PROWESS

Dell™ PowerEdge™ R750 Servers with NVMe® RAID Unleash Microsoft® SQL Server® Database Performance

Remove performance bottlenecks, expand database capacity, and reduce rebuild times with Dell PowerEdge R750 servers built with 3rd Generation Intel® Xeon® Scalable processors, fast NVM Express® (NVMe) SSDs, and the latest generation of RAID controllers based on Broadcom® technologies.

Executive Summary

Countless small-to-medium-sized businesses (SMBs) rely on Microsoft® SQL Server® for daily operations. Because it's common for these organizations to run SQL Server on a standalone platform, the performance of that platform is critical to keeping up with the massive growth of actionable data needed for business success. In addition, the RAID controller is also a key component on these systems because the data must be protected from drive failures.

Given these requirements, it's clear that the overall performance of SQL Server depends on the server hardware, particularly 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, including 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. Prowess testing compared these components in the current-generation Dell PowerEdge R750 server against the 2nd Generation Intel Xeon Scalable processors, single RAID controller, and Serial ATA (SATA®)-based solid-state drives (SSDs) found in the previous-generation Dell PowerEdge R740xd platform. The testing allowed us to quantify what upgrading server infrastructure can mean for SMBs.

Market and Technology Trends

SQL Server is one of the most popular database management systems (DBMSs) in the world, with more than 29,000 companies worldwide relying on the software for critical business operations.[1] For many companies, SQL Server is deployed on a single, on-premises server because it is the most cost-effective and least complex option to deploy and maintain. But that means the underlying system and storage are all the more critical for meeting performance needs.

Our results showed that:

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

Up to **14x** new orders per minute (NOPM)

Up to **13.5x** disk-write performance

Up to **9.0x** disk-read performance

Up to **5.25x** faster RAID rebuild times

Unfortunately, many companies are discovering that their aging systems aren't keeping up with the deluge of data inundating operations as their businesses grow. IT admins can struggle to meet the needs of line-of-business (LOB) managers and database administrators (DBAs) who want to quickly process more data, in order to provide timely results for customers and achieve faster time to insights for their businesses.

To respond to this growing influx of data, IT administrators need to consider both the server platform and the storage system supporting their SQL Server database deployments. For example, medium-sized businesses often rely on RAID storage arrays for handling SQL Server data because this simple but reliable solution offers data protection without the complexity or higher costs of a storage-area network (SAN) or a hyperconverged infrastructure (HCI) deployment. The importance of the data also means that customers using RAID must also consider rebuild times because the loss of multiple drives can be catastrophic.

However, legacy SATA or Serial Attached SCSI (SAS) SSDs might not be fast enough to keep up with growing demands. Furthermore, RAID rebuild times can be slow with SATA SSDs. These converging realities can mean that getting data to the processor can become a primary bottleneck for business-critical deployments of SQL Server, which 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 because 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 interface (compared to the PCIe Gen3 interface)

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 and faster database rebuild times. Specifically, the newer controllers based on Broadcom 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 lower on VMware vSAN™ deployments, compared to local storage. 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

Can the Dell PowerEdge R750 server live up to its promises? To answer this question, Prowess compared SQL Server performance between older- and newer-generation PowerEdge servers. Specifically, we compared the platforms and components shown in Table 1.

Table 1. System configurations used for Microsoft® SQL Server® performance testing[2]

	Dell™ PowerEdge™ R740xd	Dell™ PowerEdge™ R750	
Processor	2 x Intel® Xeon® Gold 6230 processor	2 x Intel® Xeon® Gold 6330 processor	2 x Intel® Xeon® Gold 6338 processor
Processor base frequency	2.1 GHz	2.0 GHz	2.0 GHz
Cores/threads	20/40	28/56	32/64
Memory	24 x 32 GB (768 GB total) Micron® DDR4 DIMMs, 2,933 MT/s	16 x 64 GB Samsung® M393A8G40AB2-CWE DDR4 DIMMs, 3,200 MT/s	16 x 16 GB (256 GB) Hynix™ HMA82GR7DJR8N-XN ECC DDR4 DIMMs, 3,200 MT/s
RAID array 1 (Microsoft® SQL Server® 2019 database data and log volumes)			
Controller	Dell™ PERC H740P	Dell™ PERC 11 H755N Front NVM Express® (NVMe®) controller	2 x Dell™ PERC 11 H755N Front NVM Express® (NVMe®) controller
Disks	8 x 1.92 TB Intel® SSD D3-S4510 (SATA®)	8 x 1.6 TB Samsung® PM1735 NVMe®	16 x 3.2 TB enterprise NVMe® mixed-use AG drive U.2 Gen4 with carrier
Disk sequential bandwidth	560 MB/s (100% read) 510 MB/s (100% write)[3]	8,000 MB/s (100% read) 3,800 MB/s (100% write)[4]	6,900 MB/s (100% read) 4,000 MB/s (100% write)[5]
Configuration	SQL Server® data virtual disk: • RAID configuration: RAID 5 • Number of disks: 3 SQL Server® log virtual disk: • RAID configuration: RAID 10 • Number of disks: 4 SQL Server® TempDB virtual disk: • RAID configuration: RAID 0 • Number of disks: 1	SQL Server® data virtual disk: • RAID configuration: RAID 5 • Number of disks: 3 SQL Server® log virtual disk: • RAID configuration: RAID 10 • Number of disks: 4 SQL Server® TempDB virtual disk: • RAID configuration: RAID 0 • Number of disks: 1	SQL Server® data virtual disk: • RAID configuration: RAID 5 • Number of disks: 8 SQL Server® log and TempDB virtual disk: • RAID configuration: RAID 10 • Number of disks: 8
RAID array 2 (boot volume)			
Controller	Dell™ Boot Optimized Server Storage (BOSS)-S1	Dell™ Boot Optimized Server Storage (BOSS)-S2 Hot plug, rear-facing accessibility	Dell™ Boot Optimized Server Storage (BOSS)-S2 Hot plug, rear-facing accessibility
Disks	2 x 240 GB Dell™ M.2 multi-level cell (MLC) SATA® 6 Gbps SSD	2 x 480 GB Micron® M.2 NVMe® SSD	2 x 480 GB Micron® M.2 NVMe® SSD
Networking			
Network adapters	25 Gb, dual-port Intel® Ethernet Network Adapter E810-XXV 10G, dual-media Broadcom® BCM57416 NetXtreme® E-Series Ethernet controller	10/25 Gb, dual-port Broadcom® BCM57504 NetXtreme® E-Series PCIe® 4.0 Ethernet controller 1G, dual-port Broadcom® BCM5720 NetXtreme® Ethernet controller	10/25 Gb, dual-port Broadcom® BCM57414 NetXtreme® E-Series remote direct memory access (RDMA) Ethernet controller 1G, dual-port Broadcom® BCM5720 NetXtreme® Ethernet controller

We performed our testing of the Dell PowerEdge R750 and Dell PowerEdge R740xd platforms on bare-metal servers only, with Red Hat® Enterprise Linux® 8.4 installed (that is, with no virtualization layer). 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. Note that the Intel Xeon Gold 6330 processor in the Dell PowerEdge R750 server is Intel's targeted replacement for the Intel Xeon Gold 6230 processor used in the Dell PowerEdge R740xd server, while the Intel Xeon Gold 6338 processor would be considered an upgrade. 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 configurations used for testing[2]

		Dell™ PowerEdge™ R740xd	Dell™ PowerEdge™ R750	
Processor in tested configuration:		Intel® Xeon® Gold 6230 processor	Intel® Xeon® Gold 6330 processor	Intel® Xeon® Gold 6338 processor
Cores	In tested configuration	20	28	32
	Configurations available with up to:	28	40	40
Memory DIMMs	In tested configuration:	24	16	16
	Configurations available with up to:	24	32	32
Intel recommended customer pricing for processor used in testing:[6]		~$2,033.00	~$2,038.00	~$2,796.00

Measuring SQL Server Performance

The goal of our testing was to generate performance data showing the NOPM performance of a SQL Server database running on each Dell PowerEdge system. 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 similar to 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:

- Logs residing on a four-disk RAID 10 stripe
- TempDB space configured on a one-disk RAID 0 stripe
- Database residing on a three-disk RAID 5 stripe

In the final phase of testing, the Dell PowerEdge R750 server was configured as follows:

- Two separate Dell PERC 11 H755N Front NVMe controllers
- 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 30 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 in order to compare performance between the two platforms.

A Clear Winner

The newer platform, built on a Dell PowerEdge R750 server, demonstrated a 7x increase in performance over the older-generation Dell PowerEdge R740xd platform when using eight NVMe drives, and a 14x increase using 16 NVMe drives, as shown in Figure 1.[2]

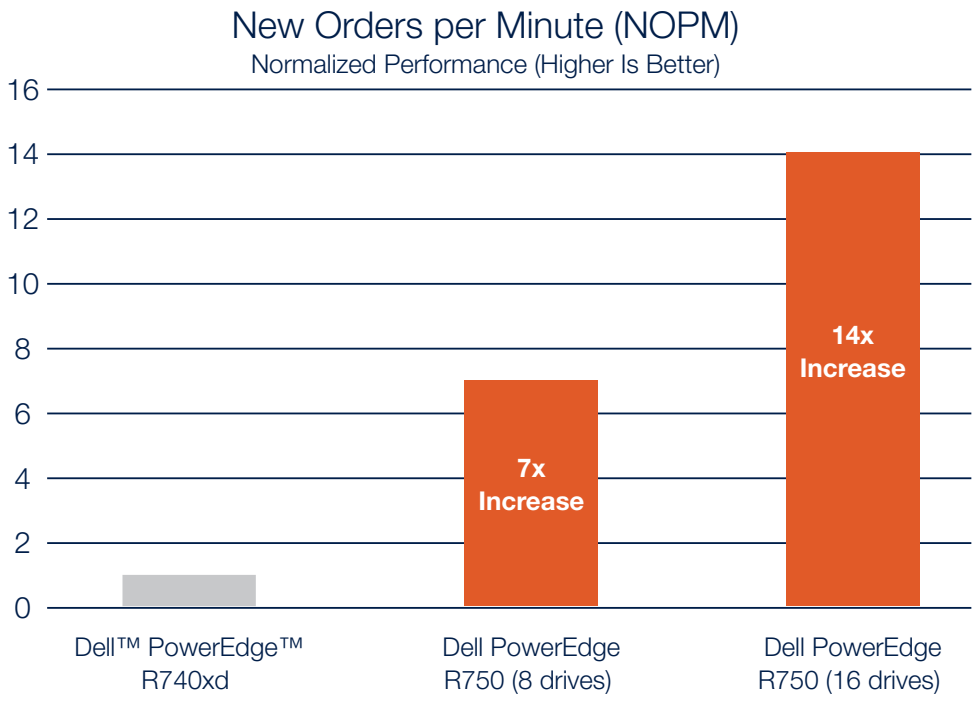


Figure 1. The additional processor cores in the newer Dell™ PowerEdge™ platform enabled it to process 7x the NOPM of the previous-generation platform; the additional RAID controller and twice the NVMe® drives enabled the 16-drive Dell PowerEdge R750 server to process 14x the NOPM of the previous-generation platform[2]

Disk read and write times are also greatly reduced for the newer servers examined. For example, the Dell PowerEdge R750 server had 5.6x greater log disk-write performance compared to the Dell PowerEdge R740xd platform when running eight NVMe drives, and a 13.5x increase running 16 of them, as shown in Figure 2.[2]

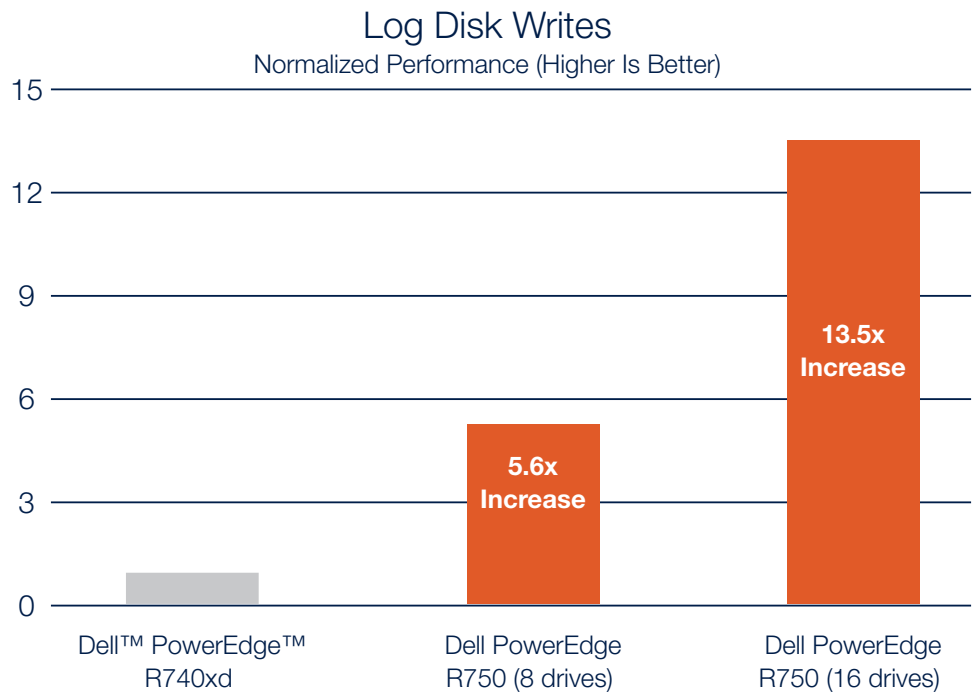


Figure 2. NVMe® drives in the newer Dell™ PowerEdge™ platform provide much more efficient disk writes than the SATA® SSDs in the previous-generation platform; increasing the number of NVMe drives and the additional RAID controller provided even more efficient disk writes[2]

For log-disk reads, the Dell PowerEdge R750 server was more performant than the Dell PowerEdge R740xd server, clocking in 1.6x read performance over the older platform with eight NVMe drives, and 9.0x performance with 16 NVMe drives, as shown in Figure 3.[2]

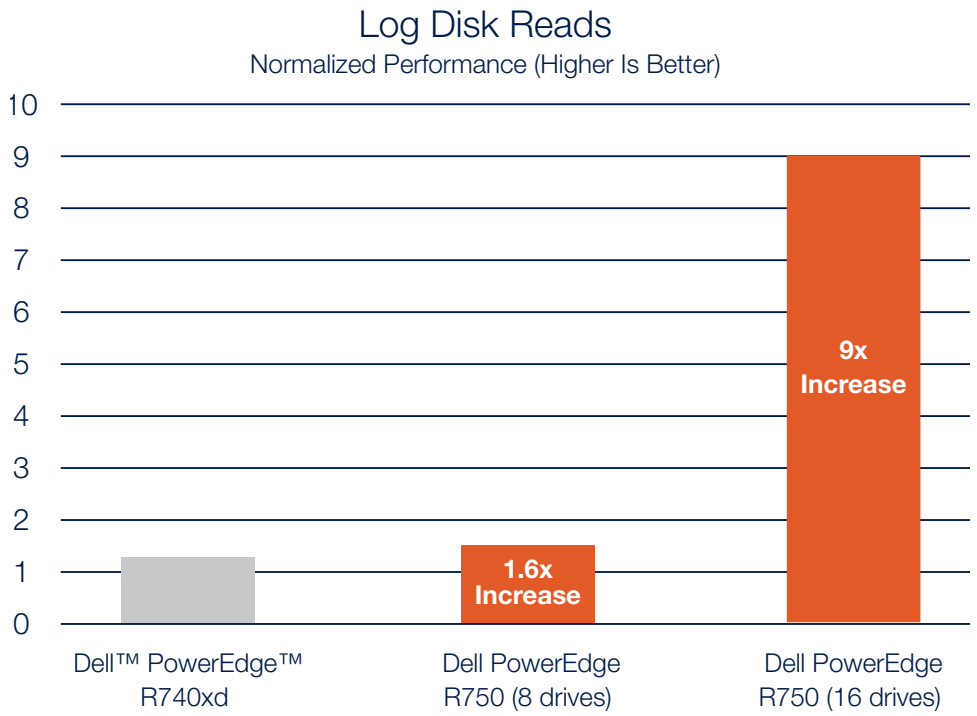


Figure 3. NVMe® drives in the newer Dell™ PowerEdge™ platform provide higher performance for log-disk reads compared to the SATA® SSDs in the previous-generation platform, with more NVMe drives providing nine times the performance for disk reads[2]

Rebuild Times Plummet

Prowess also tested the time taken to rebuild RAID arrays on Dell PowerEdge R750 servers compared to Dell PowerEdge R740xd servers.[2] When platforms are built on RAID arrays, rebuild times after a drive failure or replacement are important considerations. Downtime can result in lost productivity and—even worse—lost revenue.

Rebuild times can be critically important to organizations that are weighing the pros and cons of an upgrade. If enough other drives in the array fail while the array is rebuilding, all data in the array can be lost. For small drives, rebuild time might be manageable, but for large drives (such as those that are 1 TB or larger), the time to rebuild a RAID array can be greater than a day.[10] And this time can be longer still with inefficient RAID controllers that are slow at not just copying data onto replacement drives, but also at checking and conditioning new drives for the array.

To determine if the newer system offered an advantage in this area, Prowess compared rebuild times for the two systems described earlier. To perform this testing, our engineers removed one of the drives from the data array, and then recorded the time required to rebuild the system and resume SQL Server production use. We performed this process twice, and then repeated that process for the log file array. Figure 4 shows the median of the two runs for each array, comparing the older generation platform to the newer one. (Note that Prowess testing did not include large-size disks; absolute rebuild times in Figure 4 are less important than the proportional decrease in array-rebuild times illustrated in Prowess testing with the use of NVMe drives and RAID controllers.)

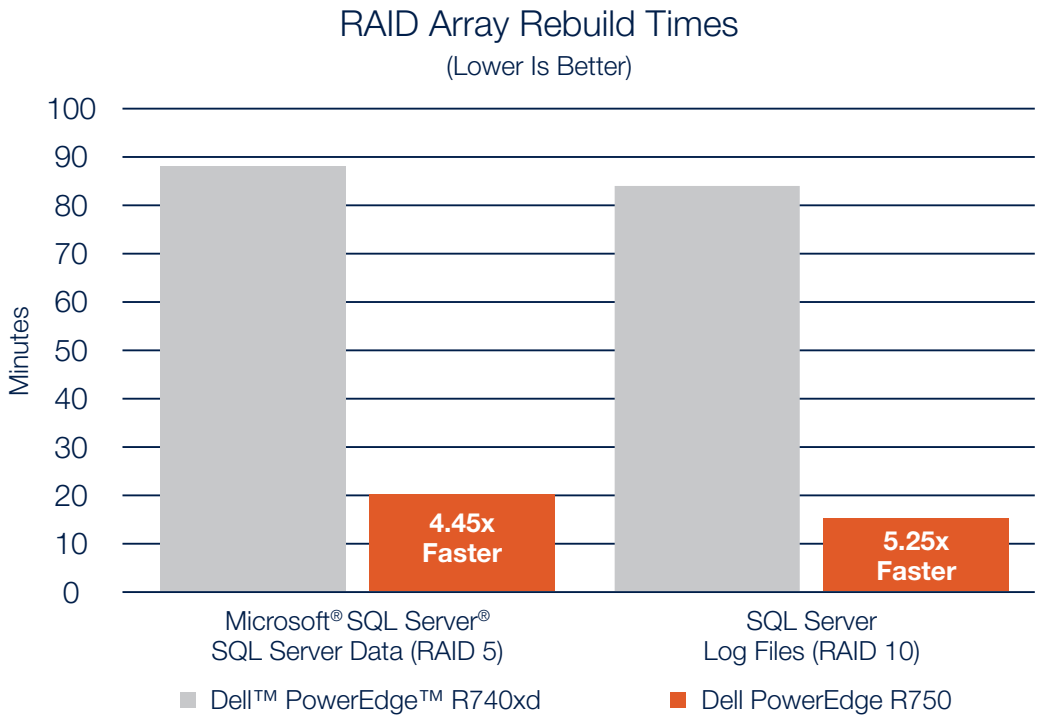


Figure 4. NVMe® storage makes rebuild times for RAID arrays considerably faster on the newer-generation platform[2]

Out with the Old, in with the New

Several differences likely accounted for the large jump in performance on the newer system. Beyond just the raw value provided by additional storage drives, these differences include 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 servers that we tested were built with two Intel Xeon Gold 6330 processors and Intel Xeon Gold 6338 processors, which include 28 and 32 cores each, respectively (the maximum number of cores supported by 3rd Generation Intel Xeon Scalable processors is 40). 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:

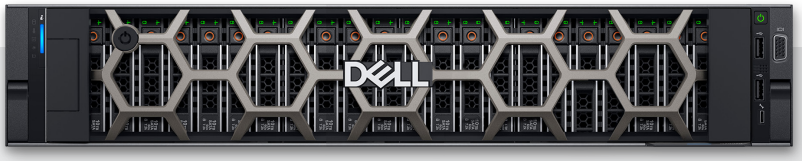
- 1.46x average generation-on-generation performance improvement[8]
- Up to 1.60x higher memory bandwidth[9]
- Up to 2.66x higher memory capacity[10]
- Up to 1.33x more PCIe lanes per processor,[11] at PCIe Gen4 speeds

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 I/O operations per second (IOPS), compared to previous generations.[12]

The Dell PERC 11 H755N Front 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 servers used in our testing paired first one and then two Dell PERC 11 H755N Front NVMe adapters with all-NVMe SSDs to maximize storage bandwidth and throughput. Previous-generation servers supported NVMe drives only as individual, discrete disks. To achieve RAID functionality, the older Dell PowerEdge R740xd server would have to be configured with slower, bandwidth-constrained SATA SSDs.



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 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.**

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.

Significant Performance Boost Justifies an Upgrade

Organizations are looking to maximize actionable information from massive and growing data volumes. For the 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 NVMe helps meet this requirement by providing critical protection for data, with significant improvements for database new order transactions and database rebuilds compared to older-generation servers built with SATA RAID drives.

The newer platform processed up to 14x more NOPM, up to 13.5x more disk writes, up to 9x more disk reads, and up to 5.25x faster RAID rebuild times compared to the older generation platform. For detailed testing methodology and configurations used in this study, see the Dell PowerEdge R740xd server versus Dell PowerEdge R750 server benchmark methodology report.

Learn More

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

[1] Datanyze. "Market Share, Databases: Microsoft SQL Server." 2021. **www.datanyze.com/market-share/databases--272/microsoft-sql-server-market-share**.

[2] Testing previously conducted by Prowess using the Dell™ PowerEdge™ R750 server powered by Intel® Xeon® Gold 6330 processors and eight NVM Express® (NVMe®) drives. For details, see: Prowess. "Can Newer Dell™ Servers Offer Significantly Better Performance for Microsoft® SQL Server®?" 2022. **www.prowesscorp.com/project/nopm-microsoft-sql-server-dell-r740xd-dell-r750-dell-poweredge/**.

[3] Intel. "Intel® SSD D3-S4510 Series." **https://ark.intel.com/content/www/us/en/ark/products/134924/intel-ssd-d3s4510-series-1-92tb-2-5in-sata-6gbs-3d2-tlc.html**.

[4] Samsung. "Today's Highest-Performing NVMe SSDs – Samsung PM1733 & PM1735." **https://news.samsung.com/global/samsung-brings-revolutionary-software-innovation-to-pcie-gen4-ssds-for-maximized-storage-performance**.

[5] KIOXIA. "CM6-V Series Enterprise SSD." **https://business.kioxia.com/en-ca/ssd/enterprise-ssd/cm6-v.html**.

[6] Recommended customer pricing provided by Intel as of January 21, 2022. For details, see **https://ark.intel.com/content/www/us/en/ark/products/192437/intel-xeon-gold-6230-processor-27-5m-cache-2-10-ghz.html**, **https://ark.intel.com/content/www/us/en/ark/products/212458/intel-xeon-gold-6330-processor-42m-cache-2-00-ghz.html**, and **www.intel.com/content/www/us/en/products/sku/212285/intel-xeon-gold-6338-processor-48m-cache-2-00-ghz/specifications.html**.

[7] Memset. "RAID Disk Failure Calculator from Memset." **www.memset.com/support/resources/raid-calculator/**.

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

[9] 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).

[10] 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).

[11] 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.

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