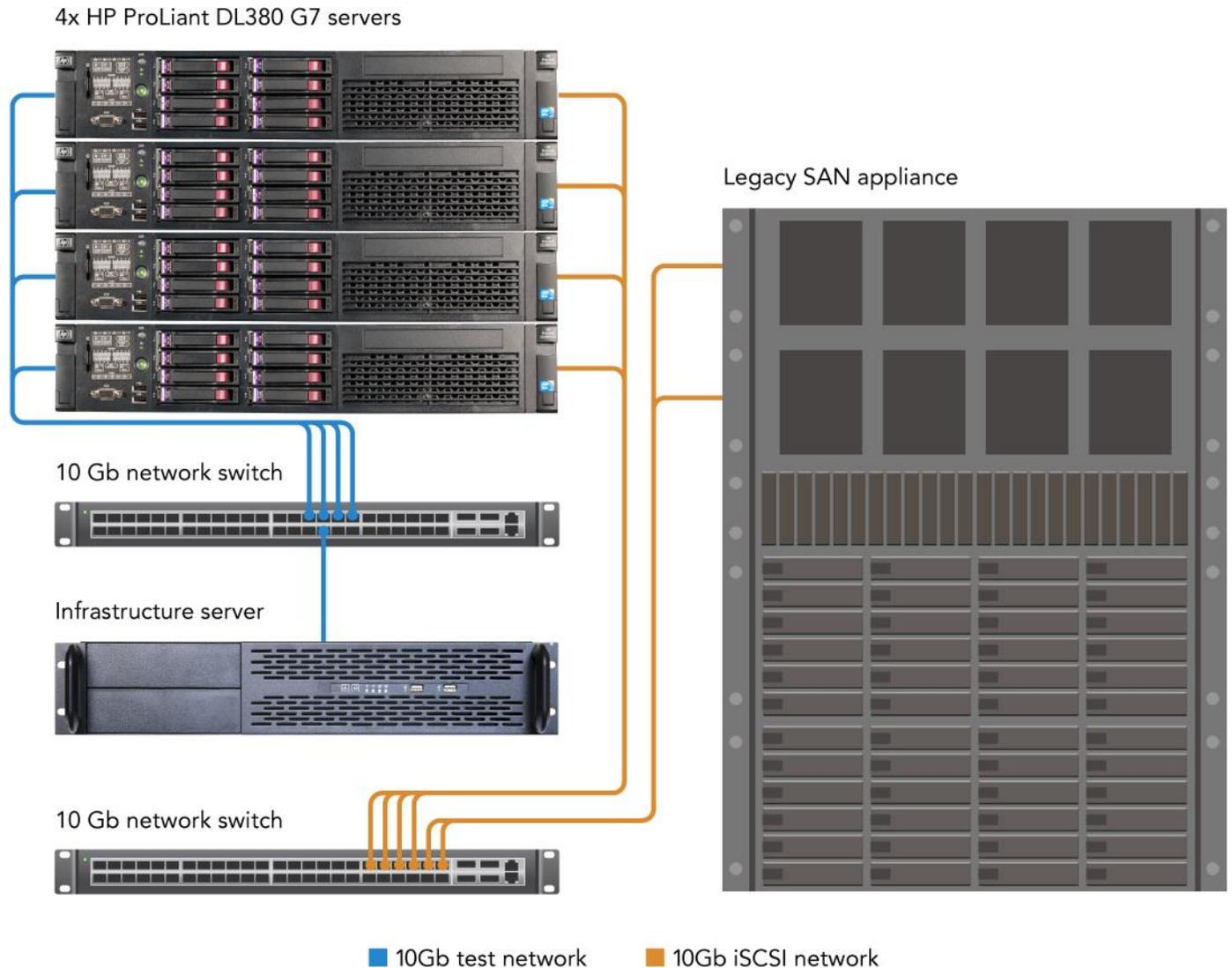


Figure 9: Our testbed for the HP solution with traditional SAN.

Installing VMware ESXi™ 6.0 on the infrastructure servers and servers under test

1. Attach the installation media.
2. Boot the server.
3. At the VMware Installer screen, press Enter.
4. At the EULA screen, press F11 to Accept and Continue.
5. Under Storage Devices, select the appropriate virtual disk, and press Enter.
6. Select US as the keyboard layout, and press Enter.
7. Enter the root password twice, and press Enter.
8. Press F11 to start installation.
9. After the server reboots, press F2 and enter root credentials.

10. Select Configure Management Network, and press Enter.
11. Select the appropriate network adapter, and select OK.
12. Log into the server using the VMware vSphere client.
13. Select the Configuration tab, and click Networking.
14. Click Add Networking...
15. Create the Mgmt_Net network for management.
16. Click Add Networking...
17. Create the PRIV_NET network for private traffic.
18. Click Add Networking...
19. Create the Storage-Net network for storage traffic.
20. Select the configuration tab, and click Storage.
21. Click Add Storage, and add the necessary datastores to all available servers.
22. Click the Configuration tab, and select Time configuration to configure server time.
23. Click DNS and Routing, and confirm the settings.

Creating a Windows Server 2012 R2 VM template for deployment

1. Add the infrastructure server to an existing VMware vCenter™ server's inventory.
2. In the VMware vSphere client, under Basic Tasks, select Create a new virtual machine.
3. Choose Custom, and click Next.
4. Assign the name `template_vm` to the virtual machine, and click Next.
5. Select infrastructure as the host, and click Next.
6. Select the appropriate storage, and click Next.
7. Select Virtual Machine Version 11, and click Next.
8. Select Windows, select Microsoft® Windows Server® 2012 (64-bit), and click Next.
9. For CPUs, select one virtual processor socket and two cores per virtual socket, and click Next.
10. Choose 8 GB RAM, and click Next.
11. Click 1 for the number of NICs, select VMXNET3, connect to the PRIV-NET network, and click Next.
12. Leave the default virtual storage controller, and click Next.
13. Choose to create a new virtual disk, and click Next.
14. Make the OS virtual disk size 120 GB, choose thin-provisioned lazy zeroed, specify external storage, and click Next.
15. Keep the default virtual device node (0:0), and click Next.
16. Click Finish.
17. Right-click the VM, and choose Edit Settings.
18. Click the Resources tab, and click Memory.
19. Select Reserve all guest memory, and click OK.
20. Connect the VM virtual CD-ROM to the Microsoft Windows Server 2012 R2 installation disk.
21. Start the VM.

Installing Microsoft Windows Server 2012 R2 Datacenter Edition

1. When prompted to boot from DVD, press any key.
2. When the installation screen appears, click My language is English (United States).
3. Leave language, time/currency format and input method as default, and click Next.
4. Click Install now.
5. When the installation prompts you, enter the product key.
6. Select Windows Server 2012 R2 Datacenter (Server with a GUI), and click Next.
7. Check I accept the license terms, and click Next.
8. Click Custom: Install Windows only (advanced).
9. Select Drive 0 Unallocated Space, and click Next, at which point Windows begins automatically, and restarts automatically after completing.
10. When the Settings page appears, fill in the Password and Reenter Password fields with the same password.
11. Log in with the password you set up previously.
12. Install VMware Tools. For more information, see kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=340.
13. Reboot the server.

Configuring Windows Update

1. In the left pane of the Server Manager window, click Local Server.
2. In the main frame, next to Windows Update, click Not configured.
3. In the Windows Update window, in the main pane, click Let me choose my settings.
4. Under Important updates, select Never check for updates (not recommended), and click OK.
5. In the left pane, click Check for updates, and install all available updates.
6. Close the Windows Update window.
7. Reboot the server when required.

Converting VM into a template

1. Right-click the VM named "template vm," and select Template.
2. Select Convert to template.

Deploying a VM to host Active Directory® Domain Services

1. Select Inventory→VMs and Templates.
2. Right click the VM named "template vm," and select Deploy Virtual Machine from this Template...
3. Under the name field, enter DC1 and select the infrastructure server as the inventory and host location. Click Next.
4. Select the appropriate storage destination, and click Next.
5. Select Power on this virtual machine after creation.
6. Select Customize using an existing customization specification, and select one. Click Next.
7. Click Finish.
8. After the server reboots, log in using administrator credentials.

9. Click Start→Control Panel→Network Connections→ View network status and tasks→Change adapter settings.
10. Right-click the PRIV-NET NIC, and select Properties.
11. Double click Internet Protocol Version 4 (TCP/IPv4)
12. Select Use the following IP address and set the appropriate IP address, Subnet mask, Default gateway and DNS server.
13. Click OK twice.

Installing Active Directory Domain Services and DNS on DC1

1. Open Server Manager.
2. On the Welcome screen, click manage, and click Add roles and features.
3. At the initial Before you begin screen, click Next three times.
4. At the Server Roles screen, select Active Directory Domain Services.
5. On the pop-up window, click Add Features.
6. Click Next three times.
7. Verify the desired role is being installed, and click Install.
8. Once installation has finished, close the Add roles and features wizard.
9. In Server Manager, click the flag at the top, and select the Promote this server to a domain controller link.
10. Select Add a new forest, enter a root domain name of `test.local` and click Next.
11. On the Domain Controller Options window, enter a password, and click Next.
12. On the DNS Options screen, click Next.
13. On the Additional Options screen, click Next.
14. On the Review Options screen, click Next.
15. On the Prerequisites screen, verify all prerequisites have passed, and click Install.
16. Once Active Directory Domain Services finishes installing, click Finish, and restart the system.

Deploying a VM to host vCenter Server 6.0

1. Select Inventory→VMs and Templates.
2. Right-click the VM named “template vm,” and select Deploy Virtual Machine from this Template...
3. Under the name field, enter `vCenter` and select the infrastructure server as the inventory and host location. Click Next.
4. Select the appropriate storage destination and click Next.
5. Select Power on this virtual machine after creation.
6. Select Customize using an existing customization specification and select one. Click Next.
7. Click Finish.
8. After the server reboots, log in using administrator credentials.
9. Click Start→Control Panel→Network Connections→ View network status and tasks→Change adapter settings.
10. Right-click the PRIV-NET NIC, and select Properties.
11. Double-click Internet Protocol Version 4 (TCP/IPv4).
12. Select Use the following IP address and set the appropriate IP address, Subnet mask, Default gateway and DNS server.

13. Click OK twice.

Installing VMware vCenter 6.0

1. Log into vCenter as `test\administrator`
2. From the VMware vCenter 6 install media, click Autorun.
3. Click Run.
4. Select vCenter Server for Windows, and click Install.
5. At the Install wizard welcome screen, click Next.
6. Accept the End User License Agreement, and click Next.
7. Select embedded deployment as the deployment type, and click Next.
8. Verify the system FQDN, and click Next.
9. Select Create a new vCenter Single Sign-On domain.
10. Enter and confirm the password you wish to use, and click Next.
11. Select Use Windows Local System Account and the service account, and click Next.
12. Select Use embedded database (vPostgres), and Click Next.
13. At the Configure Ports screen, click Next.
14. Accept the default installation path, and click Next.
15. Click Install.
16. Using the vSphere web client, log into the vCenter server using the credentials previously provided.
17. Right-click the root of vCenter, and click New Data center.
18. Name the new datacenter `datacenter`
19. Add the servers under test and infrastructure servers to the datacenter.

Configuring VMware Virtual SAN 6.0

1. Using ESXCLI, flag the SSDs that will be used for data persistence.
2. Log into vCenter via the vSphere Web Client.
3. Add a VMkernel Network Adapter, and enable the Virtual SAN traffic service on the adapter on all servers.
4. Right-click the datacenter, and select New Cluster.
5. Name the cluster `Dell VSAN`, and turn on the Virtual SAN feature.
6. Click OK.
7. Move all four FC430 servers into the cluster.
8. Select the new cluster, and under Manage, select Virtual SAN.
9. Under General, select Edit.
10. Select turn on Virtual SAN, and chose to manually add disks to storage.
11. Select Disk Management, and click the Create a Disk Group icon.
12. Select one 400GB SSD and three 800GB SSDs (now listed as HDDs) to create a disk group per server.
13. Click OK to add the group to VSAN.
14. Repeat steps 9 through 13 to create a total of four disk groups.

Deploying SQL virtual machine

1. Select Inventory→VMs and Templates.

2. Right-click the VM named “template vm,” and select Deploy Virtual Machine from this Template...
3. Under the name field, enter `SQLVM_temp`, and select the infrastructure server as the inventory and host location. Click Next.
4. Select the appropriate storage destination, and click Next.
5. Select Power on this virtual machine after creation.
6. Select Customize using an existing customization specification, and select one. Click Next.
7. Click Finish.
8. After the server reboots, log in using administrator credentials.
9. Click Start→Control Panel→Network Connections→View network status and tasks→Change adapter settings.
10. Right-click the PRIV-NET NIC, and select Properties.
11. Double-click Internet Protocol Version 4 (TCP/IPv4).
12. Select Use the following IP address and set the appropriate IP address, Subnet mask, Default gateway and DNS server.
13. Click OK twice.
14. Power off the server, and from the VM console, select Edit settings...
15. Increase the memory size to 16GB, and change the number of cores per socket to 4. Click OK.

Installing SQL Server 2014 on SQL virtual machine

1. Power on the server.
2. Insert the SQL Server® 2014 installation media into the DVD drive.
3. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2014 DVD, and double-click it.
4. In the left pane, click Installation.
5. Click New SQL Server stand-alone installation or add features to an existing installation.
6. Select the Enter the product key radio button, and enter the product key. Click Next.
7. Click the checkbox to accept the license terms, and click Next.
8. Click Use Microsoft Update to check for updates, and click Next.
9. Click Install to install the setup support files.
10. If no failures are displayed, click Next.
11. At the Setup Role screen, choose SQL Server Feature Installation, and click Next.
12. 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.
13. At the Installation Rules screen, after the check completes, click Next.
14. At the Instance configuration screen, leave the default selection of default instance, and click Next.
15. At the Server Configuration screen, choose NT Service\SQLSERVERAGENT for SQL Server Agent, and choose NT Service\MSSQLSERVER for SQL Server Database Engine. Change the Startup Type to Automatic. Click Next.
16. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.

17. Enter and confirm a password for the system administrator account.
18. Click Add Current user. This may take several seconds.
19. Click Next.
20. At the Error and usage reporting screen, click Next.
21. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click Next.
22. At the Ready to Install screen, click Install.
23. After installation completes, click Close.
24. Close the installation window.
25. Shutdown the virtual machine.

Converting SQL virtual machine into a template

1. Right-click the SQL VM named "SQLVM_temp," and select Template.
2. Select Convert to template.

Deploying SQL virtual machines from the SQL VM template

1. Deploy a total of 24 SQL virtual machines onto each solution using the following VMware vSphere PowerCLI command:

```
1..24 | Foreach {  
  New-vm -vmhost <server_name> -Name SQLVM0$_ -Template SQLVM_temp -  
  Datastore <datastore_name>  
}
```

2. Migrate VMs to the appropriate host using the Migrate feature on vCenter Server.

Configuring the database

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 20GB database size and the database platform we used. We ran the Install.pl script on a utility system running Linux® to generate 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. We built the 20GB database in SQL Server, and then performed a full backup, storing the backup file remotely for quick access. We used that backup file to restore the database when necessary.

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. Other than this file size modification, we created and loaded the database in accordance 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 20GB database, and made the appropriate changes to drive letters.
2. We transferred the files from our Linux data generation system to a Windows system running SQL Server.
3. We created database tables, stored procedures, and objects using the provided DVD Store scripts.

4. We set the database recovery model to bulk-logged to prevent excess logging.
5. We loaded the data we generated into the database. For data loading, we used the import wizard in SQL Server Management Studio. Where necessary, we retained options from the original scripts, such as Enable Identity Insert.
6. We created indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. We updated statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
8. On the SQL Server instance, we created a ds2user SQL Server login using the following Transact SQL (TSQL) script:


```
USE [master]
GO
CREATE LOGIN [ds2user] WITH PASSWORD=N'',
    DEFAULT_DATABASE=[master],
    DEFAULT_LANGUAGE=[us_english],
    CHECK_EXPIRATION=OFF,
    CHECK_POLICY=OFF
GO
```
9. We set the database recovery model back to full.
10. We created the necessary full text index using SQL Server Management Studio.
11. We created a database user, and mapped this user to the SQL Server login.
12. We then performed a full backup of the database. This backup allowed us to restore the databases to a pristine state.

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.

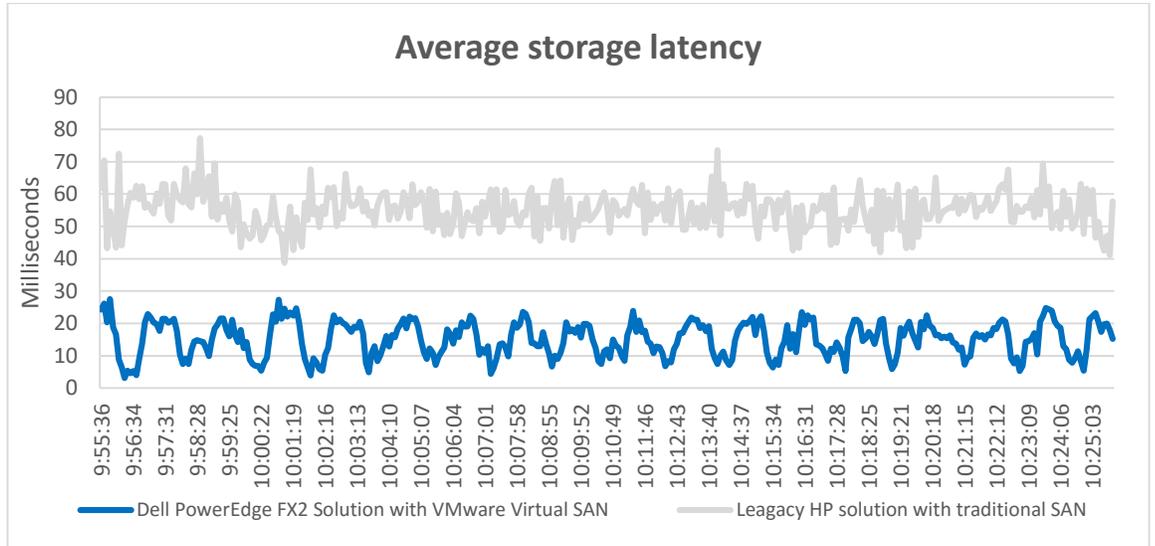
We used the following DVD Store parameters for testing:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=5 --run_time=30 --
n_threads=32 --db_size=20GB --think_time=0.05 --detailed_view=Y --
warmup_time=5 --csv_output=<drive path>
```

APPENDIX D – DETAILED RESULTS

Figure 10 shows the average storage latency for the solutions over the duration of the test. Lower latency means better database response time.

Figure 10: Average storage latency throughout the duration of the test.



APPENDIX E – COSTS AND CALCULATIONS

Hardware and software cost calculations

Figure 11 shows the costs for the two solutions.

	Dell PowerEdge FX2 solution	Legacy HP solution with traditional SAN
Hardware and support cost	\$96,498.00	\$47,028.00
VMware software cost	\$70,248.48	\$17,256.00
Total cost	\$166,746.48	\$64,284.00

Figure 11: Three-year costs for the Dell PowerEdge FX2 and legacy HP solutions.

Hardware and three-year support cost

Dell PowerEdge FX2 solution

We used the list price for the hardware and Dell ProSupport Plus: 3 Year Mission Critical 4Hr On-site Service plans for the chassis, servers, and storage nodes. Dell provided the prices. We used 60GB SSDs as the internal disks of our FC430s in testing, but those drives were no longer available when we received the price quote for the Dell FX2 solution; we instead used 120GB SSDs to calculate pricing.

HP solution with traditional SAN

We used three-year support costs for the HP servers and traditional storage. We assumed the hardware was purchased five years ago, so we did not include purchase costs. For the servers, we used the cost of HP post-warranty 4-hour 24x7 DL380 G7 Proactive Care Service.⁴ For the five-year-old traditional SAN storage, we assumed a support cost of \$10,000 per year, 10 percent of our estimated \$100,000 initial cost of that traditional storage solution.

VMware software cost

Dell PowerEdge FX2 solution

We included CPU-based software costs for VMware vSphere Enterprise,⁵ Virtual SAN 6,⁶ and the VMware Virtual SAN 6 All Flash Add-on.⁷ For the two VSAN products, we included the license purchase. For all three products, we included three-year production support and subscription (SnS) services from VMware. We assumed the vSphere Enterprise licenses from the legacy solution migrated to the Dell solution, which has the same CPU count, so we did not include the purchase price of those licenses. However, we assumed the VSAN licenses were unique to the Dell solution, so we included their purchase price.

HP solution with traditional SAN

This is the cost of three-year production SnS for the vSphere Enterprise licenses. This cost is the same for the two solutions because they each have the same number of processors.

⁴ cpc.hpe.com/portal/site/cpc/details/?serviceProductNumber=U1NH0PE

⁵ www.vmware.com/products/vsphere/pricing.html

⁶ www.vmware.com/company/news/releases/vmw-newsfeed/VMware-Launches-New-Generation-of-Enterprise-Storage---%C2%A0Virtual-SAN-6-and-vSphere-Virtual-Volumes-to-Enable-Mass-Adoption-of-Software-Defined-Storage/1920298 (Support estimated at 22% per year)

⁷ www.virtualizationworks.com/Virtual-SAN.asp#pricing

Cost per OPM calculations

Figure 12 shows the costs and performance measurements to calculate the cost per OPM.

	Dell PowerEdge FX2 solution with VMware Virtual SAN	Legacy HP solution with traditional SAN
Three-year cost	\$166,746.48	\$64,284.00
OPM	530,817	184,446
Cost per OPM	\$0.314	\$0.348

Figure 12: Total three-year cost and total OPM from testing used in our cost per OPM calculation.

Energy cost calculations

For energy cost calculations, we assumed an energy cost of \$0.1069 per kWh.⁸ We assumed the cost to cool the hardware is the same as the cost to power it. We calculated costs for three years, assuming 24-7 usage at the power utilization levels we measured during our testing of the two solutions.

	Dell PowerEdge FX2 solution	Legacy HP solution with traditional SAN
Active watts	927.00	2,099.97
Three-year cost for power and cooling	\$5,212.08	\$11,807.10

Figure 13: Wattage and costs used in our cost per watt calculation.

⁸ Average commercial cost for 12 months ending in July 2015, from US Energy Information Administration monthly report. Data from Table 5.3. Average Retail Price of Electricity to Ultimate Customers (www.eia.gov/electricity/monthly/pdf/epm.pdf).

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