

Upgrading to Microsoft® SQL Server® 2019? Here's Why Dell EMC™ PowerEdge™ Servers Are a Great Option

Bundled, all-in-one solutions make upgrades easy with simplified OEM licensing and technical support.

New and improved versions of major relational database management systems (RDBMSs) are released every year or two, but business customers rarely rush to upgrade their database software. Cost-conscious management teams and overworked IT staff both face incentives to “leave well enough alone,” and, as long as critical applications are still supported on the old database servers, the resource-intensive job of performing these upgrades is often relegated to the back burner.

But if businesses continue to put off upgrades, they can fall several generations behind in their RDBMS software—and also find themselves stuck on outdated hardware. Many businesses, for example, are still relying on Microsoft® SQL Server® 2012 R2 or earlier, for which support officially ends in July 2022.¹ And in fact, as many as 60 percent of businesses running SQL Server were running SQL Server 2008 or SQL Server 2008 R2 as late as July 2019—the same month support ended for these versions.²

Relying on unsupported software is extremely risky for both your company and your customers because it leaves your servers exposed to newly discovered security exploits. And falling behind technically short-changes your organization by depriving you of the many new software enhancements and hardware advancements that help you remain competitive.

If your company is running an outdated version of SQL Server on legacy hardware, but you've been held back by concerns about the difficulty and cost of upgrading, the best way forward is to find a simple and cost-effective upgrade path from a trusted source.



Cost-effective with low total cost of ownership (TCO)



Simple licensing with one-stop support



Pre-validated all-in-one server solutions

Dell EMC PowerEdge All-in-One Solutions for SQL Server 2019

Dell Technologies provides just such an upgrade path by offering Dell EMC™ PowerEdge™ servers together with all Windows Server® 2019 and SQL Server 2019 OEM licensing. This offer of hardware bundled with software, together with Dell Technologies' no-cost pre-sales sizing tool, Live Optics (www.liveoptics.com), makes deploying SQL Server easy. And Dell Technologies' combination of one-stop technical support, rich tools for smart management, and multi-layer security helps contribute to a simple and dependable solution with low total cost of ownership (TCO).



Figure 1. To reduce TCO, you can purchase Dell EMC™ PowerEdge™ servers bundled with OEM-licensed versions of Windows Server® 2019 and Microsoft® SQL Server® 2019 Standard

Prowess evaluated this attractive option of upgrading to an OEM-licensed version of SQL Server 2019 on Dell EMC PowerEdge servers and, as part of this investigation, completed a performance analysis of running SQL Server 2019 on bare-metal PowerEdge. This paper presents the results of our evaluation.

Can You Save Money by Moving to the Standard Edition?

Some features that used to belong only to the enterprise editions in previous versions of Microsoft® SQL Server® are now available in SQL Server 2019 Standard edition. As a result, if you require these features, you might be able to save money by moving from an old enterprise edition to the current standard edition.

Transparent Data Encryption (TDE) is one such example. This built-in encryption feature first appeared in SQL Server 2008 Enterprise edition, but beginning with SQL Server 2019, it is now included in the standard edition.

Another example is PolyBase, the technology that allows SQL Server to process T-SQL queries for both relational and non-relational data. PolyBase was first introduced in SQL Server 2016 Enterprise edition, but as of SQL Server 2019, it is available in the standard edition.

Dell EMC PowerEdge Servers: A Rock-Solid Foundation for SQL Server

There are good reasons to feel confident in choosing PowerEdge as the hardware platform for your SQL Server workloads. Dell Technologies is Microsoft's largest partner, and the two companies have collaborated for decades to ensure that SQL Server runs optimally on Dell EMC PowerEdge servers. PowerEdge servers have also long acted as reliable cornerstones in the data center, dependably running SQL Server and many other crucial workloads all over the world.

Flexible, Validated Solutions for SQL Server 2019

One of the benefits of the long-standing popularity of the PowerEdge line of servers is that it is mature enough to offer an unusually wide array of validated options for SQL Server 2019, which gives you complete flexibility in selecting a solution to match your needs. These options come preinstalled with either Windows Server or Linux®, and they range from standalone servers with SQL Server 2019, to standalone servers bundled with VMware® software and SQL Server 2019, to converged solutions, to hyperconverged solutions, to a range of predefined **Dell EMC™ Ready Solutions for Microsoft SQL Server**. And these options exist in a variety of form factors, including both towers and rack servers.

Intelligent Automation and Management

IT teams in businesses of all sizes are looking to increase productivity through automation. To this end, Dell Technologies offers automation through its Dell EMC™ OpenManage™ portfolio of systems-management tools. Dell EMC PowerEdge servers also include the Integrated Dell™ Remote Access Controller (iDRAC), an agent-free, hardware-embedded server-management solution that allows your IT staff to remotely connect to your server, even when the operating system fails.

Integrated Security

When you select a server, security considerations are paramount to protect your business and your customers' businesses. PowerEdge servers answer this need by delivering a database environment with end-to-end security capabilities, from the hardware through the firmware and up the software stack.

Attackers recently have upped their game, aiming at levels below the operating system (OS), where exploits can hijack the system and evade detection by anti-malware software. PowerEdge servers offer a hardware root of trust that protects against these low-level attacks and validates that both iDRAC and Unified Extensible Firmware Interface (UEFI)/BIOS firmware are unmodified as each module is booted in a chain of trust. All firmware for critical components (network interface controllers [NICs], host bus adapters [HBAs], RAID, complex programmable logic devices [CPLDs], storage drives, power supply units [PSUs], and so on) is similarly validated by using cryptographic signatures to ensure that only authentic firmware is running on the system.

PowerEdge servers also support UEFI Secure Boot, which checks the cryptographic signatures of UEFI drivers and other code that is loaded prior to the OS running.

Another important security feature of PowerEdge servers is System Lockdown mode, included with the iDRAC Enterprise license. System Lockdown helps prevent inadvertent or malicious modification of server firmware and configuration.

The Familiarity of Windows Server® 2019

SQL Server 2019 is available in versions for both Windows Server 2019 and Linux (with support available on Red Hat® Enterprise Linux, SUSE® Linux, and Ubuntu® distributions). The Linux version does not yet offer the full set of features available on the Windows Server 2019 version, although the two are drawing closer to complete feature parity. Aside from a richer feature set, Windows Server 2019 offers the continuity, comfort, and familiarity of the Windows Server environment for IT staff who might not be as well-versed in the Linux platform.

The Blazing Performance of Intel® Optane™ Persistent Memory

Intel® Optane™ persistent memory (PMem) offers an excellent option to turbo-charge the performance of your database server. This new type of non-volatile solid-state drive (SSD) delivers DRAM-like performance with the benefits of persistence (when used in App Direct Mode) that are available with traditional storage media.

Some performance benefits of running SQL Server 2019 with Intel Optane PMem, compared to NAND SSDs, include:

- Up to 2.7x transactions per second⁴
- 171 percent faster transactional performance⁴
- 42 percent faster overall performance⁵

Note that for our benchmark testing of SQL Server 2019, Prowess Consulting used Intel Optane PMem in our PowerEdge hardware configuration.

Microsoft® SQL Server®, Then and Now

If you are running SQL Server 2008, SQL Server 2008 R2, or SQL Server 2012, SQL Server 2019 offers a number of notable updated features, including:

- More RAM and CPU support: SQL Server 2019 has grown to support the ever-increasing amount of server CPU cores and RAM. SQL Server 2019 Enterprise edition is only limited by your operating system, whereas SQL Server 2019 Standard edition supports up to 24 CPU cores and 128 GB of RAM of memory-optimized data per database in the SQL Server Database Engine.
- Always On Availability Groups: First introduced in SQL Server 2012 Enterprise edition, Always On Availability Groups are an enterprise-grade disaster-recovery alternative to database mirroring. Always On Basic Availability Groups are available in SQL Server 2019 Standard edition.
- Big-data support: SQL Server 2019 introduces SQL Server big data clusters that allow you to deploy large, scalable clusters of SQL Server, Apache Spark™, and HDFS containers running on Kubernetes®.

Performance Testing

We completed performance testing on a standalone Dell EMC PowerEdge R740xd server, running two Intel® Xeon® Gold 6246 processors with 192 GB of DDR4 RAM and 512 GB of Intel Optane PMem configured in App Direct Mode. The servers were equipped with eight 960 GB Intel® SSD DC S4610 drives. The drives were connected to a Dell EMC™ PowerEdge RAID Controller (PERC) H740P storage controller and configured as follows, in accordance with best practices and recommendations from the Dell support team:

- Two SSDs in a RAID 1 configuration for the Windows Server 2019 operating system
- Two SSDs in a RAID 1 configuration, initially used to store the SQL Server log files (these log files were later moved to persistent memory as part of pre-testing optimizations)
- Four SSDs in a RAID 6 configuration for the SQL Server data files

The standalone server also contained a dual-port 25 gigabit Ethernet (GbE) Intel® Ethernet Network Adapter XXV710 PCIe® network adapter.

Optimizations Before Testing

We configured the following performance optimizations before conducting the testing with HammerDB:

Storage Configuration

- TempDB files for SQL Server placed on a persistent memory Direct Access Storage (DAX)-enabled volume
- Log database files placed on a persistent memory DAX-enabled volume
- Database files placed on an Intel SSD RAID 6 volume
- Statically size the HammerDB database and log files in the following configurations:
 - 500 warehouses, 50 GB database size, 12.5 GB log-file size, 10 percent growth
 - 1,000 warehouses, 100 GB database size, 25 GB log-file size, 10 percent growth

Best Practices Settings

Our team configured optimizations for the following four settings before performing the benchmark testing. For detailed information about how these settings were configured, see the [appendix](#).

- **Enable a hybrid buffer pool.** This setting is new for SQL Server 2019. When database files are stored in persistent memory, SQL Server 2019 can access certain data pages directly, improving performance. More information about this feature can be found [in this Microsoft article](#).
- **Configure the max_server_memory setting.** By default, SQL Server 2019 automatically allocates all available RAM to the SQL Server process. Under some conditions, SQL Server 2019 might use memory that is needed by the operating system or other applications, which can lead to performance degradation due to disk paging. The max_server_memory setting lets administrators manually restrict the amount of memory that SQL Server 2019 accesses, which leaves memory available for other processes. More information about max_server_memory can be found [in this Microsoft article](#).
- **Enable the Lock Pages In Memory (LPIM) option.** The LPIM option is used by the account that runs the SQL Server 2019 executable (sqlserver.exe) to keep data in physical memory, rather than paging data to disk. This setting can help boost performance, and it is enabled as a Windows® policy. More information can be found [in this Microsoft article](#).

- **Configure max degree of parallelism (MAXDOP).** The MAXDOP option determines how many processors or cores can be used to execute a single statement that is part of a query that has a parallel execution plan. Highly parallelized queries can reduce speed, so MAXDOP can limit the amount of parallel executions. More information can be found [in this Microsoft article](#).

Testing Plan

Our tests included performing SQL Server performance tests running HammerDB five times for 10 minutes each with the following configurations:

- 500 warehouses with 1,000,000 transactions and 5, 10, 20, and 50 users
- 1,000 warehouses with 1,000,000 transactions and 10 users

After each test, the test database was deleted and recreated. We took the variance of the five passes to ensure that they were within plus-or-minus five percent of each other.

An Overview of HammerDB and Its Measurements

Prowess engineers used HammerDB 3.3 for the performance tests. HammerDB is an open-source database load testing and benchmarking tool that simulates users accessing both transactional and analytical database workloads. The HammerDB workload is based on the TPC-C[®] specification, but it is not a full TPC-C implementation.

HammerDB provides two measurements: transactions per minute (TPM) and new orders per minute (NOPM). TPM measures user commits plus the number of user rollbacks. However, TPM measurements are database-specific, so the TPM performance values generated by HammerDB cannot be used to compare performance between different DBMSs, such as Oracle[®] Database versus SQL Server. On the other hand, the NOPM value is based on a metric captured from within the test schema itself. As such, NOPM is a performance metric independent of any particular database implementation and is therefore the more relevant metric to use for comparing performance among different DBMSs.

Testing Results

The following charts display the results of our internal testing. These scores are useful as a model of good performance results, with the NOPM scores in Figure 3 most useful for comparing performance among different database systems.

HammerDB Results—Transactions per Minute (TPM)

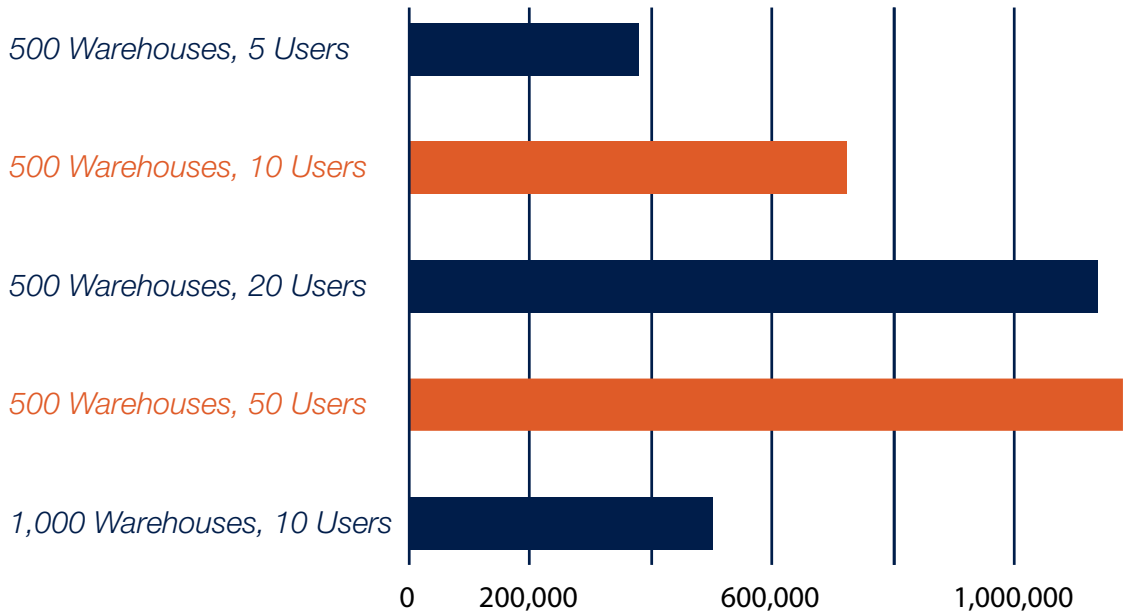


Figure 2. TPM scores in HammerDB—these scores are best used to compare performance against other systems also running Microsoft® SQL Server®

HammerDB Results—New Orders per Minute (NOPM)

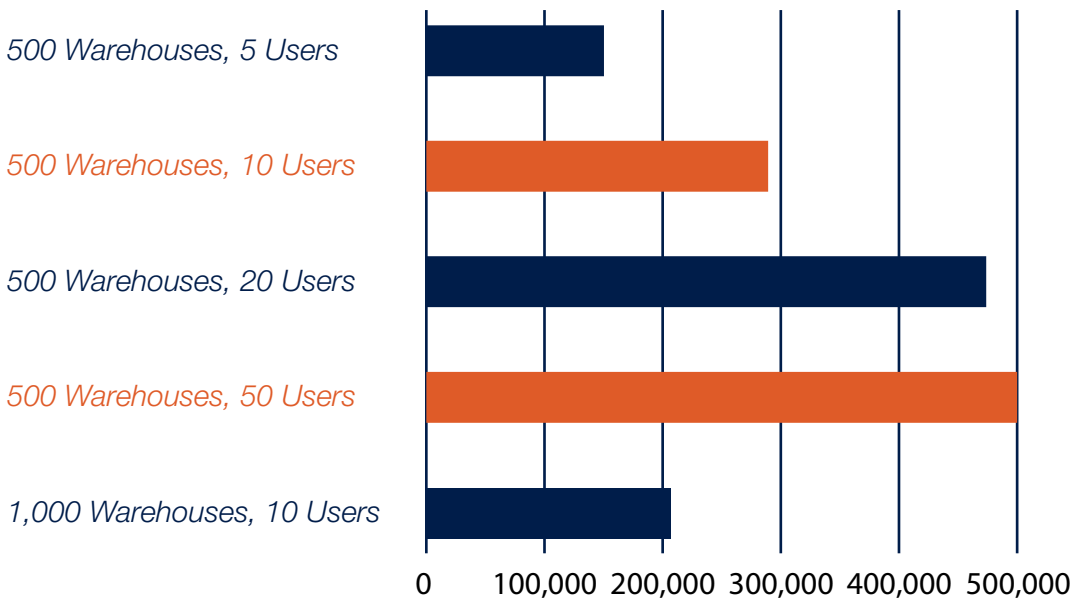


Figure 3. NOPM scores in HammerDB—these scores model good performance for comparisons among any DBMSs

These results demonstrate that a well-tuned PowerEdge server running SQL Server 2019 is capable of achieving lightning fast performance, with rates of more than one million TPM and approximately 500,000 NOPM. Note that for this testing, we used the Intel Optane PMem drives for the TempDB database and log files only. For further performance acceleration, you can also store data files in Intel Optane PMem in DAX mode, which will allow SQL Server to reduce the amount of calls along the storage stack.

The results also serve as a reminder that maximum performance is tied to specific load levels. The maximum level of performance for the PowerEdge server we tested was found at a heavy load of 500 warehouses and 50 simultaneous users for the well-known TPC-C workload. SQL Server performance will vary depending on factors such as the number of users, query complexity, indexing, database size, and availability group or cluster configuration. Depending on your environment, your results may vary.

The Simplicity of OEM Licensing and Support

The licensing aspect of a server purchase can be surprisingly complex, especially when a license is needed both for the OS (Windows Server 2019) and an application running on top of it (SQL Server 2019). IT professionals are frequently overworked, and the challenge of finding the time to determine the right licensing options can block them from following through with an upgrade. Typically, resellers also offer long-term volume licensing agreements, with confusing and expensive terms. And technical support is often divided between hardware and software, with each party able to blame the other as the root cause of any issue. That leaves your IT staff needing to assess each situation with independent research, and then spending hours going back and forth between support teams.

Through OEM licensing, Dell Technologies makes software licensing easy. Software licenses are combined and sold with Dell EMC hardware as part of a complete hardware and software solution.

Dell Technologies also simplifies support for your Dell Technologies hardware and OEM-licensed software. For example, suppose you need help configuring SQL Server 2019 for the best performance on your Dell EMC PowerEdge servers. Instead of calling Dell Technologies and Microsoft separately, Dell Technologies gives you one number to call for your OEM-licensed products and Dell Technologies hardware.

Downgrade Kit

Dell Technologies can bundle PowerEdge hardware with OEM-licensed SQL Server 2019 software, but what if your applications require SQL Server 2016 or SQL Server 2017? Dell Technologies and Microsoft can provide you with downgrade kit options for older, supported SQL Server versions. You can use these earlier versions of SQL Server until you are ready to migrate to SQL Server 2019.

Help with Getting Started Through Customer Solution Centers

Dell Technologies Customer Solution Centers help customers explore and validate the Dell Technologies portfolio of hardware, software, and solutions. Each of the Dell Technologies global Customer Solution Centers is staffed by deep subject-matter experts (SMEs), working in state-of-the-art labs equipped with the latest technologies and showcases. Services provided by Customer Solution Centers include technical briefings, architectural design workshops, and proofs-of-concept that allow customers to validate their chosen solutions. Customers can engage with their Dell Technologies account team to take advantage of one of these free services. (For more information about Customer Solution Centers, visit [this link](#).)

A Simple and Powerful Upgrade Path

Dell Technologies offers an easy, cost-effective, and pre-validated upgrade path to SQL Server 2019 through its all-in-one solution on PowerEdge servers, which provide simplified Microsoft OEM licensing and one-stop support for both hardware and software. Furthermore, our research confirmed that PowerEdge offers a high-performance platform for SQL Server 2019 workloads on Windows Server 2019.

To get you started on your upgrade path, Customer Solution Centers help you architect, validate, and build solutions to fit your particular needs.

Learn More

Dell Technologies solutions for Microsoft SQL Server: www.delltechnologies.com/en-us/solutions/sql/index.htm

Appendix

Configuration

Hardware

PowerEdge R740xd server:

- 2 x Intel Xeon Gold 6246 processors (12 cores at 3.30 GHz)
- 12 x 16 GB DDR4 DRAM at 2,667 megatransfers per second (MT/s) (192 GB total)
- 4 x 128 GB Intel Optane PMem at 2,677 MT/s (in App Direct Mode—512 GB total)
- Dell EMC PERC H740P storage controller
- 8 x 960 GB mixed-use Intel SSD DC S4610 drives
- Broadcom® dual-port 25 gigabit Ethernet (GbE) network daughter card

Software

Windows Server 2019 and SQL Server 2019 in a bare-metal environment with no virtualization.

Storage Configuration

The eight Intel SSD DC S4610 drives were allocated in the following way:

- Two drives in RAID 1 for the Windows Server 2019 operating system
- Two drives in RAID 1, used initially to store the SQL Server database log files (these log files were later moved to persistent memory as part of pre-testing optimizations)
- Four drives in RAID 6 for SQL Server database data files
- TempDB files placed on a persistent memory DAX-enabled volume
- Database log files placed on a persistent memory DAX-enabled volume
- Statically size the HammerDB database and log files in the following configurations:
 - 500 warehouses, 50 GB database size, 12.5 GB log-file size, 10 percent growth
 - 1,000 warehouses, 100 GB database size, 25 GB log-file size, 10 percent growth

Best Practices Settings

1. Enable a hybrid buffer pool for the server:

```
ALTER SERVER CONFIGURATION SET MEMORY_OPTIMIZED HYBRID_BUFFER_POOL = ON;
```

2. Configure SQL Server 2019 memory settings:

```
sp_configure 'show advanced options', 1;

GO

RECONFIGURE;

GO

sp_configure 'max server memory', 186951;

GO

RECONFIGURE;

GO
```

Note that configuring the max server memory of 186,951 MB in this case is not necessary, strictly speaking, because the maximum amount of server memory that can be assigned to SQL Server 2019 Standard edition is limited to 128 GB (131,071 MB). However, we have performed the math to determine the maximum recommended server memory to demonstrate the importance of this step for servers that have less than 128 GB of system memory available, or for servers running SQL Server 2019 Enterprise edition (which is able to consume all available system memory).

In each of these cases, you want to ensure that SQL Server 2019 does not consume more or less memory than is advisable for the overall performance of the system. Setting the **max server memory** value too high can cause a single instance of SQL Server to compete for memory with other SQL Server instances hosted on the same host. However, setting this value too low could cause significant memory pressure and performance problems.

To determine the maximum recommended server memory setting, begin by subtracting 1–4 GB from the total system memory. This memory will be reserved for the OS itself. From the remaining amount of memory, then subtract the product of the stack size (which is 2,048 KB in an x64 system) and the calculated maximum worker threads (which you can read about [in this Microsoft article](#)).

For more information about calculating the maximum server memory value, see “[Server memory configuration options](#).”

3. Configure lock pages in memory:
 - a. In the **Local Group Policy Editor** console, expand **Computer Configuration**, and then expand **Windows Settings**.
 - b. Expand **Security Settings**, and then expand **Local Policies**.
 - c. Select the **User Rights Assignment** folder. The policies are displayed in the details pane.
 - d. Double-click **Lock pages in memory**.

- e. In the **Local Security Setting – Lock pages in memory** dialog box, click **Add User or Group**.
- f. In the **Select Users, Service Accounts, or Groups** dialog box, add an account that has privileges to run sqlservr.exe.
- g. Log out and then log back in to implement the change.

4. Configure SQL Server 2019 max degree of parallelism (MAXDOP) settings:

```
EXEC sp_configure 'show advanced options', 1;

GO

RECONFIGURE WITH OVERRIDE;

GO

EXEC sp_configure 'max degree of parallelism', 12;

GO

RECONFIGURE WITH OVERRIDE;

GO
```

Testing Plan

1. Run five separate configurations of HammerDB:
 - a. 500 warehouses, 1,000,000 transactions, 5 users
 - b. 500 warehouses, 1,000,000 transactions, 10 users
 - c. 500 warehouses, 1,000,000 transactions, 20 users
 - d. 500 warehouses, 1,000,000 transactions, 50 users
 - e. 1,000 warehouses, 1,000,000 transactions, 10 users(Note that for the 500 warehouse runs, we used the Autopilot feature in HammerDB.)
2. Set **Run Time** to **10 minutes**.
3. Run five passes of each configuration of HammerDB.
4. Take the variance of the five passes and ensure that they are in the range +/- 5 percent of each other.
5. After each test, delete the test database, recreate it, and then run the test again.



Windows Server 2019



¹ End-of-support date according to <https://support.microsoft.com/en-us/lifecycle/search>.

² CRN. "Microsoft Inspire 2019: The 6 Biggest Statements From Gavriella Schuster And Judson Althoff." July 2019. www.crn.com/news/channel-programs/microsoft-inspire-2019-the-6-biggest-statements-from-gavriella-schuster-and-judson-althoff.

³ Prowess Consulting. "Streamline Your Server Deployments by Choosing Dell EMC™ PowerEdge™ Servers with Preinstalled Microsoft® Software." January 2020. www.prowesscorp.com/project/dellemc-poweredge-windowsserver-report.

⁴ Based on Dell EMC internal testing in March 2019 comparing a Dell EMC™ PowerEdge™ R740xd with 2nd Generation Intel® Xeon® Scalable processors and 2 x 1.6 TB mixed-use NVMe Express® (NVMe®) drives using Microsoft® SQL Server® 2019 CTP 2.3, VMware ESXi™ 6.7U1, and Red Hat® Enterprise Linux® 7.6GA against the same PowerEdge R740xd configuration except for substituting the NVMe drives for 12 x 256 GB DIMMs of Intel® Optane™ PMem. The workload used is derived from TPC-C® to SQL Server 2019 CTP 2.3 performance. The results obtained with the derived workload are not comparable to published TPC-C results. Actual results will vary.

⁵ Based on a Dell EMC engineering study using the TPC-C® benchmark to test Microsoft® SQL Server® 2016, July 2017. Actual performance will vary.



The analysis in this document was done by Prowess Consulting and commissioned by Dell Technologies.

Results have been simulated and are provided for informational purposes only. Any difference in system hardware or software design of configuration may affect actual performance.

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