



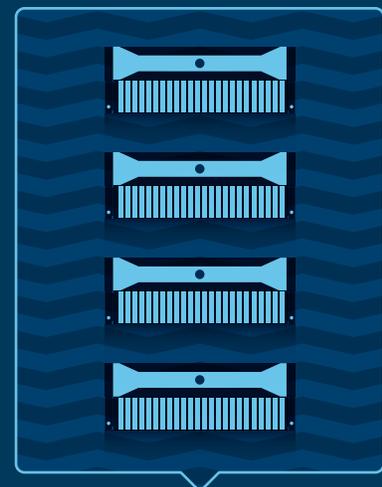
## Consolidate your work and manage datacenter resources efficiently

by upgrading to newer Dell™ PowerEdge™ R730 servers powered by Intel® Xeon® processors E5-2660 v4

If your company hasn't upgraded its servers in the past few years, you could be missing out on key features that can add value to your business. When you already have powerful storage, upgrading to the latest servers can enable you to make full use of your resources. An upgrade could even allow you to consolidate work from several departments onto fewer servers, cutting down on physical space, electricity, and cooling costs.

In our datacenter, we tested a legacy server solution that included a PowerEdge R710 server with Microsoft® Hyper-V®, backed by the powerful Dell Storage SC4020. The legacy server could only handle six virtual machines running Microsoft SQL Server® 2016 before its CPU became saturated, leaving a lot of storage performance on the table. We then upgraded to a PowerEdge R730 server with Hyper-V and Intel Xeon processors E5-2660 v4. We found that the upgraded servers could comfortably do several times the work of the older solution while making better use of the SC4020 storage array.

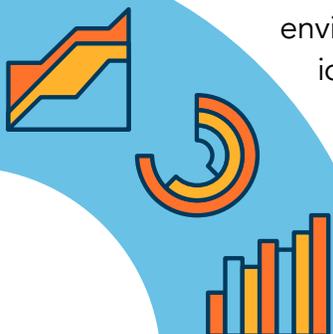
We ran the Dell Performance Analysis Collection Kit (DPACK) to gather information on the performance of the new environment. By running DPACK in your own datacenter, you can characterize your environment's performance and resource utilization and identify bottlenecks for troubleshooting. Then, take a look at the DPACK data for our newer solution to see its performance metrics. In your environment, using DPACK can highlight upgrade opportunities and help you better understand specific performance requirements.



A new Dell PowerEdge R730 solution with Microsoft Hyper-V did

**4X**

the database work of a legacy solution



Get performance data with DPACK

## Are you due for an upgrade?

As time goes on, technology races ever forward. While your current technology may have perfectly suited your needs a few years ago, it's just not feasible to stay ahead in a tech-driven field with aging hardware. New technologies come with features and upgrades that can make your business more organized and efficient. And an efficient datacenter could help your company save money. While older servers do less work and suck up energy and cooling costs, newer servers are able to do the work of multiple legacy solutions. With less space to manage and fewer servers to cool and power, new technologies could help you save every day.

## Keep using your team's familiar tools

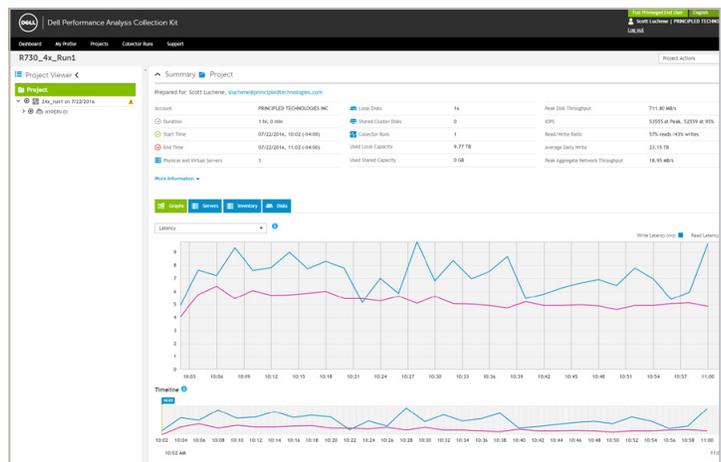
If you use Dell OpenManage™ Essentials (OME) to manage your Dell servers, the new version of OME will let your staff keep a similar workflow. By upgrading to a newer Dell PowerEdge server, your business can harness the benefits of the latest innovations without wasting time and money while your staff learns a new workflow. Your new Intel processor-powered PowerEdge servers will be able to take advantage of the new features in OME. In previous studies, we found that OME helped save time and improved efficiency in datacenter management.<sup>1</sup> These advantages may enable a more straightforward transition from the old hardware to the new.

## Take a look at DPACK

DPACK measures the throughput, disk I/O, memory, capacity, and CPU utilization of your servers and storage. Its reports present this data to help you better understand what hardware you'll need when you upgrade.

You can use the DPACK online viewer to review your results in two ways: Aggregate or Individual results. Aggregate results offer performance data for the full environment, while Individual results provide numbers for a specific server. When we ran DPACK on the new Dell solution, we viewed Aggregate results.

In addition to simply running DPACK in your own environment, you can contact a Dell salesperson who can help you better understand your DPACK results and choose the solution that best fits your needs. Note that we did not test this additional service.



### DVD Store 2

We used DVD Store Version 2.1, or DS2.<sup>2</sup> DS2 is a performance measurement tool that works as a sample SQL Server workload. It models an online store where customers log in, search for products, and make purchases. It also performs other actions, such as adding new customers, to exercise a wide range of everyday database functions.

## How we navigated the path to an upgraded datacenter



Newer servers can bring a wealth of resources and flexibility to a datacenter. And when you have a formidable storage solution like the Dell Storage SC4020, new servers can help you harness more of that storage's power for your business.

In the Principled Technologies datacenter, we measured the performance of a single PowerEdge R710 server using Dell Storage. We then upgraded to an R730, which greatly improved SQL Server performance and made more use of the system's storage array.

### How we tested

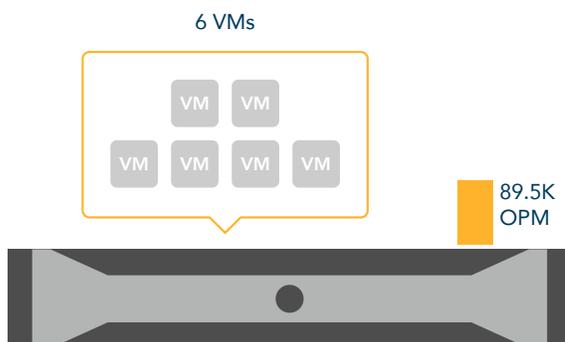
We tested the legacy and upgrade solutions using a SQL Server workload from the benchmarking tool DVD Store 2. For consistency, both solutions used the same SQL Server workload. Since each solution used the same type of Dell Storage array, we wanted to see how newer servers could affect the level of work the storage was able to do. SQL Server workloads are database intensive—so unlike other types of work, SQL Server work means constantly reading and writing to your storage. If your server isn't fast enough to keep up, your storage solution won't be able to unleash its full potential.

We measured performance in the number of operations per minute (OPM) each solution could handle across a number of virtual machines. An upgrade that can do several times the work of a legacy solution could translate to an upgrade that can handle your current work with ease, while still leaving room for your business to grow.

### Our legacy environment

For our legacy test case, we chose a server that a company might have bought five or six years ago. The PowerEdge R710 running SQL Server was able to push 89,560 OPM across 6 VMs (14,926 OPM per VM).

That may have been fine for your business previously, but your organization could benefit from a solution to handle growth and increasing user demand. The solution we tested from Dell and Microsoft could do just that.

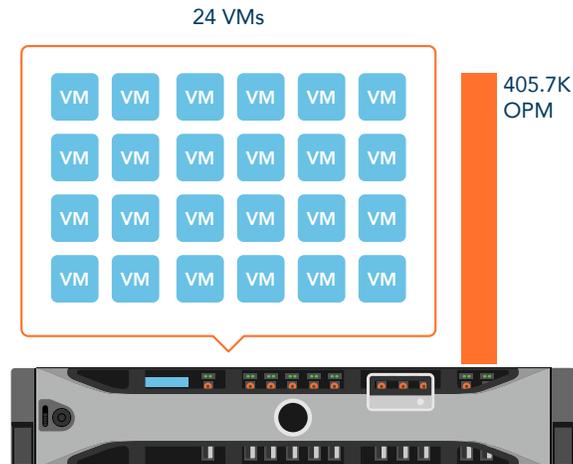


**Virtualization with Microsoft Hyper-V**

If your virtualized server environment doesn't use a hypervisor like Microsoft Hyper-V, your company's datacenter may be wasting its full potential. Hyper-V allows you to run multiple operating systems on a single physical machine, helping to consolidate workloads. Without a means to efficiently allocate resources between servers, your customers might experience delays and frustration on a high-traffic day. In a virtualized cluster environment, your server's workloads are distributed amongst all of the servers within that cluster. This ensures that resources are used efficiently, greatly reducing your risk of costly downtime.

## Our upgraded environment

After seeing modest performance from the R710 server, we moved to an R730 and found that this upgraded solution could run 24 VMs processing 405,718 total OPM (16,904 OPM per VM) before CPU saturation. The newer Intel Xeon processors along with the extra RAM boosted performance significantly—up to 4.5 times that of the legacy server. You could consolidate 4 of your current servers into a single R730, freeing up rack space in your datacenter and creating room for future growth and expansion.



## Conclusion

Your current hardware may have served you well, but upgrading to newer Dell technologies and virtualizing your system can help your business adapt to its growing needs. In our hands-on tests, a single Dell PowerEdge R730 server did the work of 4 PowerEdge R710 servers. Upgrading your own servers to take full advantage of powerful Dell storage can help you save space and power, making for a more efficient datacenter.

One final note on DPACK: If you decide to use the tool on your own environment, you can use our results as a reference. DPACK can help you characterize your datacenter's performance requirements and potential bottlenecks. Use it for yourself and consider how newer PowerEdge R730 servers could improve your business' efficiency and boost your storage performance.



- 1 See the Principled Technologies reports [Systems management savings with Dell OpenManage on 13G Dell PowerEdge servers](#) and [Dell OpenManage Essentials: Improve efficiency with fewer tools, more benefits](#)
- 2 <http://en.community.dell.com/techcenter/extras/w/wiki/dvd-store>

On July 5th, 2016, we finalized the hardware and software configurations we tested. Updates for current and recently released hardware and software appear often, so unavoidably these configurations may not represent the latest versions available when this report appears. For older systems, we chose configurations representative of typical purchases of those systems. We concluded hands-on testing on July 25th, 2016.

## Appendix A - Test systems

Server configuration information	Dell PowerEdge R710	Dell PowerEdge R730
BIOS name and version	Dell 6.4.0	Dell 2.1.7
Non-default BIOS settings	N/A	N/A
Operating system name and version/build number	Windows Server® 2012 R2	Windows Server 2012 R2
Date of last OS updates/patches applied	07/05/16	07/05/16
Power management policy	Performance	Performance

### Processor

Number of processors	2	2
Vendor and model	Intel Xeon E5520	Intel Xeon E5-2660 v4
Core count (per processor)	4	14
Core frequency (GHz)	2.26	2.0
Stepping	D0	M0

### Memory module(s)

Total memory in system (GB)	48	256
Number of memory modules	6	16
Vendor and model	Samsung® M393B1K70DH0-YH9	SK Hynix HMA42GR7MFR4N-TF
Size (GB)	8	16
Type	PC3-10600	PC4-17000
Speed (MHz)	1333	2133
Speed running in the server (MHz)	1333	2133

Server configuration information	Dell PowerEdge R710	Dell PowerEdge R730
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### Storage controller

Vendor and model	Dell PowerEdge RAID Controller (PERC) 6/i	Dell PERC H730P Mini
Cache size	256MB	2GB
Firmware version	6.3.3.0002	25.3.0.0016
Driver version	6.600.21.8	6.606.12.00-1OEM

### Local storage

Number of drives	2	2
Drive vendor and model	Western Digital® WD3000BKHG	Seagate® ST9300653SS
Drive size (GB)	300	300
Drive information (speed, interface, type)	10K, 6Gb SAS, 2.5" HDD	15K, 6Gbps SAS, 2.5" HDD

### Network adapter

Vendor and model	Broadcom® BCM5709C	Intel I350-t rNDC
Number and type of ports	4 x 1GbE	2 x 1GbE
Driver version	7.4.23.2	5.3.0

### Network adapter 2

Vendor and model	Intel Ethernet Server Adapter X520	Intel 82599 10GbE Controller
Number and type of ports	2 x 10GbE	2 x 10GbE
Driver version	3.9.58.9101	3.21.6iov

### HBAs

Vendor and model	N/A	QLogic® QLE2562
Number and type of ports	N/A	2 x 8Gbps Fibre Channel
Driver version	N/A	2.1.24.0-1OEM

Server configuration information	Dell PowerEdge R710	Dell PowerEdge R730
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#### Power supplies

Vendor and model	Dell N870P-S0	Dell N870P-S0
Number of power supplies	2	2
Wattage of each (W)	870	870

The table below provides detailed configuration information for the storage solution.

Storage configuration information	Dell Storage SC4020
Controller firmware revision	6.5.2
Number of storage controller modules	2 x CT-SC4020
Number of drives	24

#### Storage disk 1

Drive vendor and model number	12 x Dell SanDisk® LB1606R
Drive size (TB)	1.6
Drive information (speed, interface, type)	Read-Intensive, 6Gb SAS, SSD

#### Storage disk 2

Drive vendor and model number	12 x Dell SanDisk LB406S
Drive size (GB)	400
Drive information (speed, interface, type)	Write-Intensive, 6Gb SAS, SSD

## Appendix B – How we tested

### Configuring the Hyper-V server

We installed Windows Server 2012 R2 and added Hyper-V support to both the legacy and Dell PowerEdge R730 environments. We performed the same steps on both systems.

#### Installing Windows Server 2012 R2 the Hyper-V server

1. Attach the Windows Server 2012 R2 ISO to the virtual machine.
2. Open the VM console, and start the VM.
3. When prompted to boot from DVD, press any key.
4. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
5. Click Install now.
6. When the installation prompts you, enter the product key.
7. Select Windows Server 2012 Datacenter Edition (Server with a GUI), and click Next.
8. Check I accept the license terms, and click Next.
9. Click Custom: Install Windows only (advanced).
10. Select Drive 0 Unallocated Space, and click Next. This starts Windows automatically, and Windows will restart automatically after completing.
11. When the Settings page appears, fill in the Password and Reenter Password fields with the same password.
12. Log in with the password you set up previously.

#### Configuring NIC teaming

1. Open Server Manager.
2. On the left menu, click Local Server.
3. To open the NIC Teaming menu, beside NIC Teaming, click Disabled..
4. In the bottom right of NIC Teaming, select your two 10 Gb NICs. Then, right-click, and select Add to New Team.
5. Name your NIC team, and click OK.
6. On NIC Teaming menu, click Team Interfaces.
7. Right-click on your new team interface, and select Properties.
8. Select Specific VLAN, and type the VLAN you are using for your testing traffic. Click OK.

#### Installing MPIO

1. Open Server Manager.
2. Select Manage --> Add Roles and Features.
3. In the Add Roles and Features Wizard, click Next..
4. Select role-based or feature-based installation, and click Next.
5. Select your local server, and click Next.
6. In Select server roles, don't select anything, and click Next.
7. In Features, select Multipath I/O, and click Next.
8. In Confirmation, click Install.
9. In Results, click Close.

#### Configuring MPIO

1. Click the Start key. Type MPIO, and hit Enter.
2. Click the Discover Multi-Paths tab.
3. Check the Add support for SAS devices checkbox, and click Add.
4. When the system prompts you to reboot, click Yes.
5. Sign into Windows after it reboots.
6. Click the Start key, and type MPIO, then hit Enter.
7. Click the new storage, and click Add.
8. When prompted to reboot, click Yes.

## Installing Hyper-V

1. Open Server Manager.
2. Select Manage → Add Roles and Features.
3. In the Add Roles and Features Wizard, click Next.
4. Select Role-based or feature-based installation, and click Next.
5. Select your local server, and click Next.
6. In Select server roles, select Hyper-V, and click Next.
7. When prompted to add new features, click Add Features.
8. Click Next.
9. In Features, click Next.
10. In the Hyper-V introduction, click Next.
11. Select your teamed NIC as your Virtual Switch, and click Next.
12. In Migration, click Next.
13. Accept the default Default Stores, and click Next.
14. If necessary, check Restart the destination server automatically.
15. If the system prompts you, select Yes.
16. Click Install.

## Creating the workload virtual machines

We created and cloned out 6 Windows Server 2012 R2 VMs on the legacy environment and 24 Windows Server 2012 R2 VMs on the Dell PowerEdge R730 environment. We installed SQL Server 2016 on both environments. All VMs had the same virtual hardware specifications.

### Creating the base VM

1. Open the Hyper-V Manager.
2. In the right pane, select New → Virtual Machine.
3. In the New Virtual Machine Wizard start page, click Next.
4. Name your virtual machine, check the checkbox labeled Store the virtual machine in a different location, and put the virtual machine on your SAN drive.
5. Click Next.
6. Select Generation 2 as your VM generation, and click Next.
7. Type 6144 in the startup memory box, uncheck Use Dynamic Memory for this virtual machine, and click Next.
8. Select your VM network, and click Next.
9. Select Create a virtual hard disk, change your VHD to 40 GB, and click Next.
10. Select Install an operating system later, and click Next.
11. Review the choices you made, then click Finish.
12. Add new fixed size hard drives to the new VM with the following sizes:
  - Database: 210 GB (CHECK)
  - Log: 60 GB (CHECK)
  - Backup: 60 GB (CHECK)
13. Follow the instructions below to install the guest OS.

### Installing Windows Server 2012 R2 onto VMs

1. Attach the Windows Server 2012 R2 ISO to the virtual machine.
2. Open the VM console, and start the VM.
3. When prompted to boot from DVD, press any key.
4. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
5. Click Install now.
6. When the installation prompts you, enter the product key.
7. Select Windows Server 2012 Datacenter Edition (Server with a GUI), and click Next.
8. Check I accept the license terms, and click Next.
9. Click Custom: Install Windows only (advanced).
10. Select Drive 0 Unallocated Space, and click Next. This starts Windows automatically, and Windows will restart automatically after completing.
11. When the Settings page appears, fill in the Password and Reenter Password fields with the same password.
12. Log in with the password you set up previously.

## Installing SQL Server 2016

1. Attach the installation media ISO for SQL Server 2016 to the VM.
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2016 DVD, and double-click it.
3. In the left pane, click Installation.
4. Click New SQL Server stand-alone installation, or add features to an existing installation.
5. Specify Evaluation as the edition you are installing, and click Next.
6. To accept the license terms, click the checkbox, and click Next.
7. Click Use Microsoft Update to check for updates, and click Next.
8. At the Feature Selection screen, select Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, and Client Tools Backwards Compatibility.
9. Click Next.
10. At the Instance configuration screen, leave the default selection of default instance, and click Next.
11. At the Server Configuration screen, accept defaults, and click Next.
12. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.
13. Enter and confirm a password for the system administrator account.
14. Click Add Current user. This may take several seconds.
15. Click Next.
16. At the Ready to Install screen, click Install.
17. Close the installation window.
18. In the SQL Server Installation Center, click Install SQL Server Management Tools.
19. Click Download SQL Server Management Studio.
20. Click Run.
21. When the Microsoft SQL Server Management Studio screen appears, click Install.
22. When the installation completes, click Close.

## Generating the DVD Store Version 2.1 (DS2) data

We generated the data using the Install.pl script included with DS2 , providing the parameters for our 40GB database size and the Microsoft SQL Server 2014 platform. We ran the Install.pl script on a utility system running Linux® software. The Install.pl script also generated the database schema.

After processing the data generation, we transferred the data and schema creation files to a Windows-based system running SQL Server 2014. We built the 40GB database in SQL Server 2014, then performed a full backup, storing the backup file on the SQL backup LUN for quick access. We used that backup file to restore the server between test runs.

The only modifications 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 test outputs. Apart from this file size modification, we created and loaded the database schema according to the DVD Store documentation. Specifically, we followed the steps below:

1. Generate the data, and create the database and file structure using database creation scripts in the DS2 download. Make size modifications specific to the 20GB database, and make the appropriate changes to drive letters.
2. Transfer the files from a Linux data generation system to a Windows system running SQL Server.
3. Create database tables, stored procedures, and objects using the DVD Store scripts.
4. To prevent excess logging, set the database recovery model to bulk-logged.
5. Load the generated data into the database. For data loading, use the import wizard in SQL Server Management Studio. Where necessary, retain options from the original scripts, such as Enable Identity Insert.
6. Create indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. Update statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
8. On the SQL Server instance, create a ds2user SQL Server login using the following Transact-SQL (T-SQL) 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. Set the database recovery model back to full.
10. Create the necessary full text index using SQL Server Management Studio.
11. Create a database user, and map this user to the SQL Server login.
12. Perform a full backup of the database. This backup allows a restore of the database to a pristine state relatively quickly between tests.

The table below shows our initial file size modifications. *Make sure to check this when your machines are back up.*

Logical name	Filegroup	Initial size (MB)
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Database files

primary	PRIMARY	10
cust1	DS_CUST_FG	20,480
cust2	DS_CUST_FG	20,480
cust3	DS_CUST_FG	20,480
cust4	DS_CUST_FG	20,480
ind1	DS_IND_FG	16,384
ind2	DS_IND_FG	16,384
ind3	DS_IND_FG	16,384
ind3	DS_IND_FG	16,384
ds_misc1	DS_MISC_FG	1,024
ds_misc2	DS_MISC_FG	1,024
ds_misc3	DS_MISC_FG	1,024
ds_misc4	DS_MISC_FG	1,024
orders1	DS_ORDERS	10,240
orders2	DS_ORDERS	10,240
orders3	DS_ORDERS	10,240
orders4	DS_ORDERS	10,240

Log files

ds_log	N/A	51,200
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## Configuring the database workload client

We used a virtual client for the Microsoft SQL Server client. To create the client, we installed Windows Server 2012 R2 and assigned a static IP address. We then copied over the DS2 driver executable and the associated test scripts.

### Running the tests

We ran all three tests simultaneously, using a script to kick off the final step of each of the following methodologies. If necessary, running them manually also works.

### Running the DVD Store test

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 paper, we list the last OPM reported by each client/target pair. Each complete test cycle consisted of general steps:

1. Clean up prior outputs from the target system and the client driver system.
2. Drop the database from the target.
3. Restore the database on the target.
4. Shut down the target.
5. Reboot the system under test and client system.
6. Wait for a ping response from the system under test and the client system.
7. Let the system under test idle for 10 minutes.
8. Start the DVD Store driver on the client.

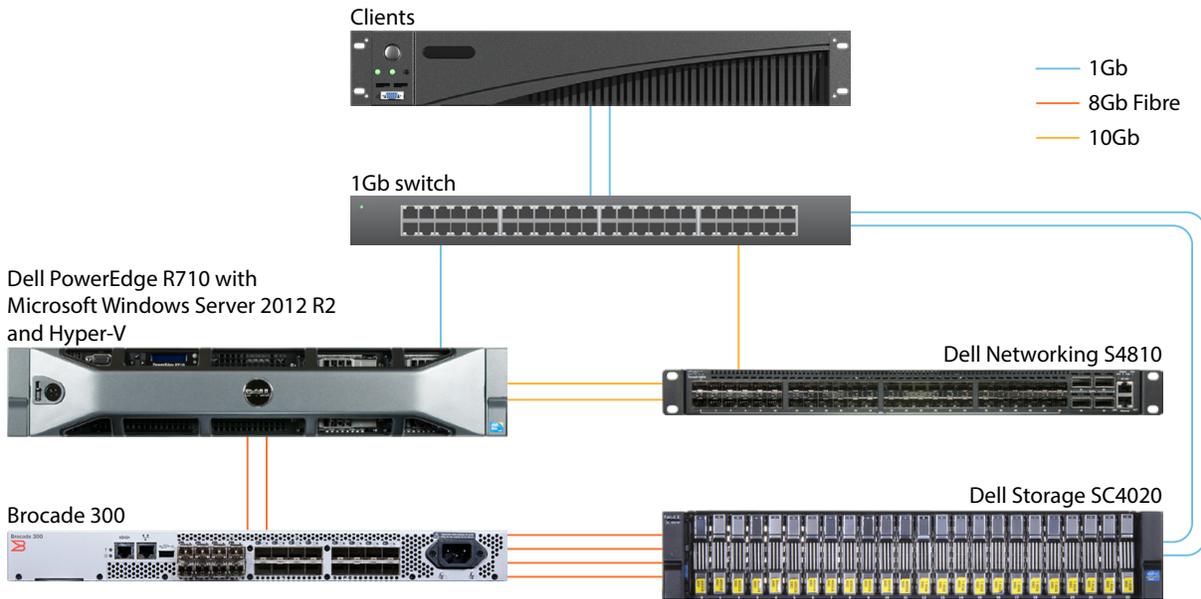
We used the following DVD Store parameters for testing:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=60 --n_threads=16 --db_size=100GB --think_time=0 --detailed_view=Y --warmup_time=10 --report_rate=5 --csv_output=<drive path>
```

# Appendix C – Our setup

## Legacy environment

We configured one Dell PowerEdge R710 server with 48 GB of RAM and dual Intel Xeon E5520 processors. We installed Windows Server 2012 R2 with updates on the R710 and added the Hyper-V role. We cabled the server to a standard 1Gb switch using the onboard 1Gb NICs for management traffic, and the 10Gb NIC to a Dell Networking S4810 switch for client and VM traffic. The diagram below shows the details of our legacy environment test bed.



### Our legacy environment test bed

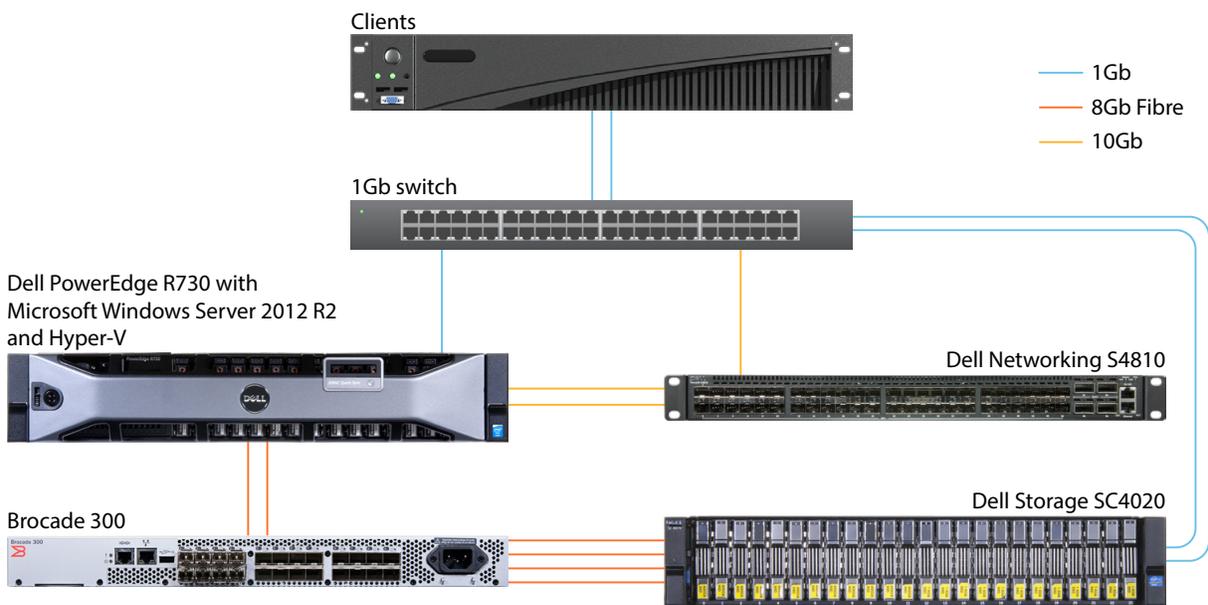
For the backing storage, we configured a Dell Storage SC4020 array with twelve write-intensive SSDs and twelve mixed-used SSDs. For storage connectivity, we connected two 8Gb fibre channel ports from each of the two storage controller modules to a Brocade 300 fibre switch with NPIV enabled. We then installed a QLogic GLE2562 8Gb fibre channel card in the PowerEdge R710 and cabled both ports to the Brocade switch. We created two 9TB LUNs on the storage for OS/log and database drives, respectively, and mapped the LUNs to the PowerEdge R710 server for VM storage with read and write cache enabled on the storage.

## Upgraded environment

We configured a Dell PowerEdge R730 server with 256 GB of RAM and dual Intel Xeon E5-2660 v4 processors. We installed Windows Server 2012 R2 with updates and added the Hyper-V role on the server. We cabled the server to a standard 1Gb switch using the onboard 1Gb NICs for management traffic. Additionally, we cabled the onboard 10Gb NICs to a Dell Networking S4810 switch for client and VM traffic.

For the backing storage, we configured a Dell Storage SC4020 array with twelve write-intensive SSDs and twelve mixed-used SSDs. For storage connectivity, we connected two 8Gb fibre channel ports from each of the two storage controller modules to a Brocade 300 fibre switch with NPIV enabled. We then installed a QLogic GLE2562 8Gb fibre channel card in the PowerEdge R730 and cabled both ports to the Brocade switch. We created 500GB and 1TB LUNs on the storage for OS/log and database drives, respectively, designing each LUN to hold four VMs, and mapped the LUNs to the PowerEdge R730 server for VM storage with read and write cache enabled on the storage. See Figure X for a detailed diagram of our upgraded environment test bed.

Our upgraded environment test bed



All servers hosted database workload VMs. We also reserved all RAM for each VM to avoid memory contention. All VHDs were thick provisioned. We used the following VM hardware settings for the VMs:

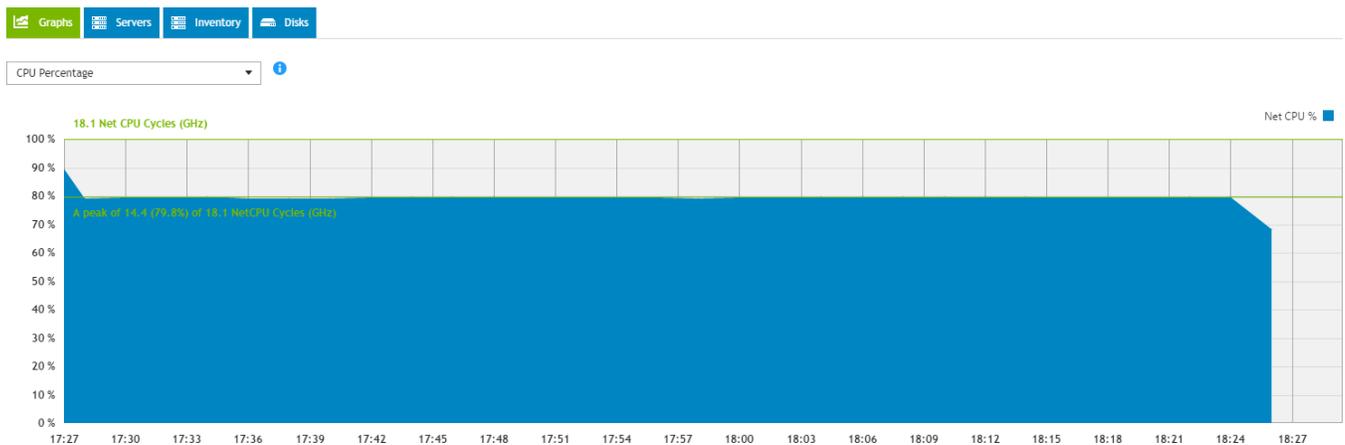
vCPU	RAM	OS VMDK	Data VMDK	Log VMDK	Backup VMDK
2 vCPU	6 GB	40 GB	210 GB	60 GB	60 GB

## Appendix D – DPACK data

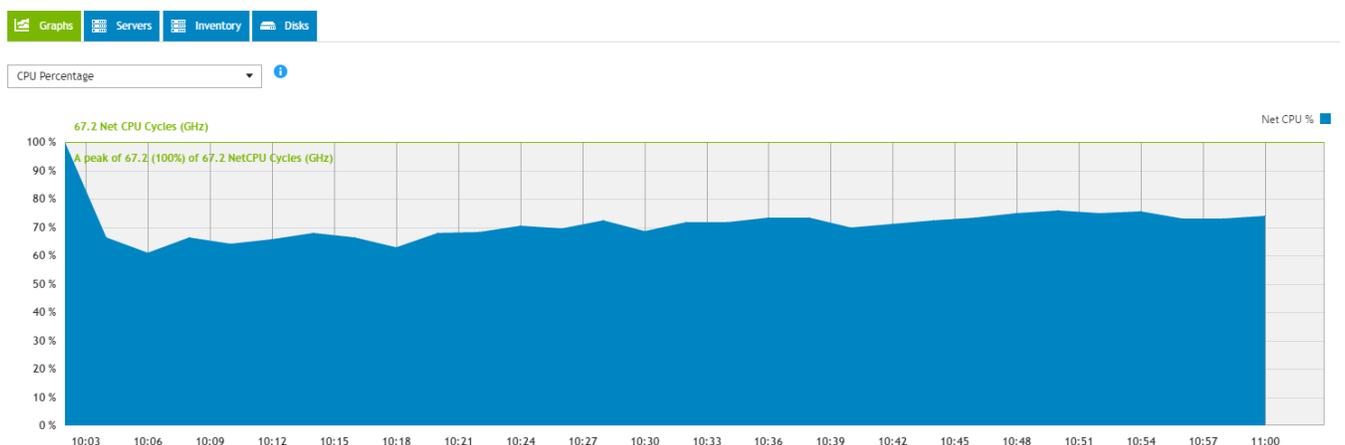
While we were testing, we ran DPACK on the legacy and upgraded Dell environments. Below are screenshots of the DPACK reports covering an hour-long test run in which the solutions ran virtualized SQL server on the Dell Compellent SC4020. We used this data for the performance analysis of our test runs, specifically CPU, IOPS, and storage latency.

### CPU

As the screenshot below shows, the legacy server consistently utilized just under 80% of the CPU during testing. This indicates that the legacy solution was bottlenecking on CPU and nearing its VM limit.

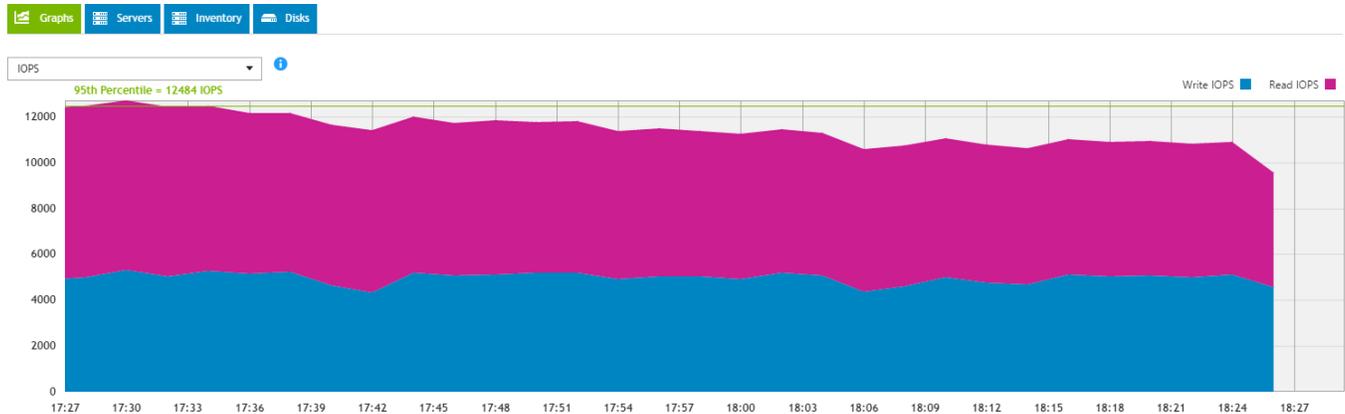


The next screenshot shows what DPACK found when we ran it on our first upgraded solution. As you can see, the R730 initially had lower CPU which increased to over 70% as the RAM in the virtual machines filled up. The R730 was also near its CPU limit.

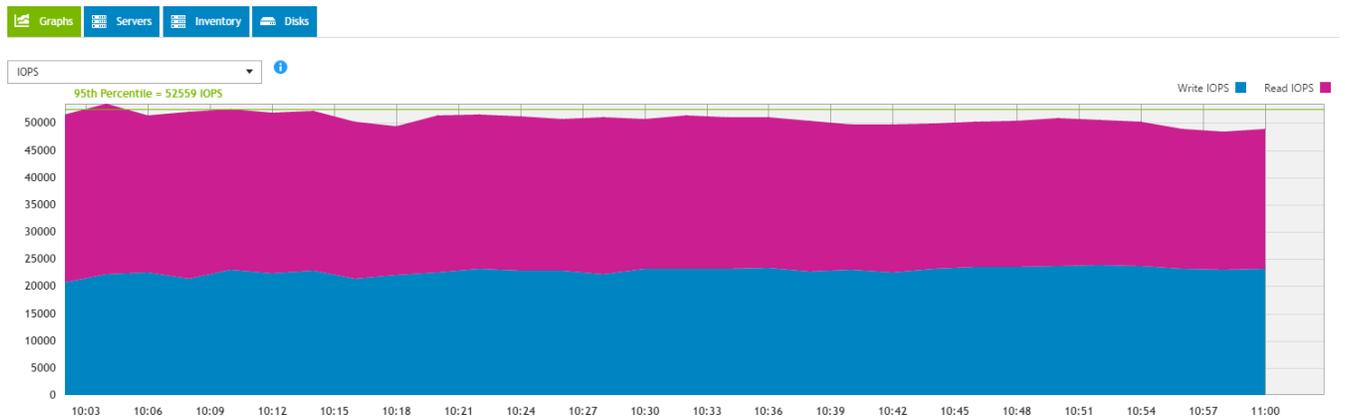


## IOPS

The screenshot below shows that the legacy system peaked around 12,500 IOPS and averaged around 11,000 IOPS. As the results show, the storage system handled more I/O; CPU was the bottleneck for the legacy system.

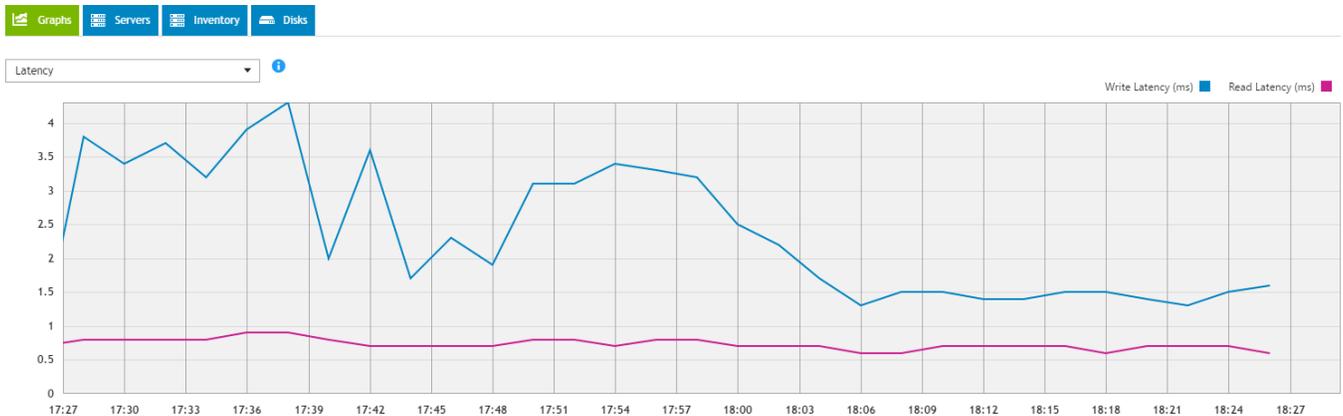


The screenshot below shows that the single R730 peaked around 53,500 IOPS and managed roughly 51,000 during the course of the run. The additional CPU and RAM capacity in the server allowed the R730 to push the storage considerably harder.

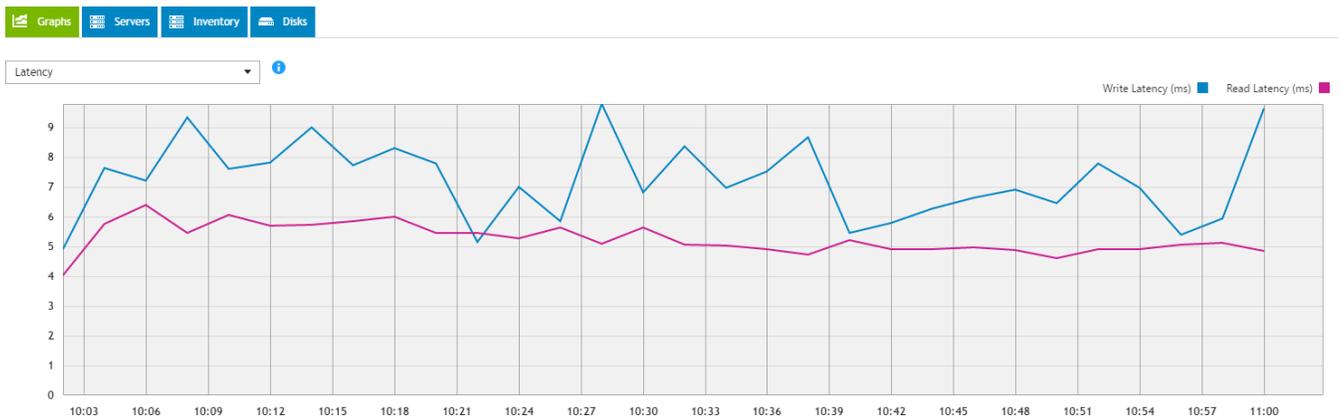


## Latency

In the screenshot below, DPACK data shows that the legacy environment's latency was consistently low throughout testing. The storage was able to handle the R710 workload with ease.



The data below shows that the additional horsepower provided by the R730 strained the legacy solution, but didn't push it to its limit. Latency peaked at just under 10 ms, and averaged around 7.5 ms.



This project was commissioned by Dell.



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