



Technical Research Study



World-Record Performance Results for Database-Management Workloads

Prowess research uncovers servers from Dell Technologies that offer exceptional performance with security for critical database-management workloads.

Executive Summary

To say database-management systems (DBMSs) are widespread would be an understatement. Nearly every business stores critical data in systems that need to be managed, backed up, secured, and optimized for exceptional user performance. Relational database management systems (RDBMSs) alone account for 71.2 percent of all database model categories.¹ These RDBMSs include several popular systems, such as Microsoft® SQL Server®, MySQL®, Oracle® Database, and PostgreSQL®, which are used to store and serve data for everything from customer details, product inventory, and sales data to insurance tables, finance and stock information, and health records.

Regardless of the DBMS in use, all need to be run on platforms that can provide exceptional performance, a good price/performance ratio, and strong security.

Because of this variety of use cases, organizations might struggle to find useful performance metrics they can relate to their own DBMS environments. As a result, many organizations turn to industry-standard benchmarks to simplify the evaluation process prior to making a spending decision. Benchmarks can provide valuable insights, but they must be evaluated properly.

In order to investigate the relationship between high benchmark performance and potential business value in the real world, Prowess Consulting dug deeper into what strong showings in industry benchmarks can mean for businesses deploying world-record servers. Because of its large market share and the number of world records Dell Technologies holds across a variety of database-management-related benchmarks, we specifically looked at Dell™ PowerEdge™ servers.

Among recent-generation Dell PowerEdge servers powered by 3rd and 4th Gen AMD EPYC™ processors, we identified several that have set world records in benchmarks specifically designed to provide real-world performance data on DBMS workloads:

- **The PowerEdge R7625 and PowerEdge R7615 servers set world records for the SAP® Sales and Distribution (SD) benchmark.**^{2,3}
- **The PowerEdge R7525 server holds the world record for the TPC Express Benchmark™ V (TPCx-V) benchmark for top overall score and top two-socket platform score.**²
- **The PowerEdge R7515 server holds the world record for the TPCx-V benchmark for top price-performance score and top one-socket platform score.**²
- **The PowerEdge R7515 and PowerEdge R6525 servers hold world records for the TPC-H benchmark.**⁴

Our research focused on what each benchmark and world record means in practical terms for businesses. We also looked deeper to see which specific components contributed to the results. Our findings identified several AMD® processor benefits, including high core counts and frequencies, support for large quantities of memory, and other advancements that can help reduce latency.

In addition, the TPCx-V benchmark record-setting servers from Dell Technologies were built using dual Broadcom® NVM Express® (NVMe®) RAID controllers, which contributed to the record-setting performance results.

This study covers the following topics:

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Industry Landscape: DBMS

Businesses of all types and sizes rely on DBMSs for critical and day-to-day functions. Shipping and logistics companies rely on systems for warehouse inventory and shipping logs. Retailers track customer and shipping information. Healthcare organizations store patient records. The list is endless.

While many of these businesses have turned to public clouds for managing their database systems, applications, and data, many others keep their systems on premises for a variety of reasons. Working with data close to where it resides can help reduce latency for applications. Additionally, regulatory requirements and data-sovereignty laws can influence a decision to keep data on premises. Regardless of the reasons, organizations that choose to run their workloads on premises often struggle to determine which server platforms will best meet their specific needs. In all cases, performance is a core requirement for businesses that want to maximize the experience for users that need to quickly access and process mission-critical data.

The demands of database-management workloads mean that the supporting infrastructure must be tuned to provide optimum performance. The interplay of processor, memory size, network bandwidth, and storage subsystems is critical. One common way to compare server performance for this interplay is to consult benchmark results. Because benchmarks produce numeric results, comparisons between competing systems can feel straightforward.

Precisely because benchmarks produce clear and seemingly objective results, however, understanding what they measure—and thus what they actually say about server platforms—is crucial. Organizations that ignore this nuance might be led astray on purchasing decisions.



Prowess Research Methodology

In order to investigate the relationship between high benchmark performance and potential business value in the real world, Prowess Consulting dug deeper into what strong showings in industry benchmarks can mean for businesses running DBMSs.

For our analysis, we specifically looked at Dell PowerEdge rack-mount servers. This is because Dell Technologies has the largest market share of servers worldwide (17.2 percent),⁵ and because Dell PowerEdge servers are popular workhorse machines, built for a variety of database workload needs. Furthermore, optimized PowerEdge servers enable a high degree of flexibility for customers to run their unique workloads according to their specific requirements.

We also selected Dell PowerEdge servers because of the number of world records Dell Technologies holds. A single benchmark world record is impressive, but what stands out for database-management workloads is that Dell platforms achieve world records across multiple benchmarks. Each benchmark can be viewed as a piece of the workload puzzle, and the achievement of multiple world records provides good insight into how Dell platforms will operate in real-world environments. When examining the benchmark results, it is important to focus on the factors that are of top importance to businesses running DBMS workloads. These include:

- Performance
- Price/performance

Dell Technologies offers several PowerEdge servers built on 4th Gen AMD EPYC processors, which offer many price-performance benefits of interest to businesses running database workloads. In addition, Dell Technologies has optimized performance for its PowerEdge platforms by incorporating newer Dell™ PowerEdge™ RAID Controller (Dell™ PERC) cards and Broadcom NVMe network adapters that bring significant bandwidth improvements to the table.

Database-Management Workload Benchmarks

We looked at three specific industry benchmarks designed to highlight database workload performance:

SAP® Sales and Distribution (SD) benchmark	Provides performance and sizing information to help evaluate server needs
TPC Express Benchmark™ V (TPCx-V)	Measures database performance in a virtualized workload environment
TPC-H	Measures database performance and price-performance for database queries performed with a variety of database sizes

DBMS Workloads: SAP® Sales and Distribution (SAP SD) Benchmark

SAP SD is a core functional module in SAP ERP Central Component (ECC) that allows organizations to store and manage customer- and product-related data. Organizations of all sizes use this data to manage sales ordering, shipping, billing, and invoicing of their goods and services.

SAP Standard Application Benchmarks, including the SAP SD benchmark, can help customers and partners find the appropriate hardware configurations for their IT solutions. SAP developed these benchmarks to test the hardware and database performance of SAP® applications and components on a variety of platforms.

The SAP SD benchmark, in particular, measures the number of benchmark users and the transactions per hour. These results provide useful data points that organizations can use to compare the performance, scalability, and power efficiency of platforms running RDBMSs and associated business applications.

The Dell PowerEdge R7615 server, powered by 4th Gen AMD EPYC processors, set an SAP SD world record for the number of benchmark users for single-socket platforms.³

In addition, the PowerEdge R7625 server, powered by 4th Gen AMD EPYC processors, set an SAP SD world record for the number of benchmark users on two-socket platforms.³ Notably, this two-socket server outperformed all published four-socket platforms for this benchmark.

The results demonstrate that these Dell PowerEdge platforms would be an ideal choice for any organization that relies on high performance for sales tracking and billing queries.

DBMS Workloads: TPC Express Benchmark™ V (TPCx-V)

To maximize efficiency, management, and support, organizations frequently rely on virtualization for their database workloads. This adds a layer of complexity for evaluating server infrastructure. Our research determined that the TPCx-V benchmark would be an ideal fit for measuring database performance in a virtualized environment. The TPCx-V benchmark measures the performance of a virtualized server platform under a demanding PostgreSQL database workload. The benchmark models multiple virtual machines (VMs) running at different, fluctuating load-demand levels.

Higher scores in this benchmark are heavily influenced by processor performance, memory, and network bandwidth. Interestingly, bandwidth for the RAID controllers also plays a significant role for this benchmark. Businesses that deploy mission-critical database workloads are required—whether internally or from industry or government regulations—to ensure data integrity through backups and redundancy, even in a virtualized environment. The TPCx-V benchmark takes this into consideration.

The PowerEdge R7525 server, powered by 3rd Gen AMD EPYC processors, holds the top published overall score and top 2-socket score for the **TPCx-V benchmark**, with 3,600 transactions per second for virtualized workloads (TpsV).² In addition, the PowerEdge R7515 server, also powered by 3rd Gen AMD EPYC processors, holds the record score for 1-socket servers, with a score of 1,520. The same server offers the best published price/TpsV ratio as well: \$35.50 USD/TpsV, showing the ability of the PowerEdge R7515 server to provide a compelling price/performance benefit for organizations.²

DBMS Workloads: TPC-H Benchmark

Real-world businesses often run database platforms that are forced to respond to ad-hoc queries and modifications that fluctuate widely throughout the day. Decision support systems (DSSs), which exemplify this pattern, are widely used across industries for a variety of tasks, including medical diagnosis, credit analysis for loan applications, or performing engineering risk assessments for large structures, such as bridges or dams.

Prowess set out to identify a benchmark that could accurately reflect these varied usage platforms. The TPC-H benchmark fills this role well because it can reflect a wide range of database sizes and can be run with a variety of databases and operating systems. This capability means organizations can better align benchmark results from specific platforms and databases to the specific needs of their businesses, resulting in more accurate evaluations.

Specifically, TPC-H examines DSSs that are built to examine large volumes of data, execute queries with a high degree of complexity, and give answers to critical business questions.

The first performance metric reported by TPC-H is queries-per-hour. This metric reflects the capability of the system to process queries by looking at several factors: the selected database size against which the queries are executed, the query processing power when queries are submitted by a single stream, and the query throughput when queries are submitted by multiple concurrent users.

The performance metric is further evaluated against cost in a TPC-H price/performance metric that expresses dollars-per-query-per-hour performance. This metric provides a useful “apples-to-apples” comparison that businesses can use to more accurately evaluate systems.

The following Dell PowerEdge servers, built on 3rd Gen AMD EPYC processors, hold published world records for the TPC-H benchmark:⁴

- TPC-H benchmark 1 TB database category: PowerEdge R7515 server running SQL Server on Red Hat® Enterprise Linux®
- TPC-H benchmark 10 TB database category: PowerEdge R6525 server running Exasol® on Ubuntu® Linux
- TPC-H benchmark 100 TB database category: PowerEdge R6525 server running Exasol on Ubuntu Linux

These results demonstrate the ability of these Dell PowerEdge platforms to provide not only outstanding performance, but also an attractive price/performance ratio. Businesses looking to achieve performance with efficiency will find these results useful for their purchasing decisions.

Behind the Performance Results

Looking at published specifications for the primary components in the tested systems provides insights into the benchmark results. The newer Dell™ platforms that achieved world-record scores were powered by 4th Gen AMD EPYC processors, powered by AMD Zen 4 microarchitecture. These latest-generation CPUs offer strong performance, performance per watt, and performance per CPU dollar.

Performance gains can be traced to several platform improvements over the previous-generation platform, including:

- 50 percent increase in core count,⁶ increased thread count, and higher frequencies, which can directly increase processing performance.
- 12 DIMMs/socket (up from 8), which allows organizations to significantly increase available memory. This translates to greater database workload performance.
- DDR5 memory support for faster access by applications.
- Advanced Vector Extensions (AVX-512) support, which enables 4th Gen AMD EPYC processors to complete more simultaneous calculations in their registers.
- Greater L2 cache, doubled from 512 KiB to 1 MiB per core, which also accelerates operations in memory.
- PCIe® Gen 5 support, which enables faster interconnects to move more data with lower latency.

Overall, 4th Gen AMD EPYC processors operate more efficiently than their predecessors. The Standard Performance Evaluation Corporation's SPEC CPU® 2017 Floating Point Rate results show a gain in performance of 121 percent in tests run on a system powered by 4th Gen AMD EPYC processors, compared to a system powered by 3rd Gen AMD EPYC processors.⁷ The SPEC CPU 2017 Integer Rates results showed gains of 102 percent.⁸ These processor performance results are reflected in the world-record benchmark results achieved by several of the PowerEdge platforms we examined.

The number of cores in these processors increased by 50 percent, compared to the previous generation, which also boosts performance. At the same time, published specifications from AMD show an increase in maximum default power consumption of only 42 percent, from 280 watt thermal design power (TDP) to 400 watt maximum TDP.⁹ When compared to the SPEC performance results above, these power numbers show the capability for servers built on 4th Gen AMD EPYC processors to provide up to a 55 percent power-performance benefit for businesses running database workloads.¹⁰

Our research also discovered that Dell Technologies offers PowerEdge platforms with optional "F"-designated SKUs from AMD. These higher-frequency processors are designed specifically to boost performance for transactional databases. The Dell PowerEdge 7515 server that achieved a world record in TPC-H benchmark testing was powered by an AMD EPYC "F" processor, which likely contributed to its exceptional performance.

The TPCx-V benchmark, which measures virtualized databases, also reflects the significant performance contributions from the Broadcom RAID controllers. Organizations deploying databases require RAID controllers for redundancies to meet internal or regulatory requirements. The PowerEdge servers that set TPCx-V world records were outfitted with Broadcom controllers with fast NVMe RAID support.

AMD® Hardware-Based Security

For all the workloads evaluated in this research study, security considerations are critical. 3rd Gen AMD EPYC™ processors and 4th Gen AMD EPYC processors can provide hardware-based security for database-management workloads. AMD® Secure Memory Encryption (AMD® SME) encrypts system memory to protect data in use. AMD® Secure Encrypted Virtualization (AMD® SEV) protects running VMs so that they are encrypted and isolated from each other and the host-system hypervisor. AMD® Secure Encrypted Virtualization-Encrypted State (AMD® SEV-ES) encrypts the CPU register contents of stopped VMs to protect the data stored in them. And AMD® Secure Boot protects servers during the boot process, providing defenses against rootkits, bootkits, and firmware while servers are most vulnerable.

In addition, businesses can gain a performance boost from dual-port Broadcom 100 gigabit Ethernet (GbE) network adapters built on the Open Compute Project (OCP) NIC 3.0 form factor. These modern designs reflect a rapid shift in the industry toward 100 GbE adapters built on a more efficient form factor and enabled by PCIe 4.0 and PCIe 5.0. In addition, support for PCIe 4.0 and PCIe 5.0 can provide performance numbers from a single NIC that are on par with dual 100 Gbps NICs. The OCP NIC 3.0 specification enables server manufacturers like Dell Technologies to use more compact designs that can support high-performance adapters with advanced hardware-acceleration capabilities.¹¹ In the benchmarks we examined, these advanced Broadcom adapters helped remove bandwidth limitations that would otherwise add latency to the workloads.

Dell™ PowerEdge™ RAID Controller (Dell™ PERC) Cards Protect Data and Boost Storage Performance

Modern PCIe® Gen 4 RAID interfaces work with high-bandwidth NVM Express® (NVMe®) solid-state drives (SSDs) to significantly boost storage performance. Dual Dell PowerEdge RAID Controller 11 and 12 (PERC 11 and PERC 12) cards and NVMe® adapters with both PCIe Gen 4 host and PCIe Gen 4 storage interfaces can help remove bandwidth and latency constraints.

Conclusion

Benchmark results in general (and world-record results in particular) are about more than bragging rights for server manufacturers. Interpreted correctly, best-in-industry results in benchmarks can offer insights as to how servers could perform in real-world use cases. Because of the company's market share and number of world records, PowerEdge servers from Dell Technologies provided a natural opportunity to examine how benchmark results can map to performance benefits for organizations in production.

While no mapping of benchmark performance (world record or otherwise) is 1:1, our investigation of three benchmarks shows compelling advantages for deploying Dell PowerEdge platforms as database-management workload servers across several use cases in a variety of industries.

Appendix A: Benchmark Performance Links

- SAP SD top performance results: www.sap.com/dmc/exp/2018-benchmark-directory/#/sd
- TPCx-V top performance results: www.tpc.org/tpcx-v/results/tpcxv_perf_results5.asp
- TPC-H top performance results www.tpc.org/tpch/results/tpch_perf_results5.asp

Appendix B: Dell Technologies System-Specification Links

- Dell PowerEdge server specification sheets: www.dell.com/en-us/dt/servers/poweredge-rack-servers.htm

¹ DB-Engines. "Knowledge Base of Relational and NoSQL Database Management Systems." October 2022. https://db-engines.com/en/ranking_categories.

² TPC. "TPCx-V Top Performance Results." Scores accessed as of October 31, 2022. www.tpc.org/tpcx-v/results/tpcxv_perf_results5.asp.

³ SAP. "SAP Standard Application Benchmarks & Certified Hardware for SAP Solutions on Microsoft Windows." Scores accessed as of November 10, 2022. www.sap.com/dmc/exp/2018-benchmark-directory/#/sd.

⁴ TPC. "TPC-H Top Performance Results." Scores accessed as of October 31, 2022. www.tpc.org/tpch/results/tpch_perf_results5.asp?resulttype=all&version=3.

⁵ History-Computer. "The 10 Largest Server Companies In The World, And What They Do." September 2022. <https://history-computer.com/largest-server-companies-in-the-world-and-what-they-do/>.

⁶ Tom's Hardware. "Zen 4 Madness: AMD EPYC Genoa With 96 Cores, 12-Channel DDR5 Memory, and AVX-512." www.tomshardware.com/news/zen4-madness-amd-epyc-genoa-with-96-cores-12-channel-ddr5-memory-and-avx-512.

⁷ Up to 121 percent higher SPEC® Floating Point performance comparing top bin 4th Gen AMD EPYC™ processors with top-bin 3rd Gen AMD EPYC processors based on SPEC Floating Point rate score of 1,410 achieved on a Dell™ PowerEdge™ R7625 server powered by AMD EPYC 9654 processors, compared to a score of 636 achieved on a Dell PowerEdge R7525 server powered by AMD EPYC 7763 processors. Scores accessed as of November 10, 2022. See Standard Performance Evaluation Corporation benchmark results. <http://spec.org/benchmarks.html>.

⁸ Up to 102 percent higher SPEC® Integer Rate performance comparing top bin 4th Gen AMD EPYC™ processors with top-bin 3rd Gen AMD EPYC processors based on SPEC Integer rate score of 1,660 achieved on a Dell™ PowerEdge™ R7625 server powered by AMD EPYC 9654 processors, compared to a score of 821 achieved on a Dell PowerEdge R7525 server powered by AMD EPYC 7763 processors. Scores accessed as of November 10, 2022. See Standard Performance Evaluation Corporation benchmark results. <http://spec.org/benchmarks.html>.

⁹ AMD. AMD EPYC 7003 Series processors specifications webpage. www.amd.com/en/processors/epyc-7003-series.

¹⁰ 55 percent CPU performance per watt improvement calculated using the SPEC® Floating Point score of 1,410 achieved on a Dell™ PowerEdge™ R7625 server powered by AMD EPYC™ 9654 processors with a processor cTDP of 400 watts, compared to a score of 636 achieved on a Dell PowerEdge R7525 server powered by AMD EPYC 7763 processors with a processor cTDP of 280 watts.

¹¹ Broadcom. "NetXtreme E-Series OCP NIC 3.0 Ethernet Adapters." 2021. <https://docs.broadcom.com/doc/12395120>.

