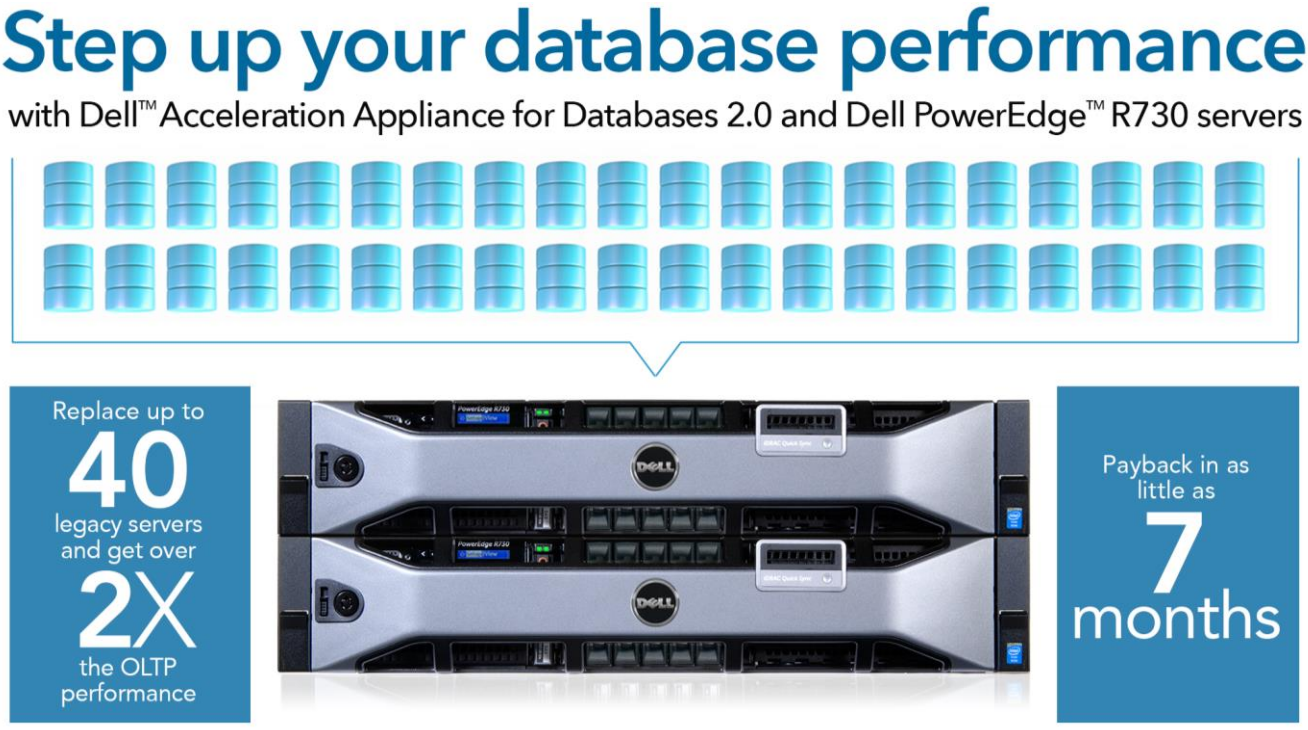
CONSOLIDATE AND SAVE WITH THE DELL ACCELERATION APPLIANCE FOR DATABASES



The right storage solution can help you get greater performance from your databases and save money over time. Upgrading many of your older servers to a highly available solution comprising Dell PowerEdge R730 servers and the Dell Acceleration Appliance for Databases 2.0 (DAAD) can be a simple and cost-effective way to improve your SQL Server 2014 database performance dramatically.

Over time, many organizations develop a server sprawl problem as a result of procuring multiple single-database servers and provisioning them for specific applications. These "siloed" servers may be architectured with only themselves in mind, and not part of a larger infrastructure design. Eventually, the organization must contend with large numbers of servers and low levels of performance.

In the Principled Technologies datacenter, we set out to show the efficiencies gained with DAAD in such situations. We found that two Dell PowerEdge R730 servers in a VMware® vSphere® cluster coupled with the DAAD could run 40 database VMs, each delivering more than twice the performance of a single legacy server. This means that you could replace 40 legacy servers with the Dell solution powered by DAAD—reducing costs for licensing and datacenter space, power, and cooling—all while doubling your database performance.

With such a large consolidation factor, the cost of the DAAD solution is outweighed by the benefits of consolidation. In fact, our total cost of ownership (TCO) analysis shows that if you bought two Dell PowerEdge R730 servers and invested in a highly available DAAD to power virtualized SQL Server 2014 workloads, you could decrease your five-year TCO by as much as 80.7 percent compared to continuing to run legacy HP servers and could achieve payback after only 7 months. This means that the Dell solution has the potential to help your business in two ways: by giving databases a big boost to handle more business as you grow, and by saving you money over the long term, letting you invest in other strategic areas.

SEPTEMBER 2015
A PRINCIPLED TECHNOLOGIES REPORT
Commissioned by Dell Inc.

WHAT'S A DAAD?

The Dell Acceleration Appliance for Databases 2.0 is a pre-integrated server/software/storage combination consisting of one or two Dell PowerEdge R730 servers with Intel® Xeon® processors E5-2667 v3, SanDisk ION Accelerator™ software, and Fusion-io ioMemory™ SX300 drives, which are high-capacity NAND Flash PCIe® SSDs. Available in 12.8TB and 25.6TB capacities, DAAD 2.0 supports Fibre Channel, iSCSI, and InfiniBand®/SRP front-end fabrics. Designed to work with many database platforms and front-end servers, DAAD makes appliance resources available to the application server and uses I/O acceleration to optimize database requests, leveraging DRAM to improve performance. To learn more about the Dell Acceleration Appliance for Databases, visit en.community.dell.com/techcenter/enterprise-solutions/m/oracle_db_gallery/20441362/download.

In this study, we configured one 25.6TB highly available DAAD appliance along with two Dell PowerEdge R730 servers in a highly available VMware vSphere cluster.[1] We measured the total database performance of this configuration and of a single legacy HP ProLiant DL380 G7 server with internal storage. Based on these results, we calculated how many legacy servers in this configuration, the Dell solution with DAAD could replace. We then analyzed the five-year total cost of ownership for the two solutions. For information about the DAAD and our other test components, see Appendix A. For detailed system configuration, see Appendix B. For step-by-step testing details, see Appendix C. For details of our TCO analysis, see Appendix D.

THE BENEFITS OF THE DELL SOLUTION POWERED BY DAAD

Replacing 40 legacy servers with two Dell PowerEdge R730 servers in a VMware vSphere cluster coupled with the DAAD offers many advantages:

- Doubling total database performance
- Using one-tenth of the datacenter space—8U with the DAAD solution versus 80U for the 40 legacy servers
- Reducing power and cooling costs with far fewer servers
- Reducing licensing and support costs due to fewer processor cores
- Minimizing downtime, because the Dell solution is highly available at both the compute layer and the storage layer, and doesn't use legacy hardware

In the scenario we tested, due to all of these factors, a company could recoup its investment in the Dell solution powered by DAAD in as little as 7 months.

[1] To learn about our configuration in detail, see our reference architecture "Dell Acceleration Appliance for Databases and Microsoft SQL Server 2014: A reference architecture" at www.principledtechnologies.com/Dell/DAAD_SQL_Server_2014_reference_architecture_0915.pdf

THE CONFIGURATIONS WE CONSIDERED

Some companies experiencing lagging database performance consider solving the problem by just replacing their aging servers with newer servers. For this reason, we considered not only a legacy solution using internal storage and the Dell solution powered by DAAD, but also an intermediate solution, a single Dell PowerEdge R730 server using internal storage. Figure 1 summarizes the components of the three configurations we tested.

	Legacy solution	Upgraded server	Dell solution powered by DAAD
Server(s)	1 × HP ProLiant DL380 G7	1 × Dell PowerEdge R730	2 × Dell PowerEdge R730
Storage	Internal storage	Internal storage	Highly available DAAD 2.0

Figure 1: Defining the solutions we tested. For more details, see Appendix A and Appendix B.

UPGRADING ONLY THE SERVER

Figure 2 shows what we discovered when we compared the legacy server running a bare-metal instance of SQL Server with the new Dell PowerEdge R730 running the same workload in two virtual machines. The PowerEdge R730 was able to run two VMs at roughly the same performance level as the legacy server, which means it could replace two legacy servers while providing more than twice the database performance. While an improvement, this increase of 121.4 percent may not necessarily be sufficient to justify the expense of new servers. In this case, the performance of the new server is still hampered by the limited I/O capabilities of a server using traditional spinning-disk storage.

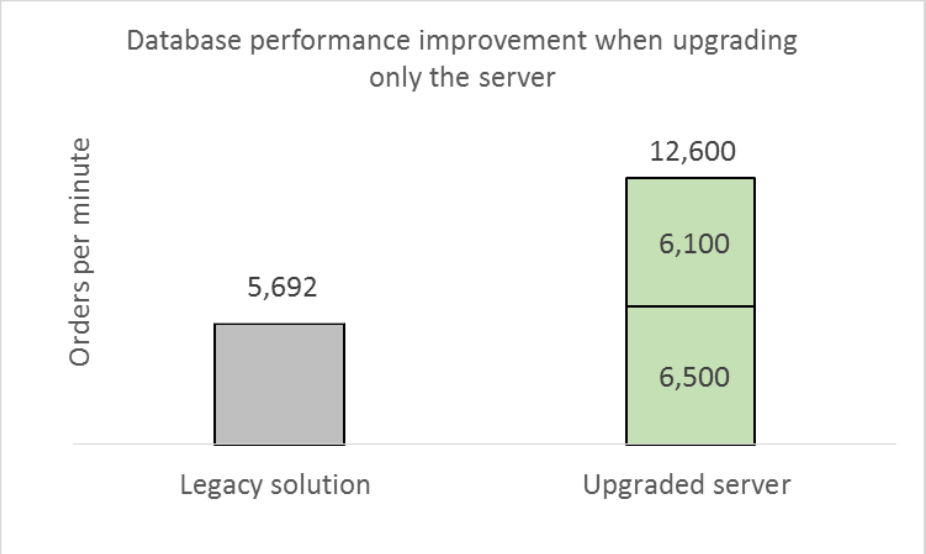


Figure 2: Upgrading the server in our legacy configuration to a new Dell PowerEdge R730 boosted total database performance by 121.4 percent.

UPGRADING THE SERVER AND THE STORAGE

Next, we created a cluster of two Dell PowerEdge R730 servers for our virtual machines and used the DAAD for storage to see how much that could improve SQL Server 2014 performance over the two configurations using internal storage. Because the Dell PowerEdge R730s each had 20 cores, we had 40 cores total to work with, so we chose to run 40 VMs, each using one vCPU per VM so as not to oversubscribe our compute resources.

We found that each of the 40 VMs in the DAAD solution delivered an average of 11,705 database orders per minute, more than twice the 5,692 OPM that a single bare-metal database instance on the legacy server delivered.

In Figure 3, we present the actual performance results of the 40 VMs in the Dell solution powered by DAAD and extrapolate the results of the legacy server we tested. As it shows, using the DAAD in conjunction with a cluster of newer servers could replace 40 legacy servers while delivering more than twice the total database performance. (We report results from the median of three runs. For details on our testing procedure, see Appendix C.)

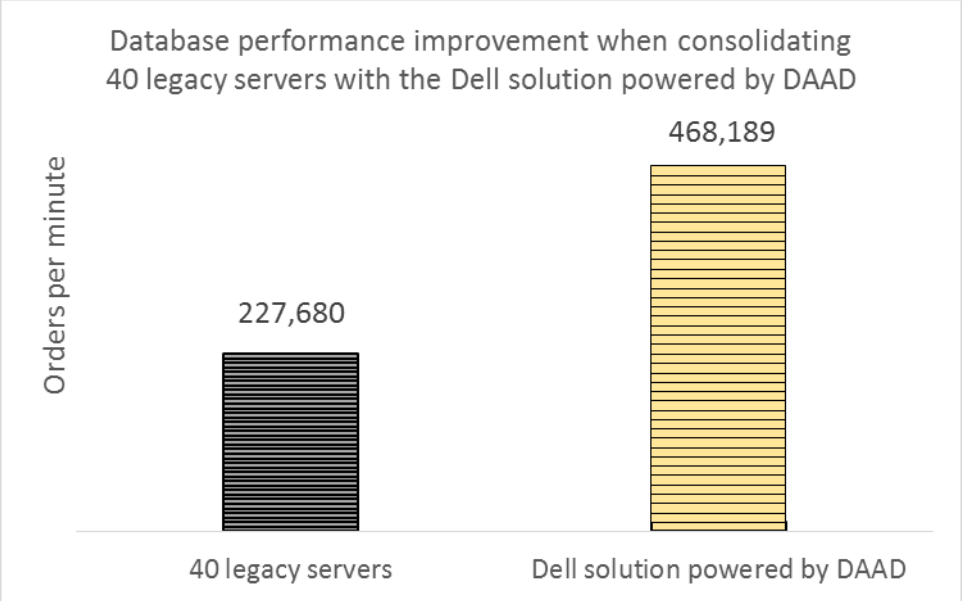


Figure 3: Consolidating with 40 VMs on two Dell PowerEdge R730 servers in conjunction with a new DAAD delivered more than twice the database orders per minute in SQL Server 2014 workloads in total than the 40 legacy servers would.

Adding up the costs

High-performance storage can be costly, but we found that investing in the DAAD and two new Dell PowerEdge R730 servers could actually reduce your five-year TCO compared to sticking with the legacy solution. Because you can consolidate 40 legacy servers running SQL Server Enterprise Edition, you can save up to 80.7 percent (see Figure 4) compared to running legacy servers with internal storage.

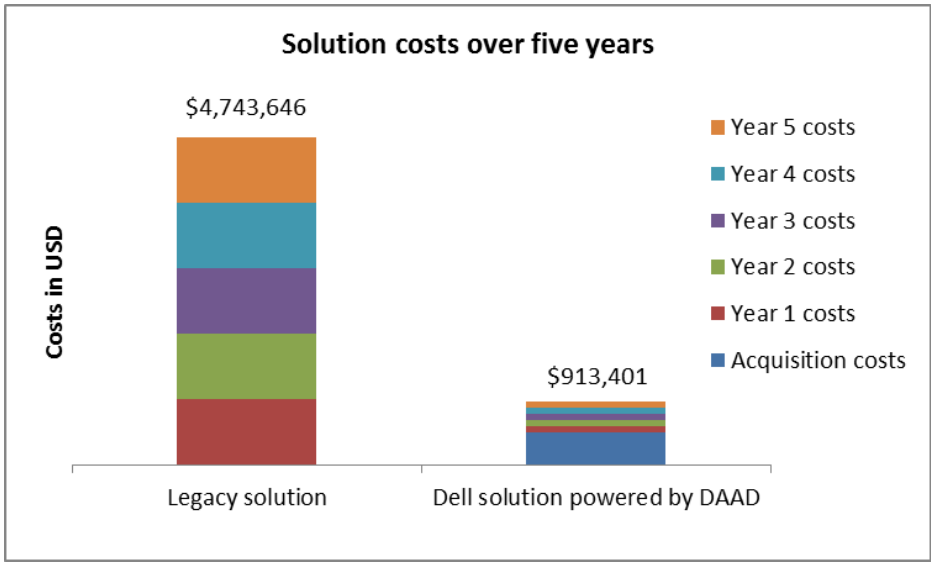


Figure 4: Consolidating multiple legacy HP ProLiant DL380 G7 servers onto the all-Dell solution powered by DAAD could net you savings of 80.7 percent over the next five years.

As Figure 5 shows, these savings mean that you could see a return on your initial hardware investment in only 7 months when you consolidate legacy database workloads onto a Dell PowerEdge R730 cluster with DAAD.

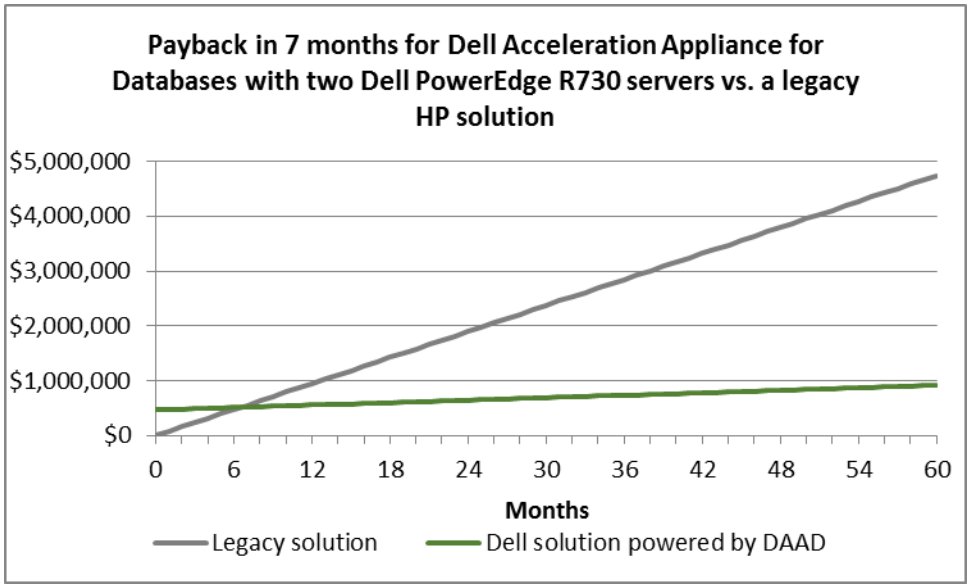


Figure 5: Consolidating onto a Dell PowerEdge R730 cluster with DAAD could give you a return on your investment in 7 months.

These savings are possible due to the ability of the Dell solution to consolidate a large number of legacy servers, avoiding the heavy licensing and software assurance costs of supporting physical servers. For a list of all our TCO assumptions and calculations, see Appendix D.

CONCLUSION

As our performance testing and TCO analysis show, continuing to run your SQL database workloads on older servers can be very expensive. Investing in the highly available Dell Acceleration Appliance for Databases 2.0 and a two-node cluster of Dell PowerEdge R730 servers would allow you to replace 40 older servers. You would see a dramatic savings on datacenter space, power and cooling, and licensing, and would see your total database performance more than double.

Thanks to its ability to consolidate the workloads of so many older servers, the Dell solution could make a great deal of financial sense, offering a return on your investment in only 7 months and delivering a five-year TCO that is one-fifth of that of continuing to run legacy servers.

APPENDIX A – ABOUT THE COMPONENTS

About the Dell Acceleration Appliance for Databases 2.0 hardware

The 2U Dell PowerEdge R730 rack servers used in the highly available DAAD configuration are each powered by two Intel Xeon processors E5-2667 v3, 384 GB of DDR4 RAM, and QLogic® QLE2662 16Gb Fibre Channel HBAs, providing functional flexibility in the datacenter. The Dell PowerEdge R730 rack servers are each powered by four 6,400 GB SanDisk® Fusion ioMemory SX300 PCIe SSDs to reduce storage bottlenecks.

With redundant power supply units, hot-swappable hardware, and a Dual SD™ card option for Failsafe Hypervisors, the Dell PowerEdge R730 supports hardware high availability. The PowerEdge R730 comes standard with iDRAC8 with Lifecycle Controller and Dell OpenManage™, which all work to streamline management. For more details on the Dell PowerEdge R730, visit www.dell.com/us/business/p/poweredge-r730/pd. For more details on the Intel Xeon processor E5-2600 v3 series, visit www.intel.com/content/dam/www/public/us/en/documents/product-briefs/xeon-e5-brief.pdf.

About the benchmark, DVD Store 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 6 provides detailed configuration information for the test systems.

System	HP ProLiant DL380 G7 (1)	Dell PowerEdge R730 (2)	Dell Acceleration Appliance for Databases
Power supplies			
Total number	2	2	2
Vendor and model number	HP DPS-750RB A	Dell 0G6W6KX02	Dell 0G6W6KX02
Wattage of each (W)	750	750	750
General			
Number of processor packages	2	2	2
Number of cores per processor	6	10	8
Number of hardware threads per core	2	2	2
System power management policy	Performance	Performance	Performance
CPU			
Vendor	Intel	Intel	Intel
Name	Xeon	Xeon	Xeon
Model number	X5650	E5-2650 v3	E5-2667 v3
Socket type	LGA 1366	FCLGA2011-3	FCLGA2011-3
Core frequency (GHz)	2.67	2.3	3.2
Bus frequency	6.4 GT/s	9.6 GT/s	9.6 GT/s
L1 cache	32 + 32 KB (per core)	32 + 32 KB (per core)	32 + 32 KB (per core)
L2 cache	256 KB (per core)	256 KB (per core)	256 KB (per core)
L3 cache	12 MB	25 MB	20 MB
Platform			
Vendor and model number	HP ProLiant DL380 G7	Dell PowerEdge R730	Dell PowerEdge R730
Motherboard model number	82801JR	0599V5	0599V5
BIOS name and version	P67	1.2.10	1.1.4
BIOS settings	Defaults	Defaults	Defaults
Memory module(s)			
Total RAM in system (GB)	12	256	384
Vendor and model number	Samsung® M393B5673FH0-CH9Q5	Samsung M386A4G40DM0-CPB	Hynix HMA42GR7MFR4N-TFT1
Type	PC3-10600R	PC4-17000	PC4-17000
Speed (MHz)	666	2,133	2,133
Speed running in the system (MHz)	666	2,133	2,133
Size (GB)	2	32	16

System	HP ProLiant DL380 G7 (1)	Dell PowerEdge R730 (2)	Dell Acceleration Appliance for Databases
Number of RAM module(s)	6	8	24
Chip organization	Double-sided	Double-sided	Double-sided
Rank	2Rx8	2Rx4	2Rx4
Operating system			
Name	Windows Server® 2012 R2 Standard Edition	VMware® ESXi™ 5.5	ION Accelerator (SUSE® Linux® Enterprise Server)
Build number	9600	2068190	2.5.1-413
Language	English	English	English
RAID controller			
Vendor and model number	HP Smart Array P410i Controller	Dell PERC H730P Mini	Dell PERC H730P Mini
Firmware version	6.64	25.2.1.0037	25.2.1.0037
Cache size (GB)	1	2	2
RAID configuration	1 × RAID10	1 × RAID10	1 × RAID10
Hard disk types			
Hard disks (OS)			
Vendor and model number	HP EG0146FAWHU	Dell ST9300653SS	Dell ST300MM0006
Number of disks	8	8	2
Size (GB)	146	300	300
RPM	10K	15K	10K
Type	SAS	SAS	SAS
PCIe SSDs			
Vendor and model number	N/A	N/A	Fusion ioMemory SX300
Number of disks	N/A	N/A	4
Size (GB)	N/A	N/A	6,400
Type	N/A	N/A	PCIe
Ethernet adapters			
Vendor and model number	HP NC382i DP Multifunction Gigabit Server Adapter	Intel I350-t Network Daughter Card	Broadcom® NetXtreme® BCM5720 Quad-port Gigabit
Firmware	4.1.0.4	7.10.18	7.10.18
Type	On-board	PCIe	PCIe
Fibre Channel adapters			
Vendor and model number	QLogic QLE2672 16Gb Fibre Channel Adapter	QLogic QLE2672 16Gb Fibre Channel Adapter	QLogic QLE2672 16Gb Fibre Channel adapter
Firmware	03.11.09	03.11.09	03.11.09
Type	PCIe	PCIe	PCIe

System	HP ProLiant DL380 G7 (1)	Dell PowerEdge R730 (2)	Dell Acceleration Appliance for Databases
USB ports			
Number	4	4	4
Type	USB 2.0	USB 2.0	USB 2.0

Figure 6: Configuration information for the test systems.

APPENDIX C – HOW WE TESTED

Configuring the legacy solution

Prior to installing Windows® on the HP DL380 G7 server, we created a two-disk RAID1 for the operating system, a four-disk RAID10 for the database files, and a two-disk RAID1 for the database logs. We then connected the HP server to the local network for access by the DVD Store client server.

Figure 7 shows how we set up the legacy solution.

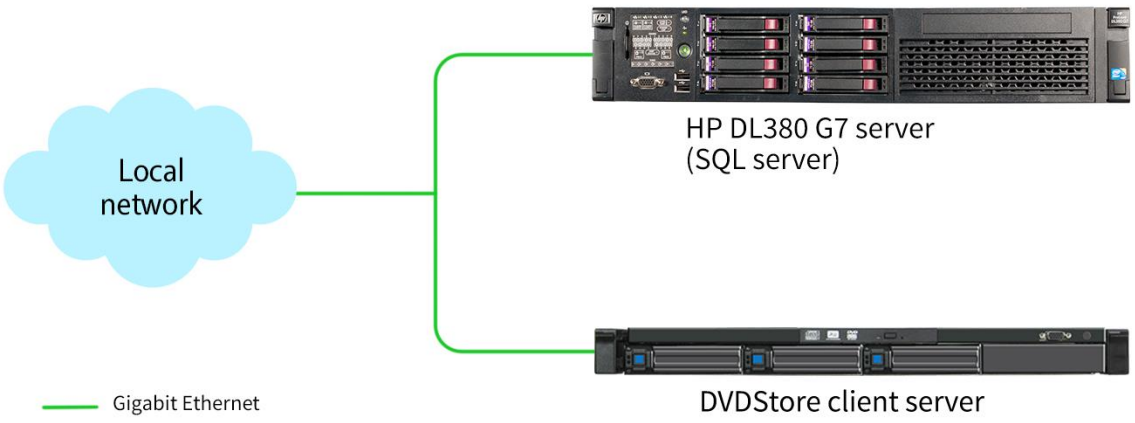


Figure 7: The testbed diagram for the legacy solution.

Installing Microsoft® Windows Server 2012 R2 Standard Edition

1. Insert the installation USB drive into the rear USB 3.0 port, and restart the server.
2. When the option appears, press F11 to enter the Boot Manager.
3. Select BIOS Boot Menu.
4. Select the USB drive, and press Enter.
5. Press any key when prompted to boot from DVD.
6. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
7. Click Install now.
8. When the installation prompts you, enter the product key.
9. Select Windows Server 2012 R2 Standard Edition (Server with a GUI), and click Next.
10. Check I accept the license terms, and click Next.
11. Click Custom: Install Windows only (advanced).
12. Select Drive 0 Unallocated Space, and click Next, at which point Windows begins automatically, and restarts automatically after completing.
13. When the Settings page appears, fill in the Password and Reenter Password fields with the same password.
14. Log in with the password you set up previously.

Installing .NET Framework 3.5

1. Click Start→Server Manager→Manage→Add Roles and Features.
2. Select Role-based or feature-based installation, and click Next.
3. Select the local server under Server Pool, and click Next twice.
4. Under Features, select .NET Framework 3.5 Features, and click Next.
5. Click Install.
6. Click Close upon completion.
7. Reboot the server.
8. When the server has rebooted, press Windows + X, and click Disk Management.
9. Right-click the first unallocated disk, and click Online.
10. Right-click the same disk, and click Initialize Disk.
11. Click OK.
12. Right-click the right side of that disk's row, and click New Simple Volume.
13. Click Next.
14. Click Next.
15. Provide a drive letter, and click Next.
16. Provide a volume label, and click Next.
17. Click Finish.
18. Repeat steps 9 through 17 for the other disk.

Installing Microsoft SQL Server 2014

1. Insert the installation DVD for SQL Server 2014 into the DVD drive.
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2014 DVD, and double-click.
3. If the installer prompts you with a .NET installation prompt, click Yes to enable the .NET Framework Core role.
4. In the left pane, click Installation.
5. Click New installation or add features to an existing installation.
6. At the Setup Support Rules screen, wait for the check to complete. If there are no failures or relevant warnings, click OK.
7. Select the Evaluation edition, and click Next.
8. Click the checkbox to accept the license terms, and click Next.
9. Click Install to install the setup support files.
10. If there are no failures displayed, click Next. You may see a Computer domain controller warning and a Windows Firewall warning. For now, ignore these.
11. At the Setup Role screen, choose SQL Server Feature Installation.
12. At the Feature Selection screen, select Database Engine Services, Full-Text Search, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools – Basic, and Management Tools – Complete. Click Next.
13. At the Installation Rules screen, once the check completes, click Next.

14. At the Instance configuration screen, leave the default selection of default instance, and click Next.
15. At the Disk space requirements screen, click Next.
16. 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 SQL Server Agent Startup Type to Automatic. Click Next.
17. On the Data Directories tab, enter the sql directories of the data and logs volumes created earlier.
18. At the Database Engine Configuration screen, select Mixed Mode.
19. Enter and confirm a password for the system administrator account.
20. Click Add Current user. This may take several seconds.
21. Click Next.
22. At the Error and usage reporting screen, click Next.
23. At the Installation Configuration rules screen, check that there are no failures or relevant warnings, and click Next.
24. At the Ready to Install screen, click Install.
25. After installation completes, click Close.
26. Download and install Cumulative Update 6 for SQL Server 2014 at support.microsoft.com/en-us/kb/3031047.

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.

Configuring the Dell PowerEdge R730 and DAAD solution

Here, we configure the DAAD's storage volumes, evenly distributing eight volumes across the two DAAD nodes. We then create an initiator group and attach the DAAD's volumes to it for presenting to the Dell PowerEdge R730 servers. Next, we install VMware vSphere 5.5 on the R730s, create a cluster, and deploy VMs running Windows Server 2012 R2 and SQL Server 2014, using the DAAD volumes as backing storage.

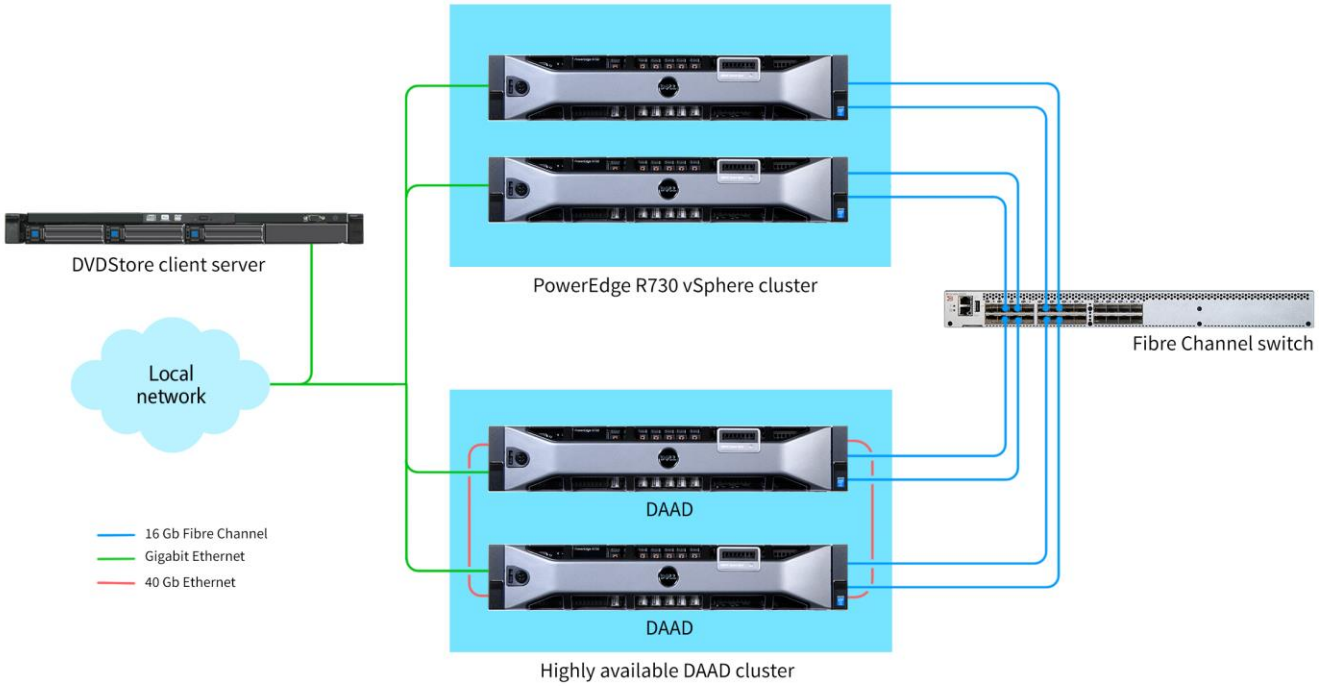


Figure 8: The testbed diagram for the Dell solution.

Setting up storage on the DAAD for the Dell PowerEdge R730 cluster

1. In a terminal, ssh into one of the DAAD nodes with the admin credentials.
2. Enter the following commands to create mirrored volumes across the DAAD nodes, an initiator group, and then eight LUNs to be presented to the ESXi cluster hosts.

```
profile:create direct
volume:create -n ion01 -n ion02 fcion_v_a1 50% jbod_pool-1
volume:create -n ion02 -n ion01 fcion_v_a2 100% jbod_pool-1
volume:create -n ion01 -n ion02 fcion_v_b1 50% jbod_pool-2
volume:create -n ion02 -n ion01 fcion_v_b2 100% jbod_pool-2
volume:create -n ion01 -n ion02 fcion_v_c1 50% jbod_pool-3
volume:create -n ion02 -n ion01 fcion_v_c2 100% jbod_pool-3
volume:create -n ion01 -n ion02 fcion_v_d1 50% jbod_pool-4
volume:create -n ion02 -n ion01 fcion_v_d2 100% jbod_pool-4
inigroup:create ig_all 20:01:00:0e:1e:09:d6:1c 20:01:00:0e:1e:09:d6:1d
20:01:00:0e:1e:09:d6:2c 20:01:00:0e:1e:09:d6:2d
lun:create fcion_v_a1 ig_all -b 512 -a
lun:create fcion_v_a2 ig_all -b 512 -a
lun:create fcion_v_b1 ig_all -b 512 -a
lun:create fcion_v_b2 ig_all -b 512 -a
lun:create fcion_v_c1 ig_all -b 512 -a
lun:create fcion_v_c2 ig_all -b 512 -a
```

```
lun:create fcion_v_d1 ig_all -b 512 -a
lun:create fcion_v_d2 ig_all -b 512 -a
```

Installing vSphere 5.5

We installed VMware vSphere 5.5 for each R730 server on local drives in a RAID 5 configuration.

1. Connect a USB DVD drive with the vSphere 5.5 installation disk or media, and boot the server.
2. On the Welcome screen, press Enter.
3. On the End User License Agreement (EULA) screen, press F11.
4. On the Select a Disk to Install or Upgrade Screen, select the virtual drive to install vSphere on, and press Enter.
5. On the Please Select a Keyboard Layout screen, press Enter.
6. On the Enter a Root Password Screen, assign a root password and confirm it by entering it again. Press Enter to continue.
7. On the Confirm Install Screen, press F11 to install.
8. On the Installation complete screen, press Enter to reboot.

Creating a datacenter and cluster

We used VMware vCenter Server 5.5 to import and configure our storage, and then to create and manage our test VMs.

1. In a web browser on a computer on the same subnet as the vCenter™ server, enter the vCenter server IP address in the address bar, and press Enter.
2. Provide the administrator credentials, and log into the vSphere Web Client.
3. In the left pane, navigate to the vCenter Server.
4. In the main pane, click Create Datacenter.
5. Provide a name, and click OK.
6. When the datacenter is created, in the main panel, click Add a host.
7. Enter the management IP address of the first R730, and click Next.
8. Provide the root credentials for the first R730, and click Next.
9. When prompted with a message about trusting the host, click Yes.
10. Click Next.
11. On the Assign License page, use the no-license option for Evaluation Mode, and click Next.
12. Click Next.
13. On the VM Location page, select the appropriate datacenter, and click Next.
14. Click Finish.
15. In the left pane, navigate to the datacenter again, and repeat steps 6 through 14 for the second Dell PowerEdge R730.
16. Navigate to the datacenter again, and click Create a cluster.
17. Provide a name, and click OK.

18. Right-click the first Dell PowerEdge R730 in the Hosts tab, and click Move To.
19. Choose the newly-created cluster, and click OK.
20. Repeat steps 18 and 19 for the second Dell PowerEdge R730.

Configuring the host network adapters

1. In the left pane, navigate to the Hosts menu, and click the first Dell PowerEdge R730 host.
2. In the Manage tab, select the Networking page.
3. Select Virtual switches, and click the Add host networking button.
4. In the menu that appears, select Virtual Machine Port Group for a Standard Switch, and click Next.
5. Select New standard switch, and click Next.
6. Select Active adapters, and click the Add button.
7. Select the network adapter to be associated with the private network virtual switch, and click OK.
8. Click Next.
9. Provide an appropriate network label, and be sure to use the same one for each host. We used `Private Network`.
10. Click Next.
11. At the Ready to complete screen, click Finish.
12. Repeat steps 1 through 11 for the second host.

Configuring the virtual storage adapters

1. In the left pane, navigate to the hosts menu, and click the cluster.
2. In the Related Objects tab, click the Datastores page.
3. Click Add new datastore.
4. When the pop-up appears, click Next.
5. Select VMFS radio button, and click Next.
6. Select one of the Dell PowerEdge R730 hosts, select one of the DAAD LUNs, and provide a name for the datastore. We named our eight datastores `Data1`, `Data2`, `Data3`, `Data4`, `Logs1`, `Logs2`, `Logs3`, and `Logs4`.
7. Click Next.
8. Select VMFS 5, and click Next.
9. Select Use all available partitions, and click Next.
10. Click Finish.
11. Repeat steps 3 through 10 for the remaining seven DAAD LUNs.

Creating the VMs

1. Right-click the first Dell PowerEdge R730 host, and choose New Virtual Machine.
2. Choose Create a new virtual machine, and click Next.
3. Provide a name for the virtual machine, and click Next.

4. Select the first Dell PowerEdge R730 host as a compute resource, and click Next. (We alternated hosts as we cloned out, so the second VM would have the second Dell PowerEdge R730, the third would have the first Dell PowerEdge R730, and so forth.)
5. Select the local datastore, and click Next.
6. Select ESXi 5.5 and later, and click Next.
7. Choose the appropriate guest OS, and click Next.
8. Set the CPU field to 1.
9. Expand the Memory section, and set the RAM to 12 GB.
10. Select the new virtual hard disk, and make sure its location is the appropriate datastore.
11. Set the appropriate SCSI controller type.
12. Add a new Network Adapter, and provide it with the Private Network.
13. Change the New Network's Adapter Type to VMXNET3.
14. For additional virtual disks, select New SCSI Controller in the New device drop-down menu, and click Add.
15. Set the appropriate SCSI controller type. For our testing, we selected VMware Paravirtual.
16. Select New Hard Disk in the New device drop-down menu, and click Add.
17. Configure your virtual drive with the desired size, provisioning type, and location. For our testing, we set this virtual hard disk to have 250 GB of storage, its provisioning to be thick provision eager zeroed, and its location to be on the Data1 datastore.
18. Set its Virtual Device Node to be SCSI(1:0).
19. If needed, configure an additional virtual drive with the desired size, provisioning type, and location. For our testing, we set this virtual hard disk to have 100 GB of storage, its provisioning to be thick provision eager zeroed, and its location to be on the Logs1 datastore. We designated this virtual device node to be SCSI(1:1).
20. Once you have designated all these settings and created the necessary virtual drives, click Next.
21. Review the configuration, and click Finish.
22. Start the VM.
23. Attach the OS installation media to the VM and complete the installation process.
24. Perform the steps outlined earlier for installing and configuring SQL Server 2014 on the VM.
25. Use the clone operation to create 39 more copies of this VM, alternating the host so that the odd-numbered VMs are on the first Dell PowerEdge R730 host, and the even-numbered VMs are on the second Dell PowerEdge R730 host. We also cycled the datastore assignments by VM, so that VM1 had its disks on Data1 and Logs1, VM2 had its disks on Data2 and Logs2, and so forth, continuing like this until cycling back to Data1 and Logs 1 at VM5. Note: You'll need to set static IP addresses on each for DVD Store testing, which we do not outline here.

Configuring the database workload client

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

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 100GB database size and the database platform on which we ran, Microsoft SQL Server 2014. We ran the Install.pl script on a utility system running Linux. The database schema was also generated by the Install.pl script.

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

The only modification we made to the schema creation scripts were the specified file sizes for our database. We deliberately 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 performed the following steps:

1. We generated the data and created the database and file structure using database creation scripts in the DS2 download. We made size modifications specific to our database and the appropriate changes to drive letters.
2. We transferred the files from our Linux data generation system to a Windows system running SQL Server.
3. We created database tables, stored procedures, and objects using the provided DVD Store scripts.
4. We set the database recovery model to bulk-logged to prevent excess logging.
5. We loaded the data we generated into the database. For data loading, we used the import wizard in SQL Server Management Studio. Where necessary, we retained options from the original scripts, such as Enable Identity Insert.
6. We created indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. We updated statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
8. On the SQL Server instance, we created a ds2user SQL Server login using the following Transact SQL (TSQL) script:

```
USE [master]
GO
CREATE LOGIN [ds2user] WITH PASSWORD=N'',
        DEFAULT_DATABASE=[master],
        DEFAULT_LANGUAGE=[us_english],
        CHECK_EXPIRATION=OFF,
        CHECK_POLICY=OFF
GO
```

9. We set the database recovery model back to full.
10. We created the necessary full text index using SQL Server Management Studio.
11. We created a database user and mapped this user to the SQL Server login.

12. We then performed a full backup of the database. This backup allowed us to restore the databases to a pristine state relatively quickly between tests.

Figure 9 shows our initial file size modifications.

Logical name	Filegroup	Initial size
Database files		
Primary	PRIMARY	10 MB
cust1	DS_CUST_FG	20 GB
cust2	DS_CUST_FG	20 GB
cust3	DS_CUST_FG	20 GB
cust4	DS_CUST_FG	20 GB
ind1	DS_IND_FG	16 GB
ind2	DS_IND_FG	16 GB
ind3	DS_IND_FG	16 GB
Ind4	DS_IND_FG	16 GB
ds_misc1	DS_MISC_FG	1 GB
ds_misc2	DS_MISC_FG	1 GB
ds_misc3	DS_MISC_FG	1 GB
ds_misc4	DS_MISC_FG	1 GB
orders1	DS_ORDERS	10 GB
orders2	DS_ORDERS	10 GB
orders3	DS_ORDERS	10 GB
orders4	DS_ORDERS	10 GB
Log files		
ds_log	Not Applicable	50 GB

Figure 9: Our initial file size modifications.

Running the test

Test start and run times

We ran the workloads with two clients per target database. The specific testing parameters we used for the benchmark are included below.

About running the DVD Store tests

We created a series of batch files, SQL scripts, and shell scripts to automate the complete test cycle. DVD Store outputs an orders-per-minute metric, which is a running average calculated through the test. In this report, we report the aggregate OPM reported by the clients for each run.

Each complete test cycle consisted of the general steps listed below.

1. Clean up prior outputs from the target system and the client driver system.
2. Drop the database from the target servers.
3. Restore the database on the target servers.
4. Shut down the target.
5. Reboot the host and client systems.

6. Wait for a ping response from the server under test (the hypervisor system), the client system, and the target.
7. Let the test server idle for 10 minutes.
8. Start the DVD Store driver on each client (two per target database).
   We used the following DVD Store parameters for testing:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30
--n_threads=16 --db_size=100GB --think_time=0.005 --detailed_view=Y --
warmup_time=15 --csv_output=<drive path>
```

APPENDIX D – TCO ANALYSIS

Lower TCO for virtualization backed by DAAD

The HP solution includes the 40 HP servers that our test results show the Dell solution powered by DAAD could replace. In our tests, the Dell solution supported 40 VMs, each running the workload of the HP ProLiant DL380 G7 we tested and in fact providing better performance on each workload. Because the Dell PowerEdge R730s each had 20 cores, we had 40 cores total to work with, we chose to run 40 VMs, each using one vCPU per VM so as not to oversubscribe our compute resources.

We show the cost advantage of migrating to two Dell PowerEdge R730 database servers and a new Dell Acceleration Appliance for Databases for an enterprise that has 40 legacy HP ProLiant DL380 G7 database servers with local storage running SQL Server Enterprise Edition workloads similar to those we tested. The two Dell PowerEdge R730s and a new Dell Acceleration Appliance for Databases would power a VMware vSphere cluster that runs those 40 workloads in individual VMs at a much lower cost.

We calculated the five-year TCO for both arrangements. The greatest savings would be due to the Dell solution powered by DAAD having fewer servers to license and support, decreasing software costs dramatically.

Basic TCO assumptions

- We estimate five-year costs for the two solutions and calculate the months to pay back the initial investment in the Dell solution powered by DAAD.
- Acquisition costs for the Dell solution powered by DAAD include the list price of the Dell PowerEdge R730 servers and the DAAD, the purchase price of the VMware vSphere 5 Standard licenses software needed to support the VMs, and a setup cost. The 40 HP legacy servers have no acquisition costs.
- We include purchase cost of the VMware vSphere 5 Standard licenses required by the Dell solution because the HP legacy solution is running the workloads non-virtualized and would not need those licenses. We assume the enterprise has already purchased Windows Server 2012 R2 Standard edition and Microsoft SQL Server 2014 Enterprise Edition licenses for use on the HP legacy solution and could transfer them to the Dell solution. The enterprise also has a licensed VMware vCenter server.
- The payback calculation compares the operational cost savings of the Dell solution powered by DAAD to the acquisition costs.
- Five-year operating costs include the following:
    - Hardware support from the vendor for the servers in both solutions and for the DAAD in the Dell solution
    - Ongoing support for the licenses each solution uses:
    - Microsoft Software Assurance for the Windows Server 2012 R2 Standard Edition and Microsoft SQL Server licenses for the database servers in each solution
    - VMware basic support for the VMware vSphere 5 Standard licenses and the VMware vCenter Standard licenses that the Dell solution uses
    - Energy costs for powering and cooling each solution, which we calculate based on the peak and idle power measurements we made for the HP server we tested and for the Dell

solution. We assume that it costs the same amount to cool the solution as it does to power it.

- We estimate datacenter space costs for the two solutions at $100 per rack unit per year.
- Estimated costs to manage the platforms in each solution and the VMs in the Dell solution.

TCO summary

Figure 10 shows the costs we included in the TCO analysis.

Five-year costs	Legacy solution	Dell solution powered by DAAD
Acquisition costs (hardware and software purchase, solution setup)	N/A	$465,344
Hardware support (servers and DAAD)	$283,800	$33,755
Software support costs (vSphere and vCenter Server basic support [Dell solution only], Windows Server 2012 R2 Standard Edition, and SQL Server 2014 Enterprise Edition Software Assurance)	$4,085,500	$390,855
Energy costs	$65,114	$9,350
Datacenter space costs	$40,000	$4,000
Staff costs for management (hardware management for both, VM management for Dell only)	$269,232	$10,096
Total	$4,743,646	$913,401

Figure 10: Five-year cost summary for both solutions. (Figures may not sum due to rounding.)

Acquisition costs for the Dell solution powered by DAAD

This includes storage appliance costs and hardware support costs.

- For the Dell solution powered by DAAD, we include the cost of a new 25.6TB highly available DAAD appliance configured for Fibre Channel and two Dell PowerEdge R730 servers, configured as we tested them. Dell provided the prices for the DAAD, and we priced the servers on the Dell online store.
- Software license costs for the Dell solution powered by DAAD are the purchase price of the VMware vSphere 5 Standard licenses for the two dual-processor Dell PowerEdge R730 servers.
- Setup cost is the staff cost to set up the Dell solution powered by DAAD, using a $56.09 an hour estimated hourly cost for a System Administrator II.[2] We estimate setup time at 12 hours based on our experience setting up the unit we used for testing.

[2] System Administrator II average US annual salary plus benefits, as of 6/26/2015: swz.salary.com/salarywizard/Systems-Administrator-II-Salary-Details.aspx?hdcbxbonuse=off&isshowpiechart=true&isshowjobchart=false&isshowsalarydetailcharts=false&isshownextsteps=false&isshowcompanyfct=false&isshowaboutyou=false

Acquisition costs	Dell solution powered by DAAD
Dell Acceleration Appliance for Databases (25.6 TB, 2 node, HA, FC)	$432,247
Dell PowerEdge R730 servers	$28,444
VMware vSphere 5 Standard	$3,980
Setup	$673
Total	**$465,344**

Figure 11: Acquisition costs for the Dell solution. (Figures may not sum due to rounding.)

Ongoing costs (five years)

Hardware support costs

For the Dell solution, hardware support costs include Dell ProSupport™ four-hour 7x24 onsite support for the DAAD and the R730 servers. Dell provided the DAAD support costs; we looked up the prices for the R730 support on the online Dell store. For the HP DL380 G7 solution, we include the cost of the post-warranty Proactive Care Service offered by HP for the servers.[3]

Hardware support costs	Legacy solution	Dell solution powered by DAAD
Server support	$283,800	$8,193
Storage appliance support	N/A	$25,563
Five-year hardware support costs	**$283,800**	**$33,755**

Figure 12: Five-year hardware support costs for both configurations. (Figures may not sum due to rounding.)

Software support costs

For the legacy HP DL380 G7 solution, we include the cost of Microsoft Software Assurance for Windows Server 2012 R2 Standard Edition licenses at a price of $216.50[4] per year for each two-processor server. We also include Software Assurance for 12 Microsoft SQL Server 2014 Enterprise Edition licenses for each server (one per core) at $1,684.25[5] per core per year.

In the DAAD solution, we include an annual cost for VMware vCenter Standard and vSphere 5.5 Standard Basic support. We also include Software Assurance for the same 40 Windows Server licenses as on the legacy solution. These support the 40 VMs the cluster includes (one per pair of VMs for each two-processor server). We include Software Assurance for 40 SQL Server 2014 Enterprise one-core licenses to support the total of 40 cores on the two servers.

	HP DL380 G7 solution	Dell solution powered by DAAD
Windows Server 2012 R2 Standard Edition (Software Assurance)	$43,300	$43,300
Microsoft SQL Server 2014 Enterprise (Software Assurance)	$4,042,200	$336,850
VMware vCenter Standard Basic Support	N/A	$5,245
VMware vSphere 5 Standard Basic support	N/A	$5,460
Five-year software support costs	**$4,085,500**	**$390,855**

Figure 13: Software support costs for both configurations.

[3] One-year post-warranty four-hour 24x7 DL380 G7 Proactive Care Service: cpc.hpe.com/portal/site/cpc/details/?serviceProductNumber=U1NH0PE

[4] Software Assurance for Microsoft Open License Program Level C license (annualized): mla.microsoft.com/default.aspx

[5] Software Assurance for Microsoft Open License Program Level C license (annualized): mla.microsoft.com/default.aspx

Energy costs

We measured the power utilization on an HP DL380 G7 and on the Dell solution powered by DAAD during test runs and while idle. We multiplied the HP power utilization numbers by 40 to estimate energy costs for a 40-server solution. We assume 50 percent active time/50 percent idle time on average for both setups, and assume that the kWh spent on powering the systems is equal to the kWh spent cooling them. We assumed both setups run 24/7 year-round for five years to find the kWh, and multiplied the kWh by an energy cost of 10.7 cents per kWh.[6]

	Legacy solution	Dell solution powered by DAAD
Typical watts (average of idle and active)	6,942	997
Five-year energy cost	**$65,114**	**$9,350**

Figure 14: Power usage and five-year energy cost for power and cooling for the two configurations. Lower numbers are better.

Datacenter space costs

We estimate datacenter space costs at $100 per rack unit per year. The Dell solution powered by DAAD would fill a total of 8U – four for the two nodes of the DAAD and four for the two Dell PowerEdge R730 servers. The 40 2U servers in the HP DL380G7 solution would fill 80U, which is 10 times the space of the Dell solution powered by DAAD.

	Legacy solution	Dell solution powered by DAAD
Datacenter space (number of rack units)	80	8
Five-year datacenter space cost	**$40,000**	**$4,000**

Figure 15: Datacenter space usage and cost for the two configurations. Lower numbers are better.

Management staff costs

We included an estimated one hour per month of hardware maintenance for the Dell solution powered by DAAD, two hours per month for VMware management, and two hours per month per server for the legacy HP servers, priced based on an estimated hourly cost for a System Administrator II.[7]

Staff costs	Legacy solution	Dell solution powered by DAAD
Hours of hardware management (both solutions) and VMware management (Dell solution only)	960	36
Five-year management staff cost	**$269,232**	**$10,096**

Figure 16: Staff costs for two configurations.

[6] Average retail price of electricity to commercial customers previous year ending June, 2015 from www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_3

[7] System Administrator II average US annual salary plus benefits, as of 6/26/2015: swz.salary.com/salarywizard/Systems-Administrator-II-Salary-Details.aspx?hdcbxbonuse=off&isshowpiechart=true&isshowjobchart=false&isshowsalarydetailcharts=false&isshownextsteps=false&isshowcompanyfct=false&isshowaboutyou=false

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