Technical Research Study

PROWESS

World-Record Power-Performance Results for Virtualization Workloads

Prowess research discovered servers from Dell Technologies that offer efficient power-performance advantages for businesses that rely on virtualized infrastructure.

Executive Summary

It's no exaggeration to say that virtualized infrastructure is ubiquitous. According to one study, more than 92 percent of businesses in North America and Europe rely on server-virtualization technology.[1] However, the workloads that are run in those virtualized environments, and the types of businesses that run those workloads, can vary dramatically. Small to medium-sized businesses (SMBs) often host a wide mix of server workloads on a single, reliable server. Businesses of all sizes host database workloads on virtual machines (VMs). And some businesses, such as healthcare organizations, might serve virtual desktop infrastructure (VDI) to users from a single, efficient physical server.

Because of this variety of use cases, organizations might struggle to find useful performance metrics they can relate to their own 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, provided they are evaluated in the right way.

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 outsized market share and the number of world records Dell Technologies holds across a variety of benchmarks, we specifically looked at Dell™ PowerEdge™ servers.

We identified several Dell™ servers that hold top spots in benchmarks specifically designed to provide real-world performance data on virtualized workloads:

- **The Dell 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 Dell 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 R7525 and PowerEdge R7515 servers hold the top two spots for the VMmark® 3.x power-performance benchmark.[3]**
- **The Dell PowerEdge R7515 server holds the top three spots for the VMmark 3.x 2-socket platform performance benchmark.[3]**
- **The Dell PowerEdge R6525 server holds the world record for the VMmark 3.x overall performance benchmark.[3]**

Our research focused on what each benchmark and world record means in practical terms to businesses. We also dug deeper to determine what specific components contributed to the results. Our findings identified several AMD EPYC™ processor benefits, including high core counts and support for large quantities of fast DDR4 memory in 3rd Gen AMD EPYC processors. 4th Gen AMD EPYC processor–based platforms take performance to new levels with even higher core counts and frequencies, larger quantities of higher speed DDR5 memory, and PCIe® Gen 5 interconnects that can 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:

Industry Landscape: Virtualization

Although many businesses have turned to public clouds for managing their workloads and data, many others prefer to keep some or all of their workloads on premises. There are many reasons for this decision. Working with data close to where it resides can help reduce the latency for applications. Moreover, regulatory requirements and data-sovereignty laws can also be compelling reasons to keep data on premises, depending on an organization's industry and location. Regardless of the reasons, when organizations choose to run workloads on premises, they frequently make strong use of virtualization for maximum efficiency, management, and control of workloads.

For example, retail businesses might roll out point-of-sale (POS) software through virtualization. SMBs frequently deploy only one or two physical servers that can run all of their general server needs, from email to productivity software to accounting workloads. Healthcare organizations often rely on VDI to maintain greater control and security over the desktops and applications used by doctors, nurses, clinicians, and other staff.

In all of these use cases, reliable performance is clearly important for business continuity and innovation. But in today's infrastructure environment, organizations have several options for server hardware that can meet essential performance needs for virtualization. This is because virtualized workloads typically do not require cutting-edge horsepower. There are cases where diverse, aggregated workloads might still put high demand on the underlying physical server, but for most businesses evaluating platforms for virtualized workloads, the power-performance ratio is a more critical reference point than raw performance.

Power and cooling costs continue to escalate globally, putting increasing pressure on businesses to increase efficiencies proportionally. That, in turn, incentivizes IT administrators to find ways to do more with less via fewer, more efficient servers.

For server OEMs, there are several ways to provide these benefits to customers. Certainly, better cooling systems and more efficient power supplies can help. But the greatest gains tend to come from modern CPU designs that can offer increased power without corresponding increases in heat output. At the same time, OEMs are finding several ways to improve operational efficiencies that don't rely on simply ramping up power. Support for larger quantities of faster, more efficient memory is one way to achieve such efficiencies. Higher-bandwidth input/output (I/O) is another.

For businesses in search of ideal power-performance results, comparisons and evaluations can be tricky. Server, processor, and platform specifications can provide valuable input by indicating CPU performance, memory speeds and quantities, and networking and storage I/O capabilities.

Benchmarks, if examined properly, can be valuable for comparing systems. Because benchmarks produce numeric results, comparisons between competing systems can seem straightforward. But to effectively translate those results into purchasing decisions can require some nuance. It's critical to understand precisely what a given benchmark measures and how the tested server's components contributed to the results. Organizations that ignore this nuance and simply rely on finding the top benchmark scores might face a disappointing return on investment (ROI).

Prowess Research Methodology

In order to determine a more effective way to evaluate servers for virtualization workloads, we investigated both benchmarks and specifications. For benchmarks, we focused on industry-proven tests that can provide insights into performance for virtualization workloads. Then we examined specifications for critical components that contribute to performance and, more specifically, power-performance results.

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%),[4] and because Dell PowerEdge servers are popular workhorse machines, built for standard to medium-heavy virtualized 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 virtualization 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 these benchmarks results, it is important to focus on the factors that are of top importance to businesses running virtualized workloads. These include:

- Performance
- Power-performance

Dell Technologies offers several PowerEdge servers built on 4th Gen AMD EPYC processors, which offer many power-performance benefits of interest to businesses running virtualized 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.

Virtualization Workload Benchmarks

For this study, we looked at two specific industry benchmarks designed to highlight virtualization workload performance:

TPC Express Benchmark™ V (TPCx-V)	Measures database performance in a virtualized environment
VMmark® 3.x	Measures power-performance for mixed virtualized workload environment

Virtualized Database Workloads: TPC Express Benchmark™ V (TPCx-V)

From retail stores running POS terminals to real-estate brokerages with customer and property databases to health clinics with patient records, businesses across the spectrum rely on virtualized database workloads for daily operations. Organizations looking to evaluate server platforms for virtualized database performance often rely on the TPCx-V benchmark because it measures the performance of a virtualized server platform under a demanding PostgreSQL® database workload. The TPCx-V benchmark models multiple 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 as well.

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 the 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]

Virtualized Mixed Workloads: VMmark® 3.x Power-Performance Benchmark

The VMmark 3.x power-performance benchmark offers a reliable, repeatable way to compare the performance and power consumption of different virtualization hosting platforms. It can be used to determine the performance impact an organization would see from making specific changes to the hardware, software, or configurations within the virtualization environment.
As a result, companies that plan to move, or that have already moved, to a highly or fully virtualized environment can gain insight on how well these platforms will perform when running their specific applications.

The VMmark 3.x benchmark combines commonly virtualized applications into predefined bundles called “tiles.” The benchmark score is based on the number of VMmark tiles a virtualization platform can run, in addition to the cumulative performance of the tiles and their respective workloads.

This benchmark is relevant for SMBs and larger enterprise organizations that need to run a wide range of workloads in virtual environments. The power-performance variant of VMmark 3.x is of particular relevance for our study because it doesn’t focus strictly on overall performance. Instead, it provides a result based on performance in relation to power usage as performance per kilowatt. This is a useful data point for most businesses deploying general-purpose virtualization workloads because it allows IT decision makers (ITDMs) to consider both capital expenditures (CapEx) and operating expenses (OpEx) when evaluating data center infrastructure for purchase.

Higher power-performance abilities can reduce costs by increasing utilization. Organizations can run more virtualized workloads or complete workload tasks faster, which can free up time for other uses. In addition, businesses can take advantage of greater processing capabilities to reduce the number of physical servers they need to purchase and support.

The Dell PowerEdge R7525 and R7515 servers, powered by 3rd Gen AMD EPYC processors, occupy the top two spots on VMware’s listings for the **VMmark 3.x power-performance benchmark**, with scores of 10.339 and 8.1263 performance per kilowatt (PPKW), respectively.[3] Based on this strong showing, organizations looking for efficient, power-optimized performance for general-purpose needs would be well-served by placing either of these Dell PowerEdge servers near the top of their list for purchasing consideration.

In addition, the Dell PowerEdge R7515 server holds the top three spots for the VMmark 3.x 2-socket platform performance benchmark, and the Dell PowerEdge R6525 server holds the world record for the VMmark 3.x overall score.[3]

Behind the Performance Results

Looking at published specifications for the primary components in the tested systems provides insights into the benchmarks results. The Dell platforms that achieved world-record scores were all powered by AMD EPYC processors. The platforms that set records in the TPCx-V and VMmark benchmark configurations were all powered by 3rd Gen AMD EPYC processors, which offer strong performance, performance per watt, and performance per CPU dollar. Performance gains can be traced to several factors, including high core counts and frequencies and support for large quantities of fast DDR4 memory.

4th Gen AMD EPYC processors, built with AMD® Zen 4 microarchitecture, take performance and efficiency even further by offering several platform improvements over the previous-generation platform, including:

- 50 percent increase in core count,[5] 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 more virtualized workloads or greater numbers of VDI sessions that can be supported on a given server.
- DDR5 memory support for faster access by applications.
- Advanced Vector Extensions 512 (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.[6] The SPEC CPU 2017 Integer Rates results showed gains of 102 percent.[7] 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.[8] 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 virtualized workloads.[9]

The TPCx-V benchmark, which measures virtualized databases, also reflects the performance brought to the table by 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 dual 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 virtualization 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, Dell PowerEdge platforms are available with Broadcom 100 gigabit Ethernet (GbE) network adapters built on the Open Compute Project (OCP) network interface controller (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.[10] These advanced Broadcom adapters can help 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® Gen4 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 uses. Because of the Dell Technologies market share and number of world records it holds, its PowerEdge servers provide a natural opportunity to examine how benchmarks 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 two benchmarks, along with server processors and components, shows compelling advantages for deploying Dell PowerEdge platforms as virtualization-workload servers across several use cases in a variety of industries.

Appendix A: Benchmark Performance Links

- TPCx-V benchmark: **www.tpc.org/tpcx-v/results/tpcxv_perf_results5.asp**
- VMmark 3.x power-performance benchmark: **www.vmware.com/products/vmmark/results3x.html**

Appendix B: Dell Technologies System-Specification Links

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

[1] Spiceworks. "The 2020 State of Virtualization Technology." September 2019. **www.spiceworks.com/marketing/reports/state-of-virtualization/**.

[2] TPC. "TPCx-V Top Performance Results." Scores recorded on October 31, 2022. **www.tpc.org/tpcx-v/results/tpcxv_perf_results5.asp**.

[3] VMware. "VMmark 3.x Results." Scores recorded on October 19, 2022. **www.vmware.com/products/vmmark/results3x.html**.

[4] 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/**.

[5] 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**.

[6] 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**.

[7] 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**.

[8] AMD. AMD EPYC 7003 Series processors specifications webpage. **www.amd.com/en/processors/epyc-7003-series**.

[9] 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.

[10] Broadcom. NetXtreme E-Series OCP NIC 3.0 Ethernet Adapters Product Brief. 2021. **https://docs.broadcom.com/doc/12395120**.