Technical Research Study

PROWESS

A Path to Virtualization at the Edge

Get next-generation performance at the edge from the Dell™ PowerEdge™ XR family of servers.

Executive Summary

Edge sensors and devices generate data on a massive scale. And much of the data is generated in rugged environments. Heavy machinery used in underground mining operations, for example, can be outfitted with smart sensors to monitor gas concentrations, air quality, and temperature. Once this data is captured by a high-performance edge server, an analytics application processes the data to generate real-time insights.

Prowess Consulting investigated options for organizations looking for rugged edge servers with the performance needed for compute-intensive analytics. We started by evaluating the Dell™ PowerEdge™ XR7620 server, a member of Dell Technologies' PowerEdge XR rugged servers portfolio. We looked at performance, durability, and compliance to military and telecom industry standards.

We then compared the PowerEdge XR7620 server to the PowerEdge XE2420 server, a previous-generation rugged edge server, and observed significant generational performance gains. Finally, we compared the PowerEdge XR7620 server to another member of the PowerEdge XR family, the PowerEdge XR4000 series servers. This helped us summarize key differences between the PowerEdge XR7620 server and the PowerEdge XR4000 series servers. We found that, for organizations looking for the ideal edge server, the PowerEdge XR7620 server delivers high performance, including excellent virtualization capabilities and VMware vSAN™ performance, whereas the PowerEdge XR4000 series servers deliver excellent density and deployment flexibility.

Life at the Edge

Modern businesses are processing more data at the edge. This brings a unique set of requirements for edge servers: the need for high performance, the ability for a server to fit into tiny spaces, and the ability to tolerate the extremes of remote field deployments, whether on a manufacturing floor or in a busy retail environment.

Workloads like data analytics and AI/machine learning (ML) that process data at the edge drive the need for high performance. Decoupled from your data center, servers at the edge combat a host of environmental and logistical challenges. A factory that combines Internet of Things (IoT) and digital twin technologies to automate resource allocation and optimize efficiency through analytics and AI will need servers on the factory floor to generate actionable data. And that means exposure to heat, vibration, dust, and more.

How your organization addresses the dual considerations of performance and durability inherent to edge computing is key. Regardless of your solution, maximizing performance and safeguarding against harsh environments is critical.

The PowerEdge XR7620 Server: Performance and Durability at the Edge

Performance

Research by Prowess Consulting shows that the new PowerEdge XR7620 server, powered by 4th Gen Intel® Xeon® Scalable processors, can meet the challenges of ensuring performance and durability. The PowerEdge XR7620 server is a two-socket server featuring data center–level compute with high performance, high capacity, and reduced latency. Moreover, its rugged form factor ensures performance-protecting durability, from military deployments to the factory floor. The PowerEdge XR7620 server can process and analyze data at the point of capture for maximum impact when away from the data center. Given its high performance, the PowerEdge XR7620 server excels at tasks like virtualization.

The PowerEdge XR7620 server also offers compact GPU- and CPU-optimized variants to further customize performance.

Durability

The PowerEdge XR7620 server—like the entire PowerEdge XR family—is purpose-built to withstand the most extreme environments. It can handle dust, humidity, extreme temperatures, shocks, and more. And it's both MIL-STD-810G and Network Equipment Building System (NEBS) Level 3, GR-3108 Class 1, tested.[1] This means the PowerEdge XR7620 server is compliant with edge-computing standards for both the telecom industry (NEBS Level 3) and military-related applications (MIL-STD-810G). These are foundational requirements, and we wanted to dive a little deeper into their importance.

NEBS Level 3

> "NEBS describes the environment of a typical United States Regional Bell Operating Company (RBOC) central office. NEBS is the most common set of safety, spatial, and environmental design standards applied to telecommunications equipment in the United States. It is not a legal or regulatory requirement, but rather an industry requirement."[2]

NEBS levels relate primarily to the telecom industry and are rated 1–3. Whereas NEBS Levels 1 and 2 are essentially office-based and targeted toward more controlled environments like data centers, NEBS Level 3 is the standard. It's what telecom and network providers base their installation requirements on, as this level ensures equipment operability.[3] It also requires the most time, effort, and cost in terms of design and maintenance.

Table 1 illustrates the specific requirements for NEBS Level 3.

Table 1 | NEBS Level 3 requirements[3]

Criteria	Requirement
Storage/Transport Temperature/Humidity	–40°C (–40°F) to +70°C (158°F), 50% to 93% relative humidity (RH)
Operational Temperature/Humidity	5°C to +50°C (ST –5°C to +55°C), 5% to 85% RH (ST 5% to 93%)
Altitude	4,000 m
Earthquake	Seismic zone 4
Airborne Contaminants	Withstand expected levels + filtration
Fire Resistance	Multiple test criteria
Electrostatic Discharge (ESD) Immunity	Contact/air discharge
Electromagnetic Interference (EMI) Emissions	Maximum over a range
EMI Immunity	8.5 V/m
Fast Transients	0.25, 0.5, 1 kV at 5 kHz
Conducted Emissions	Maximum over ranges
Power Induction	Alternating current (AC) testing
Corrosion	–VDC power recommended

MIL-STD

"This Standard contains materiel acquisition program planning and engineering direction for considering the influences that environmental stresses have on materiel throughout all phases of its service life. It is important to note that this document [the MIL-STD-810G standard] does not impose design or test specifications. Rather, it describes the environmental tailoring process that results in realistic materiel designs and test methods based on materiel system performance requirements."[4]

A military standard (MIL-STD) is a US defense standard that centers around ensuring standardization and interoperability for the products used by the US Department of Defense (DoD). There are different standards for specific use cases and industries, and the PowerEdge XR7620 server specifically addresses the 810G standard. The 810G standard centers around environmental engineering and testing, and it provides a rigorous framework—rather than universal guidelines—for vetting potential deployments through extensive testing.

Figure 1 shows a decision tree from the 810G standard guidelines that illustrates how rigorous and extensive the requirements for testing are to meet 810G compliance.

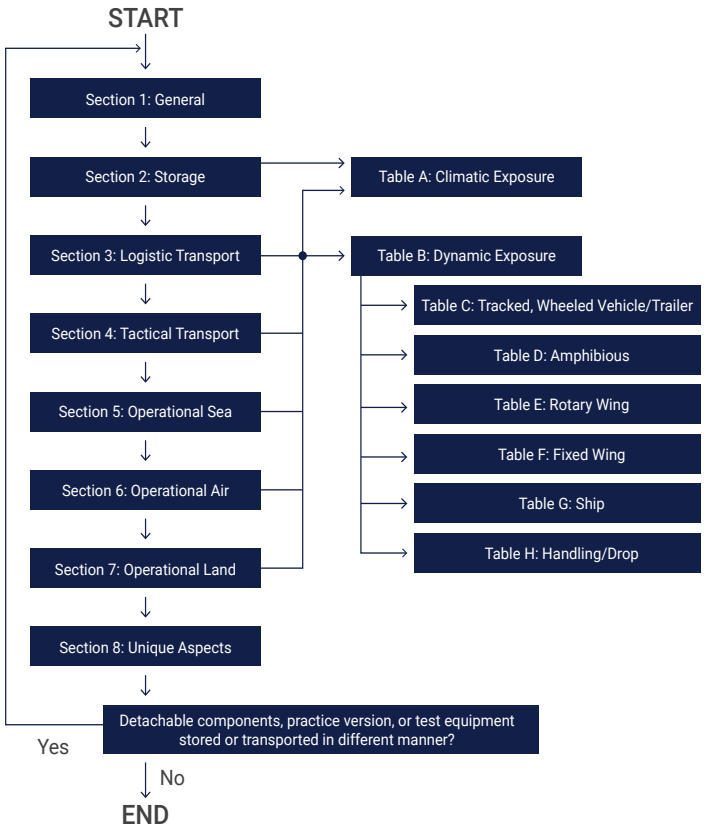

Figure 1 | A decision tree from the MIL-STD-810G guidelines[5]

The PowerEdge XR7620 Server: A New Generation

Prowess Consulting examined the performance difference between the PowerEdge XR7620 server and the previous-generation PowerEdge XE2420 server. We began by comparing the processors between the generations.

The 4th Gen Intel Xeon Scalable processors that power the PowerEdge XR7620 server provide a number of benefits over the 2nd Gen Intel Xeon Scalable processors that power the PowerEdge XE2420 server. These benefits include:

- 1.53x average generation-on-generation performance improvement[6]
- Up to 1.60x higher input/output operations per second (IOPS) and up to 37% latency reduction for large-packet sequential reads using integrated Intel® Data Streaming Accelerator (Intel® DSA) versus the prior generation[7]
- Up to 95% fewer cores and 2x higher level-1 compression throughput using integrated Intel® QuickAssist Technology (Intel® QAT) versus the prior generation[8]

We then reviewed the top-line specs between the PowerEdge XE2420 server and the PowerEdge XR7620 server, shown in Table 3 in the Methodology section. These specs show a clear and consistent improvement between generations. Further analysis of SPEC® CPU 2017 Integer and Floating Point (FP) rates—both of which measure CPU processing power by integer and floating point rates, respectively—shows the same generational increase, with the PowerEdge XR7620 server and its 4th Gen Intel Xeon Scalable processors the clear winner. These results are shown in Figures 2 and 3.

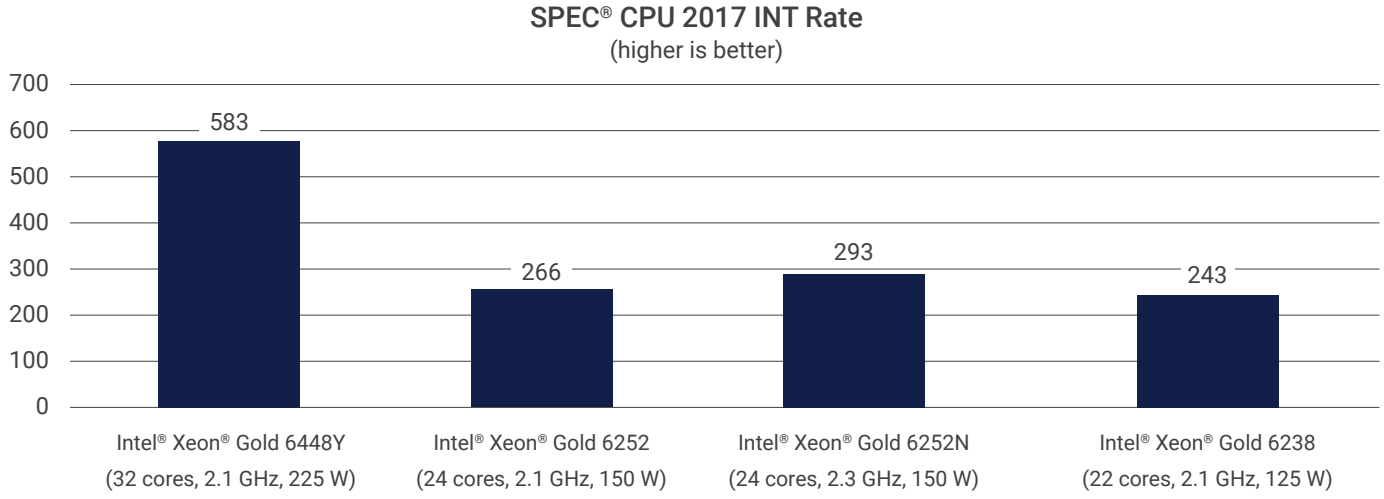

Figure 2 | SPEC® CPU 2017 INT rate for the Dell™ PowerEdge™ XR7620 server (with an Intel® Xeon® Gold 6448Y processor) versus the PowerEdge XE2420 server (with Intel Xeon Gold 6252, Intel Xeon Gold 6252N, and Intel Xeon Gold 6238 processors)[9]

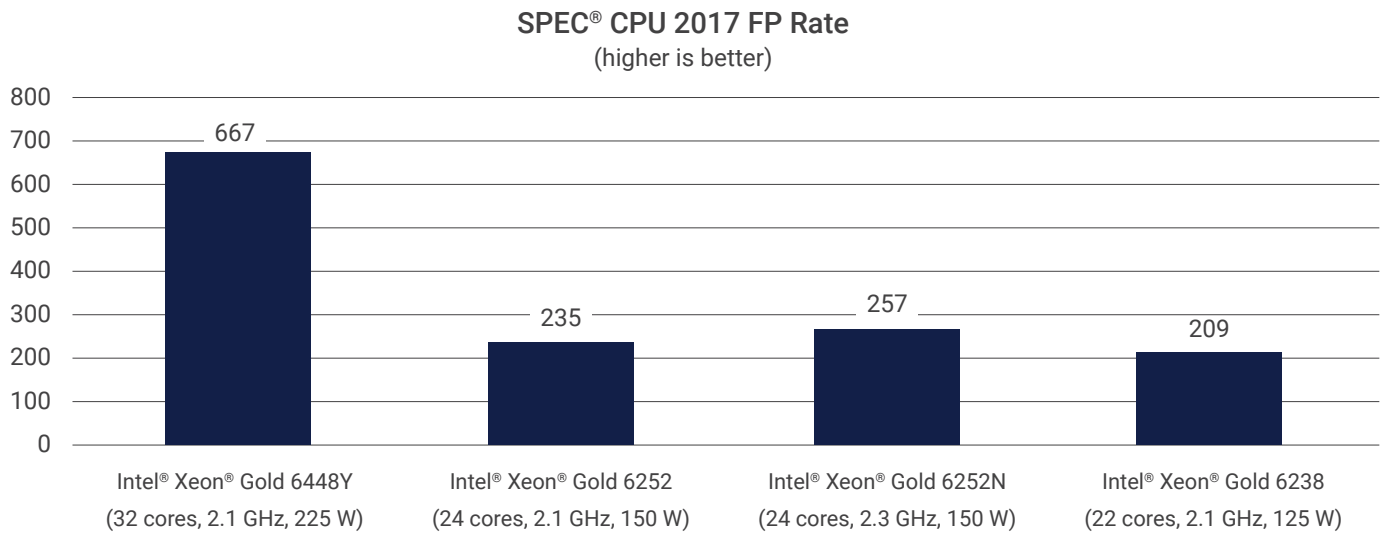

Figure 3 | SPEC® CPU 2017 FP rate for the Dell™ PowerEdge™ XR7620 server (with an Intel® Xeon® Gold 6448Y processor) versus the PowerEdge XE2420 server (with Intel Xeon Gold 6252, Intel Xeon Gold 6252N, and Intel Xeon Gold 6238 processors)[9]

This performance improvement between generations can also be seen by comparing VMware vSAN deployments. The PowerEdge XE2420 server and the PowerEdge XR7620 server can both implement two-node vSAN deployments. However, as noted previously, the PowerEdge XR7620 server will be more performant with those deployments. This higher level of performance doesn't just come from the upgraded processor, either. The 4th Gen Intel Xeon Scalable processors in the PowerEdge XR7620 are optimized to take full advantage of the new features and software improvements in VMware vSphere® 8, including GPU- and CPU-based acceleration.

The PowerEdge XR Family

Before we examine the Dell PowerEdge XR family of servers in more detail, Figure 4 provides a quick visual reference of the servers discussed in this report.

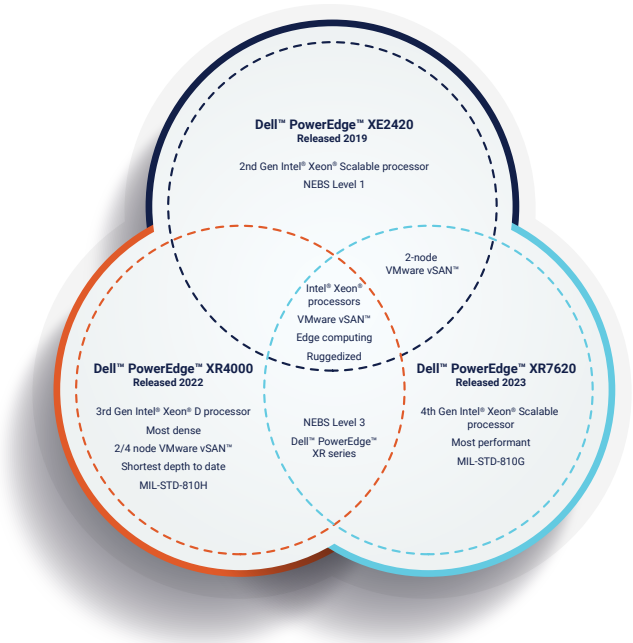

Figure 4 | Venn diagram of the Dell™ PowerEdge™ XE2420, XR7620, and XR4000 series servers

VMmark® Examination of PowerEdge XR7620 and PowerEdge XR4000 Series Servers

The PowerEdge XR7620 server is part of the PowerEdge XR family of servers, all of which are built to handle the most extreme environments while still delivering performance and reliability. We wanted to examine the PowerEdge XR7620 server alongside some of its "younger siblings," the PowerEdge XR4000 series servers, and investigate the inter-generational differences. (While not discussed in this study, PowerEdge XR8000 series servers provide excellent flexibility and stability, and would be the "elder sibling" in the family.)

To do this, we analyzed VMmark® results for both the PowerEdge XR4510c server (representing the PowerEdge XR4000 series) and the PowerEdge XR7620 server, shown in Table 4 in the Methodology section. VMmark is a tool for hardware vendors and others to measure the performance, scalability, and power consumption of virtualization platforms. VMmark allows for: benchmarking of virtual data center performance and power consumption; comparing performance and power consumption between different virtualization platforms; and examining how changes in hardware, software, or configuration affect performance within the virtualization environment.[10]

The VMmark results show the PowerEdge XR7620 server can achieve more performance across more tiles (fourteen versus four). These results also illustrate what can be achieved with a full, dual-socket server with the latest-generation processors in a short-depth, 2U ruggedized chassis at the edge. Moreover, the 4th Gen Intel Xeon Scalable processors in the PowerEdge XR7620 server also account for the higher performance. While the PowerEdge XR7620 server's overall performance wins are expected, what's missing is how performant at the edge PowerEdge XR4000 series servers are. Given the smaller size and shorter form factor overall, the PowerEdge XR4000 series servers are very performant relative to size, and they are an excellent option when a smaller, denser, more flexible deployment is called for. Moreover, their redundancy allows for more hardware failures, making them resilient and durable.

Figure 5 | Optional witness node on the Dell™ PowerEdge™ XR4000 series servers[11]

VMware vSAN is an "enterprise-class storage virtualization software that provides the simplest path to hyperconverged infrastructure (HCI) and multi-cloud."[12] VMware vSAN is widely deployed, so we also compared vSAN deployments inter-generationally. While the PowerEdge XR7620 server (and the PowerEdge XE2420 server, too) can implement two-node vSAN deployments, PowerEdge XR4000 series servers can implement four-node vSAN deployments. Additionally, the PowerEdge XR7620 server can also be deployed in a two-node architecture using a vSAN witness appliance to take advantage of the many benefits of vSAN—especially its performance benefits. While both servers take advantage of vSAN, the PowerEdge XR7620 server will offer more overall performance, whereas PowerEdge XR4000 series servers offer the highest density in the smallest form factor.

There is, however, another significant benefit to the upgraded PowerEdge XR7620 server: power savings and sustainability. As Table 4 in the Methodology section shows, the PowerEdge XR7620 server offers double the cores of the PowerEdge XR4510c server tested for less than double the wattage, indicating a smaller power draw when the PowerEdge XR7620 is deployed at the edge. The PowerEdge XR7620 server reduces power consumption, leading to higher energy efficiency and power availability for the PowerEdge XR7620 server. The reduced power consumption can also potentially lower total cost of ownership (TCO) and help meet your business's sustainability goals.

Potential PowerEdge XR Family Use Cases

The PowerEdge XR family of servers has use cases in retail, manufacturing, defense, and telecom. We explore two specific use cases in the following sections.

The PowerEdge XR7620 Server: Autonomous Driving

Let's examine how the PowerEdge XR7620 server—which excels at virtualization—might perform in a real-world setting in the auto industry. As demand increases for technologies such as advanced driver assistance systems (ADAS) and autonomous driving capabilities, the industry needs more efficient development and testing. Virtualization is a key strategy for generating this efficiency, and it's leading to a change in the way vehicles are designed, developed, manufactured, tested, and maintained.[13]

As software becomes increasingly essential to the average vehicle, updating that software as efficiently as possible becomes a customer pain point and a business requirement. Vast amounts of data are generated when physically testing the update process in the factory or out on the track. You'll need a high-performance server to capture and process that data as it's generated for the fastest analytics and most actionable insights possible. Moreover, the 4th Gen Intel Xeon Scalable processors in the PowerEdge XR7620 server are optimized to use the software upgrades in vSphere 8, allowing you to modernize your hardware and software as you replace aging assets, while increasing capacity.

Additionally, this server must be able to withstand the dust and temperature fluctuations of the factory, or the vibrations and humidity of the track, or a host of other adverse conditions. The PowerEdge XR7620 server meets both performance and durability needs, offering the levels of performance required for intense data analytics and the ruggedized form factor required at the edge.

PowerEdge XR4000 Series Servers: Telecom Deployments

Let's take a proper look at PowerEdge XR4000 series servers now. If the PowerEdge XR7620 server is at home on the factory floor, then the PowerEdge XR4000 series servers are at home under the cell tower. While the PowerEdge XR7620 server is built for durability, PowerEdge XR4000 series servers are especially rugged and come in Dell's smallest form factor for flexibility and customization in the most difficult deployments. They are NEBS Level 3 and MIL-STD-810H tested.[14] Moreover, their four sleds in a single 2U chassis offer excellent scalability and portability when in the field. They have "rackable" and "stackable" configuration options for maximum deployment flexibility, and they support multiple configurations within each option. And PowerEdge XR4000 series servers do so while still offering the high performance needed for analytics and virtualization at the edge.

Finding an Edge Within the PowerEdge XR Family

While the PowerEdge XR family of servers all feature a ruggedized, short-depth form factor, there's a spectrum of purpose-built options to consider, varying from maximum performance at one end to maximum density and durability at the other.

As our research shows, the PowerEdge XR7620 server is an excellent choice for maximum performance within the PowerEdge family of servers examined. It's powered by the next-generation Intel Xeon Gold 6448Y processor, giving the PowerEdge XR7620 server excellent virtualization capabilities and vSAN performance. And the PowerEdge XR7620 server does all this in a ruggedized, short-depth form factor that provides the durability required for intense edge computing.

The PowerEdge XR7620 Server: Under the Hood

The performance of the PowerEdge XR7620 server shouldn't be seen as a simple generational update. It owes some of its performance to the 4th Gen Intel Xeon Scalable processors and the Dell™ PowerEdge RAID Controller 12 (PERC 12).

Intel® Xeon® Gold 6448Y Processor

The Intel Xeon Gold 6448Y processor found in the PowerEdge XR7620 server is based on 4th Gen Intel Xeon Scalable processor architecture, representing a serious upgrade from 2nd and 3rd Gen processors in several ways. With double the cores, a higher max turbo frequency, and a larger cache than the previous model's processor, the Intel Xeon Gold 6448Y processor is built for performance. Moreover, the processor features Intel DSA, which helps speed up data movement and improve transformation operations to increase performance for storage, networking, and data-intensive workloads.[15]

Dell™ PERC 12

PERC 12, Dell's latest RAID controller, features the new Broadcom® SAS4116W series chip and offers increased capabilities compared with its predecessor, PERC 11. These capabilities include support for 24 gigabits per second (Gb/s) Serial-Attached SCSI (SAS) drives, increased cache memory speed, and a single front controller that supports both NVM Express® (NVMe®) and SAS. Table 2 shows the generational improvement between PERC 11 and PERC 12.[16]

Table 2 | IOPS/bandwidth comparison between the Dell™ PERC 11 and PERC 12 controllers[16]

Metric	Definition	Units	Dell™ PERC 11	Dell™ PERC 12	Dell™ PERC 12 Improvement
Read Bandwidth	100% 64K sequential	MB/s	14,108	28,205	200%
Read IOPS	100% 4K random	IOPS	3,402,370	6,918,729	200%
RAID5 Write Bandwidth	100% 64K sequential	MB/s	4,469	10,474	234%
RAID5 Write IOPS	100% 4K random	IOPS	237,006	651,166	275%
Note: All tests used fio running on Red Hat® Enterprise Linux® 8.6.					

PowerEdge XR4000 Series Servers: Inside the Box

At the density end of the spectrum, we have the PowerEdge XR4000 series servers. These are Dell Technologies' shortest-depth servers to date: modular 2U servers with a sled-based design for maximum flexibility. They come in two new 14"-depth form factors called "rackable" and "stackable," and they offer rack or wall mounting options.

PowerEdge XR4000 series servers also feature an optional nano-server-sled that can serve as an in-chassis witness node for the vSAN cluster. This replaces the need for a virtual witness node and establishes a native, self-contained, two-node vSAN cluster—even in the 14" x 12" stackable configuration. You can choose between two and four nodes in a chassis while still using vSAN because of the in-chassis witness node. This makes virtual machine (VM) deployments possible where latency or bandwidth constraints previously prevented doing so. PowerEdge XR4000 series servers offer high-performance edge computing in a form factor small enough to fit in a backpack.[17] This form factor and size also lead to high computing density, which is the measurement of the amount of information that can be stored and processed in a given area to determine efficient use of space.

When Rugged Matters as Much as Performance

Our research concludes that the Dell PowerEdge XR family of servers is a great option for organizations looking for reliable, high-performing servers in ruggedized, short-depth form factors designed specifically for edge computing. Among the range of PowerEdge XR family servers examined by Prowess, the PowerEdge XR7620 server represents a solid upgrade from the previous generation, and is the performance-focused offering in the new PowerEdge XR family of servers. PowerEdge XR4000 series servers are the high-density, performant option when durability and space are primary concerns.

Learn More

For more information on the Dell PowerEdge XR7620 server, see "Dell's PowerEdge XR7620 for Telecom/Edge Compute" and the PowerEdge XR7620 server product page.

For more information on the new offerings in the PowerEdge XR family, see "Dell PowerEdge Gets Edgy with XR8000, XR7620, and XR5610 Servers."

Methodology

Table 3 shows the configuration details for the comparison between the PowerEdge XE2420 server and the PowerEdge XR7620 server.

Table 3 | Dell™ PowerEdge™ XR7620 server versus PowerEdge XE2420 server comparison

Server	Dell™ PowerEdge™ XE2420[18,19,20]	Dell™ PowerEdge™ XR7620[21,22]
Processor	2nd Gen Intel® Xeon® Scalable processors	4th Gen Intel® Xeon® Scalable processors
Cores per Processor	Up to 24	Up to 32
Number of Processors Supported	2	2
Memory	16 x DDR4 RDIMM/LR-DIMM (12 DIMMs are balanced), up to 2,993 megatransfers per second (MT/s)	16 x DDR5 DIMM slots, supports RDIMM 1 TB max, speeds up to 4,800 MT/s; supports registered error correction code (ECC) DDR5 DIMMs only
Drive Bays	Up to 4 x 2.5-inch SAS/SATA/NVMe® solid-state drives (SSDs); up to 6 Enterprise and Data Center SSD Form Factor (EDSFF) drives	Front bays: Up to 4 x 2.5-inch SAS/SATA/NVMe® SSDs, 61.44 TB max; up to 8 x E3.S NVMe® direct drives, 51.2 TB max
Dimensions	2 x 2.5-inches or 4 x 2.5 with seven possible configurations	Rear-accessed configuration: • Height: 86.8 mm (3.41 inches) • Width: 482.6 mm (19 inches) • Depth: 448.8 mm (17.6 inches) ear to rear wall » 496.3 mm (19.53 inches) with bezel » 471.8 mm (18.57 inches) without bezel Front-accessed configuration: • Height: 86.8 mm (3.41 inches) • Width: 482.6 mm (19 inches) • Depth: 572 mm (22.51 inches) with bezel » 471.8 mm (18.57 inches) without bezel
Weight	17.36 kg (38.19 pounds) to 18.93 kg (41.65 pounds), depending on configuration	Max 21.16 kg (46.64 pounds)
Form Factor	2U rack	2U rack

Table 4 shows the configuration details for the VMmark comparison between the two PowerEdge XR family servers.

Table 4 | VMmark® comparison between the Dell™ PowerEdge™ XR7620 server and the PowerEdge XR4510c server

VMmark® 3.1.1 Results		
Summary		
Category	Dell™ PowerEdge™ XR4510c[23]	Dell™ PowerEdge™ XR7620[24]
VMmark® 3 Average Watts	1,085.50	1,878.63
VMmark® 3 Applications Score	4.93	14.08
VMmark® 3 Infrastructure Score	2.15	1.06
VMmark® 3 Score	4.37	11.48
VMmark® 3 PPKW	4.0285 at 4 tiles	6.1093 at 14 tiles
Configuration		
Server	Dell™ PowerEdge™ XR4510c[23]	Dell™ PowerEdge™ XR7620[24]
Nodes	4 physical (with local hardware-based witness node)	2 (with VMware vSAN™ witness appliance)
Storage	VMware vSAN™ 8.0—all-flash	VMware vSAN™ 8.0—all-flash
Hypervisor	VMware ESXi™ 8.0 GA, build 20513097	VMware ESXi™ 8.0b, build 21203435
Data Center Management Software	VMware vCenter Server® 8.0 GA, build 20519528	VMware vCenter Server® 8.0c, build 21457384
Number of Servers in System Under Test	4	2
Processor	Intel® Xeon® D-2776NT processor	Intel® Xeon® Gold 6448Y processor
Processor Speed (GHz)/Intel® Turbo Boost Technology Speed (GHz)	2.10 GHz/3.20 GHz	2.10 GHz/4.10 GHz
Total Sockets/Cores/Threads in Test	4 sockets/64 cores/128 threads	4 sockets/128 cores/256 threads
Memory Size (in GB, Number of DIMMs)	512 GB, 4	2,048 GB, 16
Memory Type and Speed	128 GB 4Rx4 DDR4 3,200 MT/s LRDIMM	128 GB DDR5 4Rx4 4,800 MT/s RDIMMs

[1] Dell. "Dell's PowerEdge XR7620 for Telecom/Edge Compute." May 2023. **https://infohub.delltechnologies.com/p/dell-s-poweredge-xr7620-for-telecom-edge-compute/**.

[2] Cisco. "Cisco Firepower 4112, 4115, 4125, and 4145 Hardware Installation Guide." June 2023. **www.cisco.com/c/en/us/td/docs/security/firepower/41x5/hw/guide/install-41x5.html**.

[3] Dell. "Computing on the Edge: NEBS Criteria Levels." November 2022. **https://infohub.delltechnologies.com/p/computing-on-the-edge-nebs-criteria-levels/**.

[4] MIL-STD-810. "Environmental Engineering Considerations and Laboratory Tests." May 2022. **https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=35978**.

[5] US Department of Defense. "Environmental Engineering Considerations And Laboratory Tests." Revision G Change 1 (change incorporated). Figure 402-1. Life Cycle Environmental Profile Development Guide. April 2014. **https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=35978** [then select the "Revision G Change 1 (change incorporated)" document].

[6] Intel. Performance Index (4th Gen Intel Xeon Scalable Processors, G1). Accessed May 2023. **www.intel.com/PerformanceIndex**.

[7] Intel. Performance Index (4th Gen Intel Xeon Scalable Processors, N18). Accessed May 2023. **www.intel.com/PerformanceIndex**.

[8] Intel. Performance Index (4th Gen Intel Xeon Scalable Processors, N16). Accessed May 2023. **www.intel.com/PerformanceIndex**.

[9] Data provided by Dell Technologies in May 2023.

[10] VMware. "VMmark." Accessed June 2023. **www.vmware.com/products/vmmark.html**.

[11] Dell. "XR4000w Multi-Node Edge Server (Intel)." Accessed July 2023. **https://www.dell.com/en-us/shop/ipovw/poweredge-xr4000w**.

[12] VMware. "What Is VMware vSAN?" Accessed July 2023. **www.vmware.com/products/vsan.html**.

[13] Luxoft. "Achieving the benefits of SDVs using virtualization." May 2023. **www.luxoft.com/blog/virtualization-revolutionizing-software-defined-vehicles-development**.

[14] Dell. "Dell PowerEdge XR4000 Specification Sheet." Accessed June 2023. **https://i.dell.com/sites/csdocuments/Product_Docs/en/dell-poweredge-xr4000-spec-sheet.pdf**.

[15] Intel. "Intel® Accelerator Engines." Accessed June 2023. **www.intel.com/content/www/us/en/products/docs/accelerator-engines/overview.html**.

[16] Dell. "Dell PowerEdge RAID Controller 12." May 2023. **https://infohub.delltechnologies.com/p/dell-poweredge-raid-controller-12/**.

[17] Dell. "VMmark on XR4000." January 2023. **https://infohub.delltechnologies.com/p/vmmark-on-xr4000/**.

[18] Intel. "Intel Xeon D2776NT Processor." Accessed June 2023. **https://ark.intel.com/content/www/us/en/ark/products/226239/intel-xeon-d2776nt-processor-25m-cache-up-to-3-20-ghz.html**.

[19] Dell. "Dell EMC PowerEdge XE2420 Technical Specifications." Accessed June 2023. **https://dl.dell.com/topicspdf/poweredge-xe2420_reference-guide_en-us.pdf**.

[20] Dell. "PowerEdge XE2420 Specification Sheet." Accessed June 2023. **https://i.dell.com/sites/csdocuments/Product_Docs/en/PowerEdge-XE2420-Spec-Sheet.pdf**.

[21] Intel. "Intel Xeon Gold 6448Y Processor." Accessed June 2023. **https://ark.intel.com/content/www/us/en/ark/products/232384/intel-xeon-gold-6448y-processor-60m-cache-2-10-ghz.html**.

[22] Dell. "PowerEdge XR7620 Specification Sheet." Accessed June 2023. **www.delltechnologies.com/asset/en-us/products/servers/technical-support/poweredge-xr7620-spec-sheet.pdf**.

[23] VMmark. "VMmark® 3.1.1 Results, November 29, 2022." **www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/vmmark/2022-11-29-Dell-PowerEdge-XR4510c-serverPPKW.pdf**.

[24] VMmark. "VMmark® 3.1.1 Results, May 16, 2023." **www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/vmmark/2023-05-16-Dell-PowerEdge-XR7620.pdf**.

0823/230038