PROWESS

Dell™ PowerEdge™ R750 Servers with PCIe® Gen4 Data Center NVMe® RAID Increase Microsoft® SQL Server® Database Performance

Achieve faster results and expand database capacity with Dell PowerEdge R750 servers built with 3rd Generation Intel® Xeon® Scalable processors, fast, data-center-class PCIe Gen4 NVM Express® (NVMe) drives, and the latest-generation Broadcom® RAID controllers.

Technical Research Report

Executive Summary

Small- and medium-sized businesses (SMBs) comprise 90 percent of the global business population, and many rely on Microsoft® SQL Server® for daily operations.[1] Because it's common for these organizations to run SQL Server on a standalone platform, the performance of that platform is critical—especially as SMBs struggle to keep up with the massive growth of actionable data needed for business success. The RAID controller, in particular, is a key component on these systems because it not only enhances performance but also protects data from drive failures.

The overall performance of SQL Server depends on server hardware, especially the processor, memory, networking, and storage. To examine the benefits of upgrading hardware in greater detail, Prowess Consulting compared the latest generation of the popular 2U Dell™ PowerEdge™ rack server with the previous generation.

Dell PowerEdge R750 platforms offer several performance advantages for SQL Server over previous-generation platforms. These advantages include 3rd Generation Intel® Xeon® Scalable processors, 3,200 megatransfers per second (MT/s) memory, PCIe® Gen4 interfaces, and the Dell™ PowerEdge RAID Controller 11 (PERC 11) H755N Front NVM Express® (NVMe®), built with industry-leading Broadcom® RAID technologies. With PCIe Gen4 interfaces, Dell PowerEdge R750 platforms can be configured to include data-center-class NVMe solid-state drives (SSDs).

Prowess testing compared the components in the current-generation Dell PowerEdge R750 server against the 2nd Generation Intel Xeon Scalable processors, the Dell PERC 10 H740P, and the Serial ATA (SATA®)-based SSDs found in the previous-generation Dell PowerEdge R740xd platform. This testing allowed us to quantify what upgrading server infrastructure can mean for businesses.

A Dell™ PowerEdge™ R750 server, compared to a Dell PowerEdge R740xd server, can provide:

Up to **2.6x** more new orders per minute (NOPM)

Up to **3.5x** higher disk-write performance

Up to **1.4x** Higher disk-read performance[5]

37% lower cost for PCIe® Gen4 data-center NVMe® SSDs

Additionally, Prowess Consulting noted that the Dell PCIe Gen4 data center NVMe SSDs in the Dell PowerEdge R750 platform offer not only higher data-transfer rates compared to the SATA-based Dell SSDs in the Dell PowerEdge R740xd platform, but they also cost 37 percent less:

- 960 GB Dell data center NVMe read-intensive AG drive, U2, PCIe Gen4, with carrier: $1,063.55 USD[2]
- 960 GB SATA Dell SSD, read-intensive, 6 Gbps, 512e, 2.5-in with 3.5-in hybrid carrier drive: $1,689.00 USD[3]

The Dell PCIe Gen4 data center NVMe SSDs used in the Dell PowerEdge R750 platform offer compelling value.[4]

Market and Technology Trends

SQL Server is one of the most popular database management systems (DBMSs) in the world, with more than 180,000 companies worldwide relying on the software for critical business operations.[5] For many companies, SQL Server is deployed on a single, on-premises server because it is the most cost-effective and least complex option. But that means the underlying system and storage must be optimized to deliver the necessary performance. Unfortunately, as businesses are deluged with data, many companies are discovering that their aging systems are not keeping up. IT admins struggle when tasked to support line-of-business (LOB) managers or database administrators (DBAs) who ask to process more data faster, whether to rapidly respond to customers or to quickly gain business insights.

To respond to this growing influx of data, IT administrators need to consider both the server platforms and the storage systems supporting their SQL Server database deployments. For example, medium-sized businesses often rely on RAID storage arrays for handling SQL Server data. RAID storage arrays are a simple but reliable solution for enhancing performance. They also protect data in a way that avoids the complexity or higher costs of a storage-area network (SAN) or a hyperconverged infrastructure (HCI) deployment.

Modern RAID protects data and boosts storage performance.

RAID (Redundant Array of Inexpensive Disks) has been around for many years. Traditionally, RAID has been used to increase the resilience and reliability of critical storage applications. But now, with PCIe® Gen4 RAID interfaces, RAID works with high-bandwidth SSDs to significantly boost storage performance. The Dell™ PERC 11 H755N Front NVMe® adapter, based on the Broadcom® SAS3916 PCIe to SAS/SATA/PCIe RAID-on-Chip (RoC) controller with both PCIe Gen4 host and PCIe Gen4 storage interfaces, delivers double the bandwidth and 75 percent more input/output operations per second (IOPS), compared to previous generations.[6]

However, legacy SATA or Serial-Attached SCSI (SAS) SSDs in RAID arrays might not be fast enough to keep up with growing demands. Getting data to the processor can become a primary bottleneck for business-critical deployments of SQL Server. This can keep businesses from realizing the full benefits of their hardware investments and keep them from fully meeting their current and future business needs.

Dell Technologies touts its Dell PowerEdge R750 servers as a cure for the data deluge. These platforms offer significant upgrades over previous-generation platforms, including:

- 3rd Generation Intel Xeon Scalable processors (compared to 2nd Generation Intel Xeon Scalable processors)
- Newer (and more) Dell PERC 11 H755N Front family controllers built using industry-leading Broadcom technology
- 3,200 MT/s memory
- PCIe Gen4 data center NVMe drives (compared to PCIe Gen3)

Taken together, these modern components can provide businesses a significant SQL Server performance increase over previous-generation hardware, in addition to enabling higher-capacity storage. Specifically, the newer controllers based on Broadcom technology enable protection for NVMe drives without throttling performance; customers no longer need software-defined solutions (such as VMware vSAN™) with their accompanying overhead to protect NVMe drives.

Bare metal or hypervisor?

Some businesses might be tempted to migrate their Microsoft® SQL Server® databases and storage platforms to virtualized environments for greater deployment and management flexibility, but virtualization typically incurs a performance penalty. For example, input/output (I/O) performance and throughput are generally far lower on VMware vSAN™ deployments, compared to local storage, due to additional computational overhead. In some cases, administrators might be willing to make a performance tradeoff for management convenience if the difference is within an acceptable range. But for organizations that are already struggling to process massive and growing quantities of data, any additional drop in performance wouldn't be a viable upgrade option.

Putting the Two Systems to the Test

What type of performance does the Dell PowerEdge R750 server provide? Prowess compared SQL Server performance between older- and newer-generation Dell PowerEdge servers. Specifically, we compared the platforms and components shown in Table 1.

Table 1. System configurations used for Microsoft® SQL Server® performance testing

	Dell™ PowerEdge™ R740xd	Dell™ PowerEdge™ R750
Processor	2 x Intel® Xeon® Gold 6238 processor (2nd Generation Intel® Xeon® Scalable processor)	2 x Intel® Xeon® Gold 6338 processor (3rd Generation Intel® Xeon® Scalable processor)
Processor base frequency	2.1 GHz	2.00 GHz
Cores/threads	22/44	32/64
Memory	Total memory: 256 GB, 2,933 MT/s • 4 x 32 GB Hynix® dual-rank DDR4 • 4 x 32 GB Samsung® dual-rank DDR4	Total memory: 256 GB, 3,200 MT/s 16 x 16 GB Hynix® DDR4 DIMMs
Controller details for the Microsoft® SQL Server® 2019 database data and log volume		
Controller	1 x Dell™ PowerEdge RAID Controller 10 (PERC 10) H740P	2 x Dell™ PowerEdge RAID Controller 11 (PERC 11) H755N Front powered by Broadcom® technologies
Disks	16 x 960 GB Samsung® MZ7LH960HB-JR0D3 SATA® SSDs	16 x 960 GB Dell™ PCIe® Gen4 data center NVM Express® (NVMe®) PE8010 RI U.2 (SK hynix)
Configuration	Microsoft® SQL Server® data virtual disk: • RAID configuration: RAID 5 • Number of disks: 8 Microsoft® SQL Server® log virtual disk: • RAID configuration: RAID 10 • Number of disks: 8	Microsoft® SQL Server® data virtual disk: • Controller 1 • RAID configuration: RAID 5 • Number of disks: 8 Microsoft® SQL Server® log virtual disk: • Controller 2 • RAID configuration: RAID 10 • Number of disks: 8
Controller details for the operating system (OS)		
Controller	Marvell® Technology Group Dell™ Boot Optimized Server Storage (BOSS)-S1	Dell™ Boot Optimized Server Storage (BOSS)-S2
Disks	2 x 240 GB Intel® SSDSCKKB240G8R SATA® SSD	2 x 480 GB Micron® 5300 PRO SSD

	Dell™ PowerEdge™ R740xd	Dell™ PowerEdge™ R750
Networking		
Network adapters	• 1 x Broadcom® BCM57416 NetXtreme® E-series dual-media 10 gigabit Ethernet (GbE) remote direct memory access (RDMA) Ethernet controller • 1 x Broadcom® NetXtreme® BCM5720 GbE PCIe® • 1 x 25 GbE dual-port Intel® Ethernet Network Adapter E810-XXV	• 1 x 1 GbE dual-port Broadcom® BCM5720 NetXtreme® Ethernet controller • 1 x 10/25 GbE dual-port Broadcom® BCM57414 NetXtreme® E-series RDMA Ethernet controller
Server details		
BIOS version	BIOS 2.13.3	BIOS 1.5.5
OS name and version[7,*]	Red Hat® Enterprise Linux® 8.5	Red Hat® Enterprise Linux® 8.6
OS kernel	4.18.0-348.23.1.el8_5.x86_64	4.18.0-372.9.1.el8.x86_64
Database software		
Microsoft® SQL Server® version	Microsoft® SQL Server® 2019 (RTM-CU15) (KB5008996)—15.0.4198.2 (X64) https://docs.microsoft.com/en-us/sql/linux/quickstart-install-connect-red-hat?view=sql-server-ver16	

*Red Hat® Enterprise Linux® 8.6 released May 10, 2022, during Prowess testing (see https://access.redhat.com/articles/3078). As a results, Prowess tested the Dell™ PowerEdge™ R750 server with Red Hat Enterprise Linux 8.6 and the Dell PowerEdge R740xd server with Red Hat Enterprise Linux 8.5. Prowess reviewed the release notes for Red Hat Enterprise Linux 8.6 and determined that nothing in the release would affect the testing results. (For details, see the release notes at https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/8/html/8.6_release_notes/index.)

We performed our testing of the Dell PowerEdge R750 and Dell PowerEdge R740xd platforms on bare-metal servers only, with Red Hat® Enterprise Linux® 8.5 installed (that is, with no virtualization layer).[7] In addition, we selected configurations that would represent typical deployments, rather than maxing out the systems. Both the older and newer Dell PowerEdge platforms used in our testing are available with higher CPU and memory specifications. The Intel Xeon Gold 6338 processor used in the Dell PowerEdge R750 server is Intel's targeted replacement for the Intel Xeon Gold 6238 processor used in the Dell PowerEdge R740xd server. Table 2 shows the tested configurations compared to the highest-available specifications for each platform.

Table 2. Cores, memory DIMMs, and relative CPU pricing in the configurations used for testing

	Dell™ PowerEdge™ R740xd	Dell™ PowerEdge™ R750	
Processor in tested configuration:	Intel® Xeon® Gold 6238 processor	Intel® Xeon® Gold 6338 processor	
Cores	In tested configuration:	22	32
	Configurations available with up to:	44	64
Memory DIMMs	In tested configuration:	8	16
	Configurations available with up to:	24	32
Intel recommended customer pricing for processor used in testing:[8]		$2,801.00	$2,796.00

Measuring SQL Server Performance

The goal of our testing was to generate performance data showing the new orders per minute (NOPM) performance of a SQL Server database running on each Dell PowerEdge server. We also collected other performance data to verify that the two systems were operating as intended with comparable configurations.

For these tests, we used BenchCraft®, a Microsoft benchmarking tool that processes data like a TPC-C® benchmark. Note that this workload is derived from the TPC-C benchmark and is not comparable to published TPC-C benchmark results, as this implementation does not comply with all requirements of the TPC-C benchmark. The Dell PowerEdge R740xd server was configured as follows:

- Dell PERC 10 H740P
- Database residing on an eight-disk RAID 5 stripe
- Logs and TempDB residing on an eight-disk RAID 10 configuration

The Dell PowerEdge R750 server was configured as follows:

- Dell PERC 11 H755N Front powered by Broadcom technologies
- Database residing on an eight-disk RAID 5 stripe
- Logs and TempDB residing on an eight-disk RAID 10 configuration

We configured a SQL Server 2019 database with 1,400 warehouses and ran the tests using 100 threads. We allowed each test run about 45 minutes of run time until the database reached a steady state prior to recording new orders. Our engineers then recorded total new orders performed over a 15-minute period, and we then took the average NOPM reading over the 15-minute run. Our results show the median of three runs for each server to compare performance between the two platforms.

Higher Performance

The newer platform, built on a Dell PowerEdge R750 server, demonstrated an **up to 2.6x** increase in performance over the older-generation Dell PowerEdge R740xd platform when using 16 NVMe drives, as shown in Figure 1.

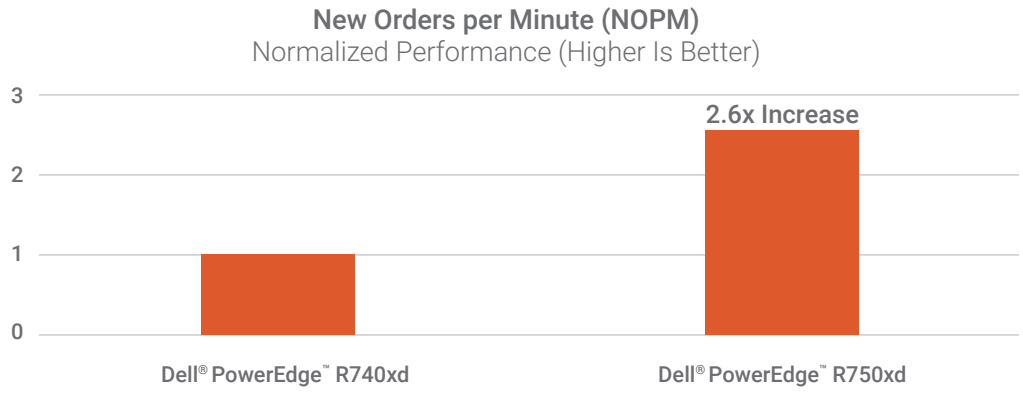

Figure 1. The combination of additional cores and the new Dell™ PERC 11 RAID controller enabled the newer Dell™ PowerEdge™ platform to process up to 2.6x the NOPM of the previous-generation platform

Disk read and write times were also improved for the newer server examined. For example, the Dell PowerEdge R750 server had **up to 3.5x** greater log-disk-write performance compared to the Dell PowerEdge R740xd platform when running eight NVMe drives, as shown in Figure 2.

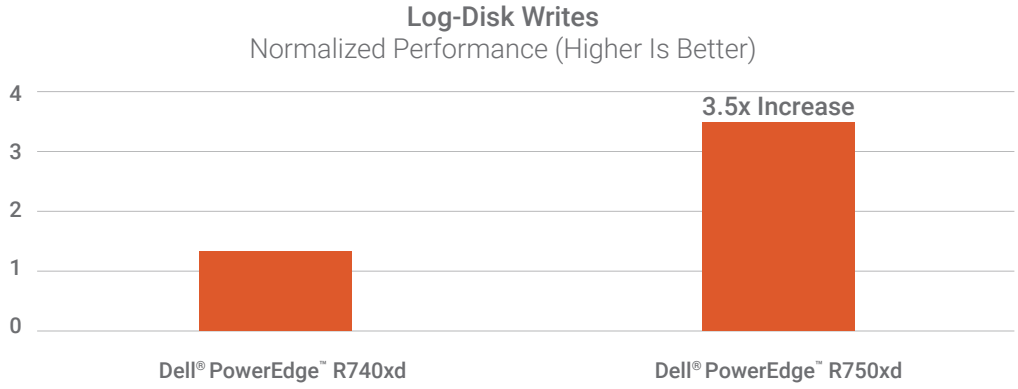

Figure 2. NVMe® drives in the newer Dell™ PowerEdge™ platform provide much more efficient disk writes than the SATA® SSDs in the previous-generation platform

For log-disk reads, the Dell PowerEdge R750 server was more performant than the Dell PowerEdge R740xd server, clocking in **up to 1.4x** read performance over the older platform with eight NVMe drives, as shown in Figure 3.

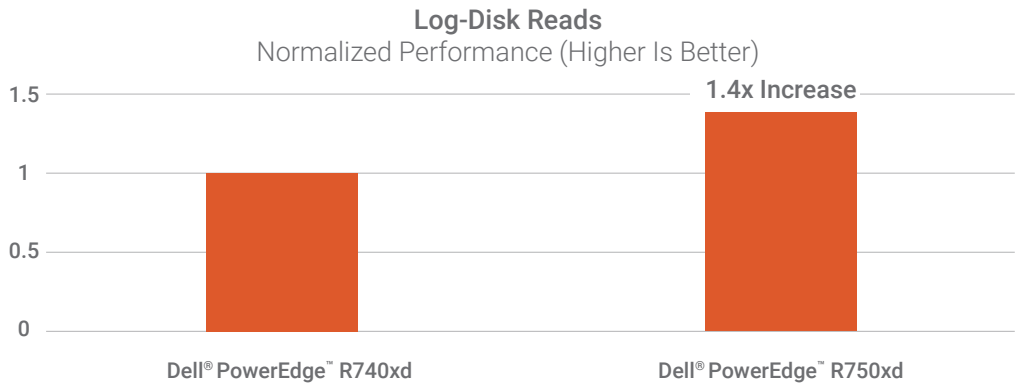

Figure 3. NVMe® drives in the newer Dell™ PowerEdge™ platform provide higher performance for log-disk reads compared to the SATA® SSDs in the previous-generation platform

Out with the Old, in with the New

Several differences likely accounted for the jump in performance on the newer system. These differences included faster storage, a faster bus between the storage and the CPU, faster CPU and memory, and faster RAID drive controllers.

Intel Xeon Scalable Processors

Compared to the previous generation, 3rd Generation Intel Xeon Scalable processors are built on a more efficient architecture that increases core performance, memory, and I/O bandwidth, and that provides additional memory channels to accelerate workloads. The Dell PowerEdge R750 server that we tested was built with two Intel Xeon Gold 6338 processors, which included 32 cores each. With support for more cores and sockets, the newer-generation processors drive enhanced performance, throughput, and CPU frequencies compared to previous-generation processors.

Compared to the previous generation, Intel claims that 3rd Generation Intel Xeon Scalable processors provide:

- **Up to 1.46x** average generation-on-generation performance improvement[9]
- **Up to 1.60x** higher memory bandwidth[10]
- **Up to 2.66x** higher memory capacity[11]
- **Up to 1.33x** more PCIe lanes per processor,[12] at PCIe Gen4 speeds

Broadcom RAID Controllers

The Dell PERC 11 H755N Front NVMe adapter is based on the Broadcom SAS3916 PCIe to SAS/SATA/PCIe RAID-on-Chip (RoC) controller. These are the first RAID controllers from Dell Technologies to offer both PCIe Gen4 host and PCIe Gen4 storage interfaces, which deliver double the bandwidth and 75 percent more IOPS, compared to previous generations.[6]

The Dell PERC 11 H755N Front NVMe adapter provides high PCIe (NVMe) storage-interface data-transfer rates of 16 gigatransfers per second (GT/s), 8 GT/s, 5 GT/s, and 2.5 GT/s per lane, in addition to reliability, high performance, and fault-tolerant disk subsystem management and support for RAID levels 0, 1, 5, 6, 10, 50, and 60.

The Dell PowerEdge R750 server used in our testing paired two Dell PERC 11 H755N Front NVMe adapters with all-NVMe SSDs to maximize storage bandwidth and throughput. The previous-generation server supported NVMe drives only as individual, discrete disks. To achieve RAID functionality, the Dell PowerEdge R740xd server was configured with slower, bandwidth-constrained SATA SSDs.

Ethernet Controllers

For the purposes of this testing, Prowess isolated the test platforms to remove network speed as a variable. However, the Dell PowerEdge R750 server includes the Broadcom® NetXtreme® E-Series BCM57414 50G PCIe 3.0 Ethernet controller, based on Broadcom's scalable 10/25/50/100/200 GbE controller architecture. This network card combines a high-bandwidth Ethernet controller with a unique set of highly optimized hardware-acceleration engines to enhance network performance and improve server efficiency for enterprise and cloud-scale networking and storage applications, including high-performance computing (HPC), telco, machine learning (ML), storage disaggregation, and data analytics.

Dell™ PowerEdge™ R750 Server Advantages

The Dell PowerEdge R750 server is an enterprise server designed to deliver high performance for demanding workloads. Powered by 3rd Generation Intel® Xeon® Scalable processors, the Dell PowerEdge R750 server is a dual-socket/2U rack server with support for eight channels of memory per CPU and up to 32 DDR4 DIMMs at 3,200 MT/s speeds. In addition, to address substantial throughput improvements, the Dell PowerEdge R750 server supports PCIe® Gen4 and up to 24 NVM Express® (NVMe®) drives (with an option for four additional rear-mounted drives) with improved air-cooling features and optional Direct Liquid Cooling (DLC) to support increasing power and thermal requirements. This makes the Dell PowerEdge R750 server an ideal server for data center standardization on a wide range of workloads including database and analytics, HPC, traditional corporate IT, virtual desktop infrastructure (VDI), and artificial intelligence (AI)/ML environments that require performance, extensive storage, and graphics processing unit (GPU) support. For more information, visit https://i.dell.com/sites/csdocuments/Product_Docs/en/poweredge-R750-spec-sheet.pdf.

Data Center NVMe Drives

The Dell data center NVMe SSDs used in testing are tailored for SMB scale-out environments where enterprise features, such as dual ports and Federal Information Processing Standard (FIPS) support, are not needed. With a targeted feature set and a lower-cost eight-channel controller, these drives offer a more attractive price comparable to SATA drives: the Dell PCIe Gen4 data center NVMe SSDs are 37 percent lower in cost, compared to SATA-based Dell SSDs ($1,063.55 versus $1,689.00, respectively).[2,3] High performance combined with a lower price-point creates a distinctive value proposition for this class of NVMe drive. It makes us ask: is it time to start transitioning completely to NVMe?[4]

Significant Performance Increase Justifies an Upgrade

Organizations are looking to maximize actionable information from massive and growing data volumes. For SMBs that run SQL Server databases on self-contained systems, the challenge is to maximize performance while ensuring all data is available and protected in the event of a drive failure. To address this challenge, businesses require modern platforms configured with high-performing processors, storage, interfaces, and controllers.

Testing by Prowess Consulting shows that the Dell PowerEdge R750 server with RAID storage based on data center NVMe SSDs helps meet this requirement by providing critical protection for data, with significant improvements for database NOPM compared to older-generation servers built with SATA RAID drives. In addition, the data center NVMe SSDs examined in our testing cost up to 37 percent less than the SATA-based SSDs we looked at.[2,3]

The newer platform processed up to 2.6x more NOPM, up to 3.5x more disk writes, and up to 1.4x more disk reads compared to the older-generation platform. For detailed testing methodology and configurations used in this study, see the methodology report, https://www.prowesscorp.com/project/dell-r750-vs-r740xd/.

Learn More

To learn more about the Dell PowerEdge R750, view its specification sheet: https://i.dell.com/sites/csdocuments/Product_Docs/en/poweredge-R750-spec-sheet.pdf

[1] Finances Online. "63 Crucial Small Business Statistics for 2021/2022: Data Analysis & Projections." 2020. https://financesonline.com/crucial-small-business-statistics/.

[2] Pricing of NVM Express® (NVMe®) data center–agnostic drive part number 400-BMTR as of May 31, 2022. Subject to change without notice. Source: Dell Technologies. "Dell 960GB Data Center NVMe Read Intensive AG Drive U2 Gen4 with carrier." www.dell.com/en-us/shop/dell-960gb-data-center-nvme-read-intensive-ag-drive-u2-gen4-with-carrier/apd/400-bmtr/storage-drives-media.

[3] Pricing of SATA® SSD part number 345-BBDJ as of May 31, 2022. Subject to change without notice. Source: Dell Technologies. "960GB SSD SATA Read Intensive 6Gbps 512e 2.5in w/ 3.5in HYB CARR Drive." www.dell.com/en-us/shop/960gb-ssd-sata-read-intensive-6gbps-512e-25in-w-35in-hyb-carr-drive/apd/345-bbdj/storage-drives-media.

[4] Dell Technologies. "New PCIe Gen4 Data Center NVMe Drives Offer Unmatched Value for PowerEdge Servers." 2021. https://infohub.delltechnologies.com/section-assets/new-pcie-gen4-data-center-nvme-drives.

[5] Enlyft. "Companies using Microsoft SQL Server." 2021. https://enlyft.com/tech/products/microsoft-sql-server.

[6] Source: Broadcom internal data, provided by Dell Technologies.

[7] Red Hat® Enterprise Linux® 8.6 released May 10, 2022, during Prowess testing (see https://access.redhat.com/articles/3078). As a results, Prowess tested the Dell™ PowerEdge™ R750 server with Red Hat Enterprise Linux 8.6 and the Dell PowerEdge R740xd server with Red Hat Enterprise Linux 8.5. Prowess reviewed the release notes for Red Hat Enterprise Linux 8.6 and determined that nothing in the release would affect the testing results. (For details, see the release notes at https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/8/html/8.6_release_notes/index.)

[8] Recommended customer pricing provided by Intel as of January 21, 2022. Subject to change without notice. For details, see: Intel. "Intel® Xeon® Gold 6238 Processor." www.intel.com/content/www/us/en/products/sku/193949/intel-xeon-gold-6238-processor-30-25m-cache-2-10-ghz/specifications.html. And Intel. "Intel® Xeon® Gold 6338 Processor." www.intel.com/content/www/us/en/products/sku/212285/intel-xeon-gold-6338-processor-48m-cache-2-00-ghz/specifications.html.

[9] Source: Claim 125 at Intel. "3rd Generation Intel® Xeon® Scalable Processors – Performance Index." www.intel.com/3gen-xeon-config.

[10] 3rd Generation Intel® Xeon® Platinum 8380 processors: 8 channels, 3,200 MT/s (2 DPC), compared to 2nd Generation Intel Xeon Platinum 8280 processors: 6 channels, 2,666 MT/S (2 DPC).

[11] 3rd Generation Intel® Xeon® Platinum 8380 processors: 8 channels, 2 DPC (256 GB DDR4), compared to 2nd Generation Intel Xeon Platinum 8280 processors: 6 channels, 2 DPC (128 GB DDR4).

[12] 3rd Generation Intel® Xeon® Platinum 8380 processors: 64 lanes of PCIe® Gen4 per processor, compared to 2nd Generation Intel Xeon Platinum 8280 processors: 48 lanes of PCIe Gen3 per processor.