Get the server I/O capacity you need for heavy mixed, write, and read workloads

Configure your Intel Xeon Scalable processor-powered Dell EMC PowerEdge R740xd with more NVMe PCIe SSDs to increase IOPS and throughput for your workloads

Choosing the right server means deciding on the right balance of I/O and compute power for your workloads. When you need a tremendous amount of raw I/O power, you may want to consider a configuration with NVMe PCIe solid-state drives (SSDs). These SSDs connect directly to the processors, bringing storage close to compute and providing fast performance. The Intel® Xeon® Scalable processor-powered Dell EMC™ PowerEdge™ R740xd has the compute and I/O scalability to handle four, eight, or twelve NVMe PCIe SSDs.

We used the Iometer tool to measure the storage capabilities of a single PowerEdge R740xd powered by Intel with varying numbers of NVMe SSDs. We configured Iometer to mimic several different types of workloads, including mixed, write-heavy, and read-heavy workloads. For all profiles we tested, input/output operations per second (IOPS) and throughput rose dramatically as we added more NVMe SSDs, while latency remained consistently under 1 ms. (For more on the importance of throughput and latency, see page 2.)

The test results in this report highlight the raw IOPS capacity of the PowerEdge R740xd in three configurations. Whether you need the I/O performance of four, eight, or twelve NVMe SSDs, the Intel Xeon Scalable processor-powered Dell EMC PowerEdge R740xd delivers.

Choose the NVMe PCIe SSD configuration that matches your needs

Up to 718K IOPS with sub-1ms latency on an OLTP workload

Up to 1.2M IOPS with sub-1ms latency on a VDI or OLTP workload

Up to 1.6M IOPS with sub-1ms latency on a VDI workload

Increase your server's I/O capacity

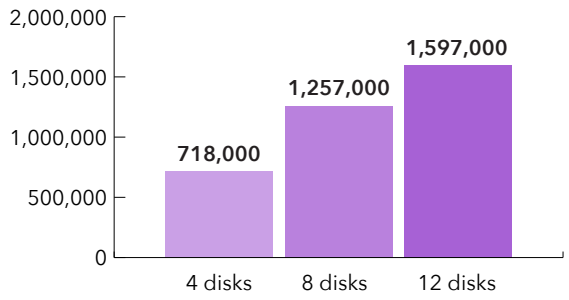
We tested each configuration of the Intel processor-powered Dell EMC PowerEdge R740xd with three different Iometer profiles. In each set of profile testing, more NVMe PCIe SSDs translated into higher IOPS and higher throughput. Not only that, but the solution delivered fast response times throughout testing. Ten years ago, solutions delivering sub-1ms latency for enterprise workloads were not widely available—but in our testing, the PowerEdge R740xd with NVMe PCIe SSDs consistently kept response times below 1 ms.

Mixed workload

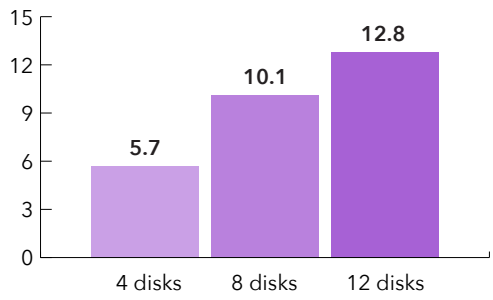
Our first Iometer profile, which imitated an online transaction processing (OLTP) workload, had an 8K block size and was 70 percent read, 30 percent write, and 100 percent random. OLTP workloads include a variety of database workloads and match up well with companies that run ecommerce websites or frequently utilize large databases of customer or employee information.

Running this profile, the solution sustained 75 percent more IOPS and 75 percent higher throughput when we moved from four to eight NVMe PCIe SSDs. Upgrading to twelve SSDs enabled the solution to handle over 27 percent more IOPS and 27 percent more throughput than it could with eight SSDs. The PowerEdge R740xd provided sub-1ms response times at each configuration.

Average IOPS: OLTP profile



Average throughput (GBps): OLTP profile



The relationship among IOPS, throughput, and latency

Though IOPS is a useful measurement metric, it does not paint a complete picture of a solution's storage performance. Throughput and latency are additional metrics that tell us more about what a solution can do for you. Throughput takes block size into account, measuring the total number of GB per second the solution can handle, while latency measures how long the system waits between processing orders. A solution with high throughput and low latency would be able to process a lot of data at a time while still responding to users quickly.

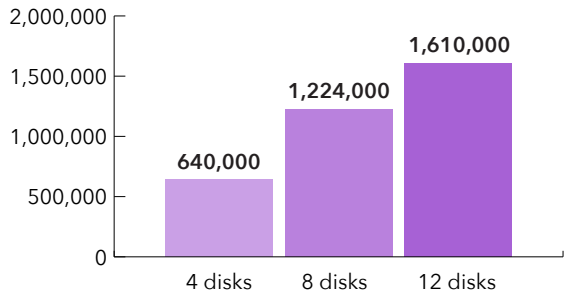
Together, the three metrics paint a more holistic picture of a solution's capabilities. If a solution has high IOPS, high throughput, and low latency, it's a good sign.

Write-heavy workload

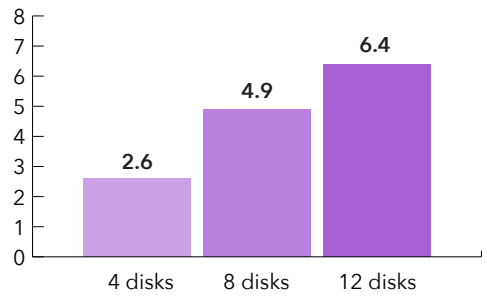
At 20 percent read, 80 percent write, 80 percent random, and 20 percent sequential with a 4K block size, we designed our second Iometer profile to mimic a virtual desktop infrastructure (VDI) workload. Reference the results for this workload if you're planning on implementing VDI in your organization, which could be useful if you have many users who work at desktops in similar programs.

When we upgraded from four to eight NVMe PCIe SSDs, we saw 91 percent more IOPS with 91 percent higher throughput. Performance continued to rise as we added four more SSDs, with the twelve-SSD configuration delivering 32 percent more IOPS and 32 percent more throughput than the configuration with eight SSDs. At all three configurations, the solution's average latency remained under 1 ms.

Average IOPS: VDI profile



Average throughput (GBps): VDI profile



Testing with Iometer

Iometer is an industry-standard tool for measuring raw I/O capacity, or the maximum number of IOPS that a solution can provide.[1] Because Iometer stresses exclusively storage, its results do not indicate how many IOPS the solution can deliver while running a real-world workload, which will also require work from the rest of the components in the hardware.

However, Iometer does permit us to create different profiles by customizing three factors:

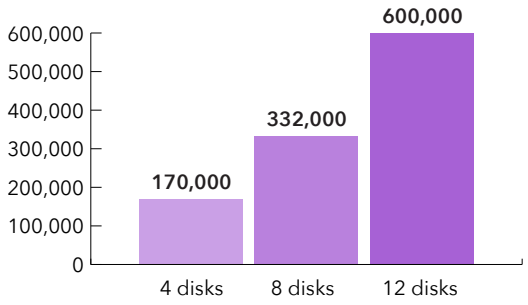
- **Block size:** The size of the file being inputted or outputted. Setting the block size larger imitates a workload that might have to deal with more complex operations and larger files, while setting a smaller block size will get you closer to a workload with many simple operations.
- **Read/write ratio:** The ratio between read operations, which simply review existing data, and write operations, which add new data or change existing data.
- **Random/sequential ratio:** The ratio between random reads or writes (the system chooses specific, random packets of data with no relation to each other) and sequential reads or writes (the system chooses the data packet that immediately follows the packet it has just chosen).

Together, these factors combine to mimic different real-world workloads. If you're trying to decide on the right storage configuration for your work, you may wish to review the results for the Iometer profile closest to your workload.

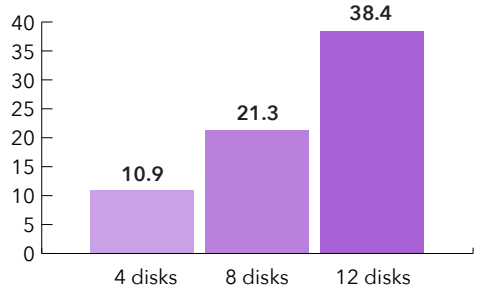
Read-heavy workload

Our final Iometer profile was 98 percent read, 2 percent write, and 100 percent sequential with a 64K block size. This profile imitates a media streaming workload, ideal if your server is sustaining many users watching videos or listening to music. Upgrading from four to eight NVMe SSDs yielded 95 percent more IOPS with 95 percent more throughput. When we added the next four SSDs, the solution delivered 81 percent more IOPS and 81 percent more throughput than it could with eight SSDs. At four, eight, and twelve disks, the solution consistently provided average response times below 1 ms.

Average IOPS: Media streaming profile



Average throughput (GBps): Media streaming profile



The Dell EMC PowerEdge R740xd

The14th-generation Dell EMC PowerEdge R740xd is available in many configurations, so when you order your PowerEdge R740xd, you can choose the number of NVMe PCIe SSDs that's right for you. According to Dell EMC, the 2U PowerEdge R740xd—powered by the latest Intel Xeon Scalable processors—offers strong storage performance and includes new management capabilities with iDRAC9, SupportAssist for proactive customer support, and an out-of-band management architecture.[2]

Choose a configuration with more NVMe PCIe SSDs, get more I/O performance with consistently low latencies

Whether you measure storage performance by IOPS, throughput, or both, the results of our Iometer testing were clear. If you choose a configuration of the Intel Xeon Scalable processor-powered PowerEdge R740xd with eight NVMe SSDs as opposed to four, or twelve as opposed to eight, you can gain substantially more raw I/O performance—all while maintaining latencies under 1 ms. We tested with several different workloads so you can compare your own I/O needs to the results of our tests and find the solution that will be right for you.

1 "Iometer," accessed June 26, 2017, http://www.iometer.org/

2 "PowerEdge R740/xd servers", accessed June 21, 2017, https://dellservervr.dell.com/poweredge-r740xd/.

On June 9, 2017, 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 June 16, 2017.

All of the hardware we used in this study, including both the server and the NVMe SSDs, is pre-production and not currently available in the market. Dell EMC provided us with this hardware for our testing.

Appendix A: System configuration information

Server configuration information	Dell EMC PowerEdge R740xd
BIOS name and version	Dell 1.0.2
Non-default BIOS settings	N/A
Operating system name and version/build number	Windows Server® 2016 Datacenter x64
Date of last OS updates/patches applied	06/01/2017
Power management policy	Performance
Processor	
Number of processors	2
Vendor and model	Intel Xeon Gold 6134 CPU
Core count (per processor)	8
Core frequency (GHz)	3.20
Stepping	4
Memory module(s)	
Total memory in system (GB)	192
Number of memory modules	12
Vendor and model	SK Hynix HMA82GR7AFR8N-VK
Size (GB)	16
Type	PC4-2666V
Speed (MHz)	2,666

Server configuration information	Dell EMC PowerEdge R740xd
Storage controller	
Controller #1	
Vendor and model	Dell PERC H730P
Cache size	2 GB
Firmware version	25.5.0.0018
Driver version	10.0.14393.0
Controller # 2	
Vendor and model	UCEA-200
Cache size (GB)	N/A
Firmware version	1.0.0
Driver version	10.0.14393.0
Local storage (type A)	
Number of drives	2
Drive vendor and model	Dell ST300MM0006
Drive size	300 GB
Drive information (speed, interface, type)	10K, 6Gb SAS, HDD
Local storage (type B)	
Number of drives	12
Drive vendor and model	Dell P/N 0JDMHM (PM1725a)
Drive size	3.2 TB
Drive information (speed, interface, type)	NVMe
Network adapter	
Vendor and model	Dell P/N 0G8RPD (BCM57800)
Number and type of ports	2 x 10 GbE, 2 x 1 GbE
Driver version	6.604.6.0
Cooling fans	
Vendor and model	Nidec 4VXP3-X30
Number of cooling fans	6
Power supplies	
Vendor and model	Dell E1100E-S0
Number of power supplies	4
Wattage of each (W)	1,100

Appendix B: How we tested

Installing Windows Server 2016 Datacenter Edition

1. Boot the target server.
2. When requested, press any key to boot to the installation media.
3. On the Windows Server 2016 screen, click Next.
4. Click Install Now.
5. On the Activate Windows Screen, click I don't have a product key.
6. Select Windows Server 2016 Datacenter (Desktop Experience), and click Next.
7. Agree to the License.
8. Select Custom Installation.
9. Select the target volume for the Windows installation, and click Next.
10. Wait for the installation to complete.
11. At the Customize settings screen, type and confirm a password, and click Finish.

Configuring Windows Server 2016

1. At the login screen, enter your password, and press enter.
2. Open Windows Update, and select Check for updates.
3. Allow the updates to install.
4. Open Windows Firewall with Advanced Security.
5. Click Windows Firewall Properties.
6. On the Domain Profile, Private Profile, and Public Profile tabs, set the Firewall state to off.
7. Open System Properties.
8. In the Remote tab, select Allow remote connections to this computer. Click to deselect the Allow Connections only…. checkbox, and click OK.
9. Using Disk Management, create a simple volume using all defaults for each disk. There will be 12 total disks.

Installing Iometer

1. Download Iometer 1.1.0 from http://sourceforge.net/projects/iometer/files/iometer-stable/1.1.0/iometer-1.1.0-win64.x86_64-bin.zip/download.
2. Unzip the downloaded files.
3. In the iometer-1.1.0-win64.x86_64-bin folder, run Iometer.exe.
4. On the Intel Open Source License window, click I agree.

We set up Access Specifications for three profiles: media streaming, VDI, and OLTP. For each Access Specification, we ran Iometer for 30 minutes on 4, 8, and 12 disks. See Figures 1, 2, and 3 for the settings we used in each profile.

Setting specifications for Access Profiles

See Figures 1, 2, and 3 to learn how we configured the Access Specifications for the OLTP, VDI, and media streaming profiles.

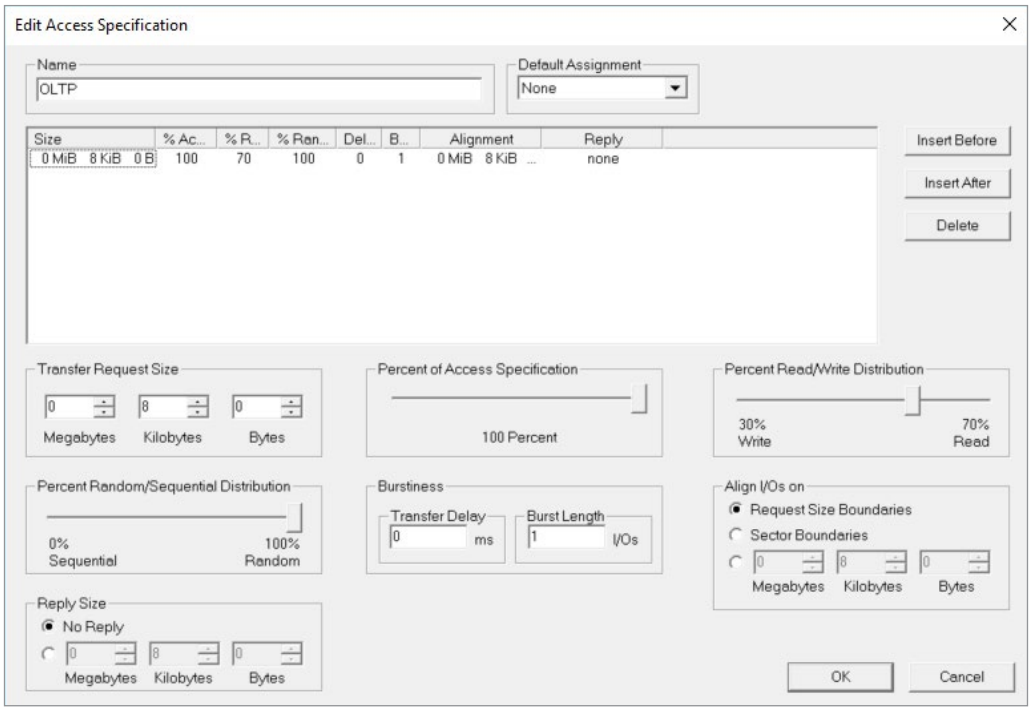


Figure 1: OLTP profile access specifications

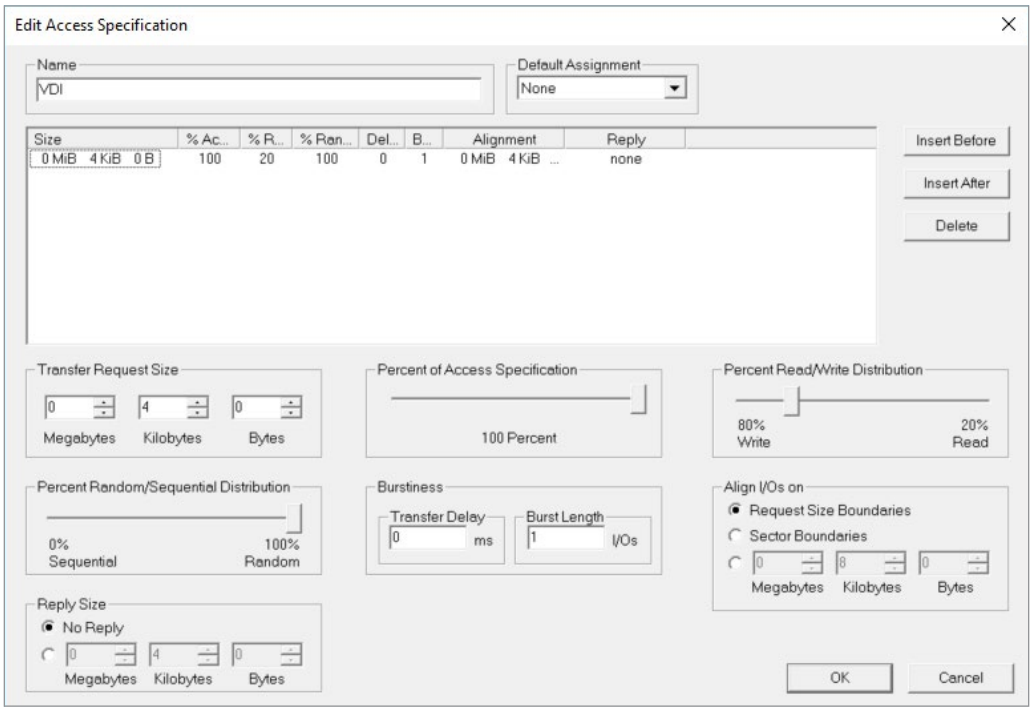


Figure 2: VDI profile access specifications

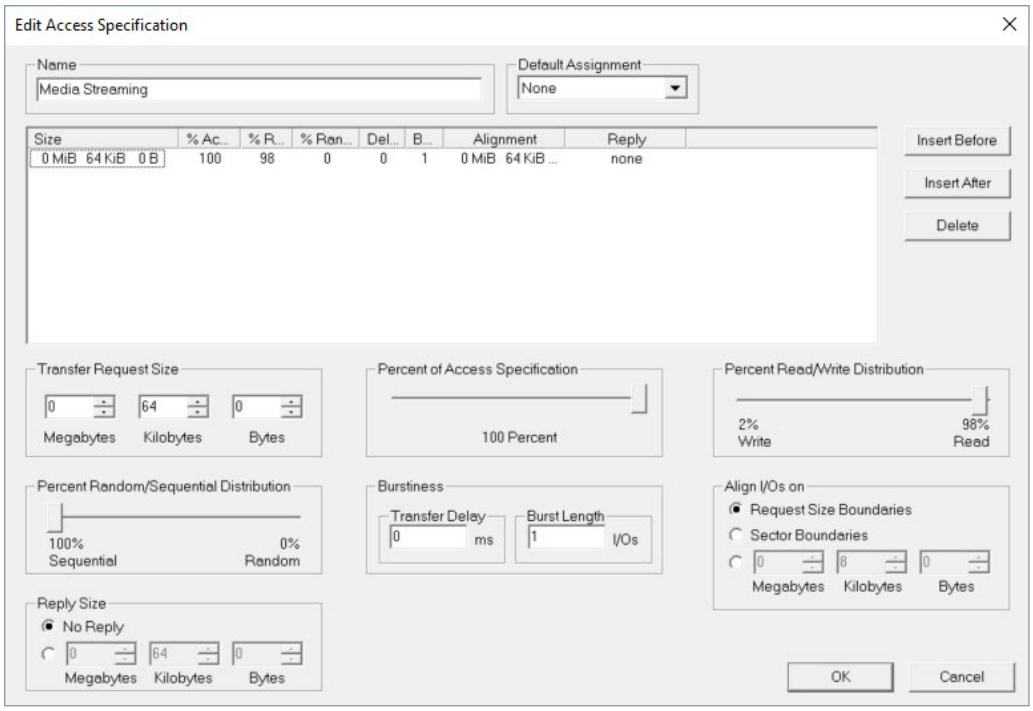


Figure 3: Media streaming profile access specifications

Configuring general settings

We used the settings listed below for all tests. If a setting is not listed, we used the default.

- Maximum disk size: 1073741824 sectors
- Run time: 30 minutes
- Ramp up time: 300 seconds

Configuring test-specific settings

The access profile, number of disks, workers per disk, and outstanding I/Os per target (queue depth) varied. See Table 1 for additional details.

	Access profile	Disks	Workers per disk	Outstanding I/Os per target
OLTP 4 disks	OLTP	4	2	48
OLTP 8 disks	OLTP	8	2	48
OLTP 12 disks	OLTP	12	2	48
VDI 4 disks	VDI	4	4	4
VDI 8 disks	VDI	8	4	4
VDI 12 disks	VDI	12	4	4
Media streaming 4 disks	Media streaming	4	1	32
Media streaming 8 disks	Media streaming	8	1	32
Media streaming 12 disks	Media streaming	12	1	32

Table 1: Test-specific Iometer settings

Appendix C: Complete test results

Test name	IO profile	Number of disks	Average IOPS	Average throughput (GBps)	Average latency (ms)	Host CPU utilization
OLTP 4 disks	OLTP	4	718,000	5.7	0.53	21.87%
OLTP 8 disks	OLTP	8	1,257,000	10.1	0.61	46.74%
OLTP 12 disks	OLTP	12	1,597,000	12.8	0.72	72.27%
VDI 4 disks	VDI	4	640,000	2.6	0.10	26.89%
VDI 8 disks	VDI	8	1,224,000	4.9	0.10	63.94%
VDI 12 disks	VDI	12	1,610,000	6.4	0.12	98.26%
Media streaming 4 disks	Media	4	170,000	10.9	0.75	7.75%
Media streaming 8 disks	Media	8	332,000	21.3	0.77	15.94%
Media streaming 12 disks	Media	12	600,000	38.4	0.64	25.17%

Table 2: Complete test results

This project was commissioned by Dell Technologies.

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