![PROWESS]

Lower Your TCO by Selecting the Right Platform for Your Oracle® Workloads

Prowess research finds that two- and four-socket Dell EMC™ PowerEdge™ servers can offer consistent high performance and better three-year total costs of ownership (TCOs) for powering Oracle workloads than two- and four-socket solutions based on IBM® POWER9™ processors.

Executive Summary

Thanks to its high performance and reliability, Oracle® Database has become the industry's most popular enterprise relational database.[1] In fact, for many IT and database admins, Oracle Database is the clear choice to support their businesses' high-performance, mission-critical workloads. What is less clear for organizations is which hardware platform and operating system they should use to support their Oracle databases:

- Proprietary platforms such as IBM® Power® Systems servers running the IBM® AIX® operating system
- Or industry-standard platforms built on x86 servers, such as Dell EMC™ PowerEdge™ servers running Red Hat® Enterprise Linux® (RHEL)

When it comes to performance and total cost of ownership (TCO), how do the competing options compare?

To find the answer, Prowess Consulting compared the costs of two- and four-socket Dell EMC™ servers against IBM® processor–based systems. Specifically, Prowess testing compared the following systems:

	Dell EMC™ PowerEdge™ Servers	IBM® Power® Systems
Two-socket systems:	Dell EMC PowerEdge R740xd (36 cores)	IBM Power System S924 (24 cores)
Four-socket systems:	Dell EMC PowerEdge R940 (72 cores)	IBM Power System E950 (48 cores)

Our analysis found:

- Up to 31 percent lower TCO with a two-socket Dell EMC PowerEdge R740xd server, compared to a two-socket IBM Power System S924.
- Up to 36 percent lower TCO with a four-socket Dell EMC PowerEdge R940 server, compared to a four-socket IBM Power System E950.

In addition, operating expenses (OpEx) for IBM Power Systems servers running AIX are higher than for Dell EMC PowerEdge systems due to the specialized expertise and subsequently higher labor costs required for administering AIX, compared to RHEL. Dell Technologies also provides several other management and support benefits that can help reduce overall OpEx, including Dell EMC™ PowerStore, which provides reliable, performant NVM Express® (NVMe®) storage, Dell EMC™ OpenManage™ Enterprise for systems management, monitoring, and automated application updates, and other tools and services.

Highlights

Up to

31%
lower TCO

with a two-socket Dell EMC™ PowerEdge™ R740xd server, compared to a two-socket IBM® Power® System S924

Up to

36%
lower TCO

with a four-socket Dell EMC PowerEdge R940 server, compared to a four-socket IBM Power System E950

Market and Technology Trends

To stay competitive, modern businesses require fast, reliable access to massive amounts of data. Relational database management systems (RDBMSs) have been industry mainstays for years for managing all that data and using it to power business operations in the enterprise. Oracle Database, in particular, continues to reign as king in the RDBMS space.[1] Oracle Database 19c is built on a long history of innovations and improvements, providing critical enterprise database features such as in-memory processing, multitenant support, and sharding capabilities. Even with the development of newer database technologies, it's clear that Oracle Database 19c will be powering businesses for years to come.

Oracle Database on IBM® Power® Systems, Compared to Intel® x86 Architecture

Administrators have multiple choices for the platform they use to power their Oracle Database deployments. Two popular options are IBM Power Systems and Intel® x86 processor–based servers offered by leading vendors such as Dell Technologies. Systems built on IBM POWER9 processors have a reputation for reliability and performance. But these systems run on IBM's proprietary AIX operating system, and they require specialized IT skills to deploy, manage, and maintain.

In contrast, platforms powered by x86 processors and Linux operating systems are non-proprietary and are more commonplace in enterprise organizations. These industry-standard systems have hardware and management tools that are already familiar to most IT administrators. That benefit allows organizations to use existing and readily available expertise for management and maintenance.

Oracle Database licensing costs can also be a concern for budget-conscious organizations comparing platforms. Oracle Database enterprise licensing can vary by customer, but it is fundamentally constructed based on the number of cores in their systems times a "core factor." The core factor for IBM POWER9 systems is 1, whereas x86 processor–based systems have a core factor of only 0.5, making the licensing costs half as costly for x86 systems built with an equivalent number of cores.[2]

The licensing core factor is compounded when deploying an Oracle Real Application Cluster (RAC). Oracle RACs improve availability and provide horizontal scalability by enabling an Oracle database to run across multiple servers, while accessing shared storage. But each multi-core server adds to the overall licensing cost for the Oracle database— particularly when applying the 1.0 core factor to an IBM POWER server, compared to the 0.5 factor for an x86 system.

Overall, the systems powered by Intel x86 architecture (and Dell EMC PowerEdge servers, in particular) offer several advantages over proprietary IBM POWER9 systems, including:

- Lower upfront infrastructure and licensing costs
- Greater server utilization, because they are able to support a wider range of workloads
- Easier and less costly scalability for responding to changing business needs
- A more readily available skillset for system support
- Support for a diverse set of management tools that can automate many infrastructure processes

On the surface, the benefits of x86 processor–based systems are compelling. But would these systems also offer a lower TCO over time?

To answer that question, Prowess compared cost factors, including capital expenditures (CapEx) and OpEx, between IBM POWER9 servers and Dell EMC PowerEdge systems built with Intel® Xeon® Scalable processors.

In addition, we measured Oracle Database online transaction processing (OLTP) transactions per minute (TPM) on two Dell EMC PowerEdge systems to determine how well performance scaled from a single two-socket to a single four-socket system.

We selected Dell EMC PowerEdge servers for the x86-processor-based systems in this study because PowerEdge servers are widely used in the enterprise, where they consistently maintain a spot in the top five for market share.[3] Dell Technologies also provides management software, highly performant NVMe flash storage, and other benefits that add additional value for administrators making a full comparison.

Overview of the TCO Comparison

This study compares both the CapEx acquisition costs for servers and licenses and the longer-term OpEx costs associated with managing, powering, and cooling the systems over a three-year period.

We selected the following systems for our study:

- Two-socket Dell EMC PowerEdge R740xd
- Four-socket Dell EMC PowerEdge R940
- Two-socket IBM Power System S924
- Four-socket IBM Power System E950

Prowess performed TCO analyses for the following combinations:

- Head-to-head comparison between the two-socket systems
- Head-to-head comparison between the four-socket systems

Prowess also examined the three-year cost-effectiveness of deploying a four-socket Dell EMC PowerEdge server compared to a two-socket Dell EMC PowerEdge server.

Details of the Comparison Methodology

Our analysis includes the following categories:

- CapEx: acquisition costs
- OpEx: ongoing expenses
- Three-year TCO
- Performance

CapEx: Acquisition Costs

In evaluating acquisition costs, our study intentionally disregarded the costs of components that would be equivalent across the platforms. These components include storage area networks (SANs), network switches, cables, and other hardware common to all tested systems.

In addition, hardware costs were based on retail pricing without discounts. Vendors typically offer discounts to customers based on the size of the order, customer relationship history, and other factors. In order to ensure an apples-to-apples comparison, we solicited non-discounted pricing from Dell Technologies and IBM for this study.

Comparing hardware across systems, our analysis found that a two-socket Dell EMC PowerEdge R740xd with 36 cores and 576 GB of memory provides 82 percent CapEx savings over a two-socket IBM Power System S924 with 24 cores and 1,536 GB of memory (see Figure 1).[4]

As shown in Figure 2, a comparison of four-socket systems yielded similar results. The Dell EMC PowerEdge R940 with 72 cores and 1,152 GB of memory provides a 90 percent savings over the IBM Power System E950 with 48 cores and 3,072 GB of memory.[5] (See **Appendix B** for a breakdown of the pricing.)

Normalized Two-Socket Server Price Comparison (Lower Is Better)

83% savings

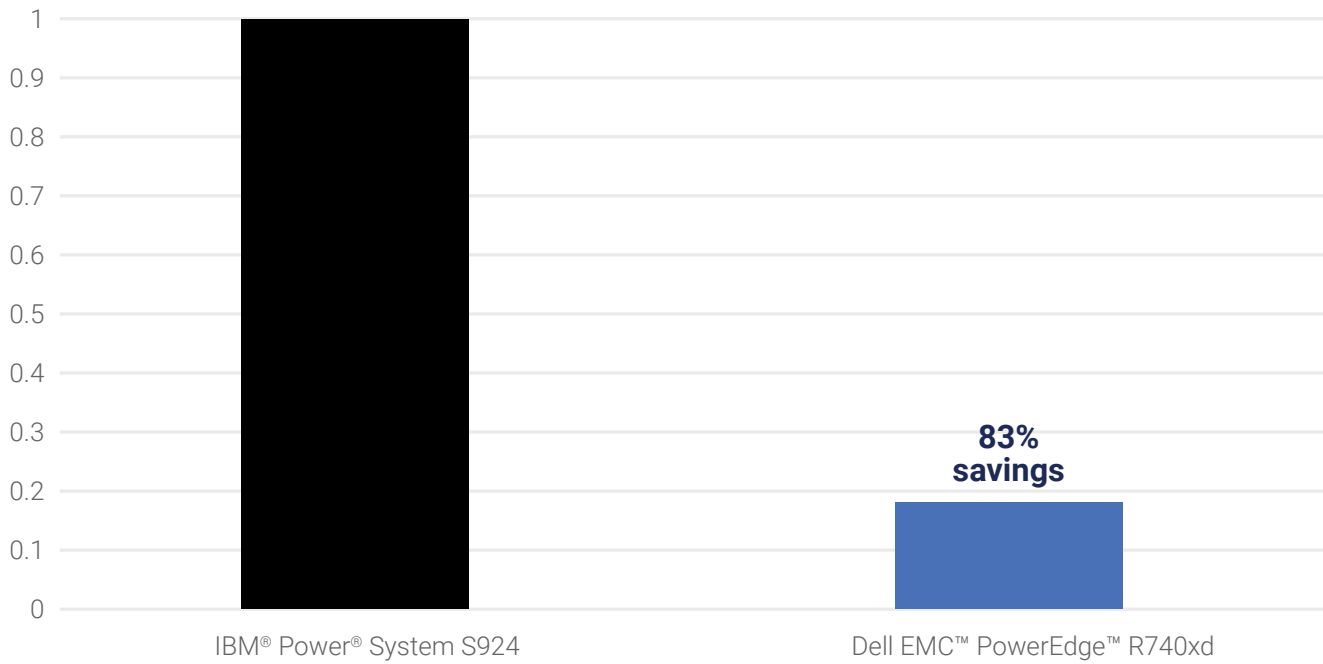IBM® Power® System S924 — Dell EMC™ PowerEdge™ R740xd

Figure 1. Normalized comparisons of hardware costs for two-socket Dell Technologies™ and IBM® Power® Systems servers (lower is better)

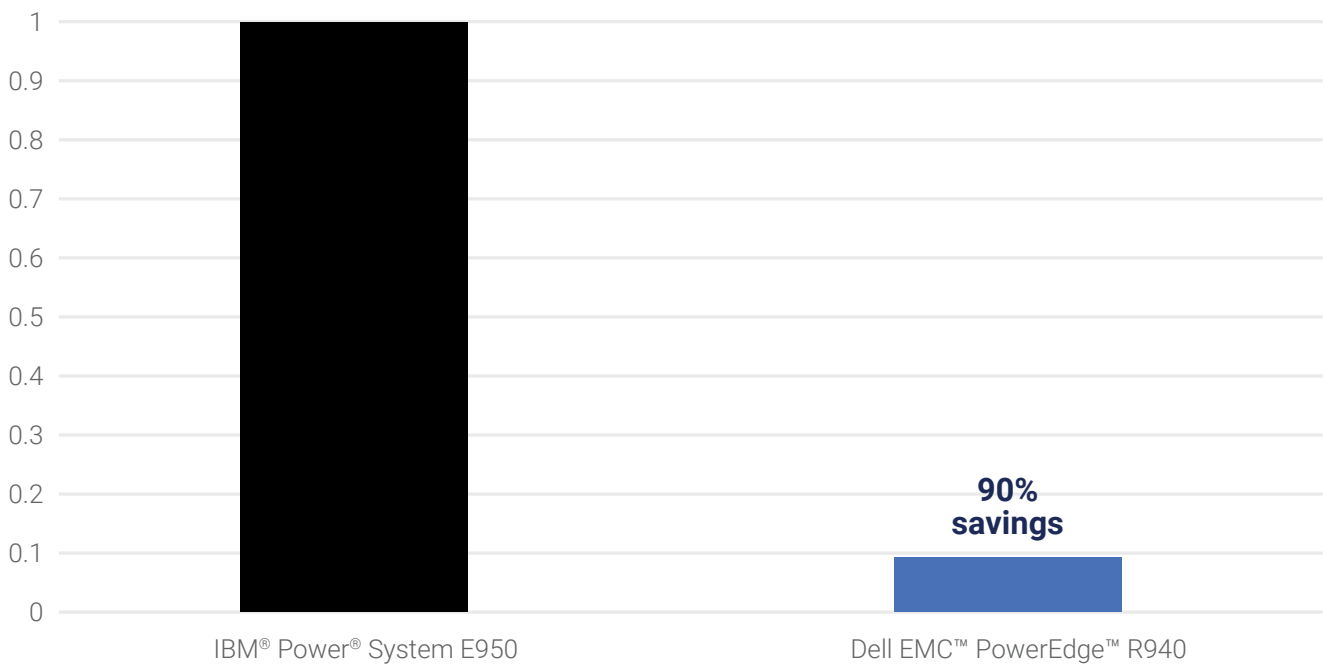## Normalized Four-Socket Server Price Comparison (Lower Is Better)

90% savings

IBM® Power® System E950 — Dell EMC™ PowerEdge™ R940

Figure 2. Normalized comparisons of hardware costs for four-socket Dell Technologies™ and IBM® Power® Systems servers (lower is better)

OpEx: Ongoing Expenses

In order to fully evaluate OpEx for the solutions, we analyzed software licensing and support fees, labor and management costs, and power and cooling expenses for the hardware.

Software Licensing and Support Costs

The IBM AIX operating system costs more than alternative products, including the RHEL operating system used with the Dell EMC PowerEdge systems. Ongoing support costs are also considerably higher for the IBM systems that we examined, compared to the Dell Technologies systems. In addition, Oracle Database licensing costs are higher for the IBM systems because they are subject to an Oracle core factor of 1.0, compared to a factor of 0.5 for the Dell Technologies systems. As noted earlier, actual customer pricing for Oracle would be determined through negotiations with Oracle. This analysis assumes that a customer would receive similar discount percentages from Oracle for IBM- or Dell-based platforms based on a business relationship, not on hardware choice.

Table 1 compares the list price of support and operating system licensing for the two-socket and four-socket systems tested in this study. Licensing and support for the Dell EMC PowerEdge R740xd is 26 percent less than for the IBM Power System S924. Similarly, licensing and support for the Dell EMC PowerEdge R940 is 26 percent less than for the IBM Power System E950.

Table 1. Three-year support and licensing costs for the two- and four-socket systems (see **Appendix B** for additional cost details)

Support and Software	Three-Year Costs: 2-Socket Systems		Three-Year Costs: 4-Socket Systems	
	Dell EMC™ PowerEdge™ R740xd (36 cores)	IBM® Power® System S924 (24 cores)	Dell EMC PowerEdge R940 (72 cores)	IBM Power System E950 (48 cores)
Support	$2,338	$12,528	$3,865	$26,676
Red Hat® Enterprise Linux® (RHEL)	$6,144	N/A	$6,144	N/A
IBM® AIX® 7.2 Enterprise Edition	Not applicable (N/A)	$29,952	N/A	$59,904
Oracle® Database licensing	$1,269,000	$1,692,000	$2,538,000	$3,384,000
Total	$1,277,482	$1,734,480	$2,548,009	$3,470,580

Labor and Management Costs

IBM AIX can be more complex to manage than the more prevalent RHEL operating system. As a result, AIX requires IT administrators with a specialized skillset, which can create an additional cost burden.[6] In contrast, x86-based systems running RHEL (including the Dell EMC PowerEdge servers tested in this study) can be administered by the broader IT organization, rather than requiring a specialist.[7]

In addition, AIX can increase TCO through limited utilization because a server running AIX can only be used for the workloads dedicated to that particular hardware. These systems also detract from organizational flexibility because workloads can't be easily moved or consolidated in response to changing business needs. Architectural differences between AIX and other operating systems (such as Linux) often require additional programming overhead for applications in order to port them between the disparate operating systems.

Power and Cooling Costs

The tested Dell Technologies systems incurred much lower power and cooling costs than the IBM systems examined in this study: $811 less over three years for the Dell EMC PowerEdge R740xd, compared to the IBM Power System S924, and $1,246 less over three years for the Dell EMC PowerEdge R940, compared to the IBM Power System E950. (See **Appendix B** for details.)

Three-Year TCO

Altogether, with CapEx and OpEx totaled over a three-year period, a two-socket Dell EMC PowerEdge R740xd server with 36 cores and 576 GB of memory provides up to 31 percent lower three-year TCO than a two-socket IBM Power System S924 server with 24 cores and 1,536 GB of memory (see Figure 3).[4]

The TCO comparison between systems running four-socket servers was also informative. A four-socket Dell EMC PowerEdge R940 with 72 cores and 1,152 GB of memory supplies up to 36 percent lower three-year TCO than a four-socket IBM Power System E950 with 48 cores and 3,072 GB of memory (see Figure 4).[5]
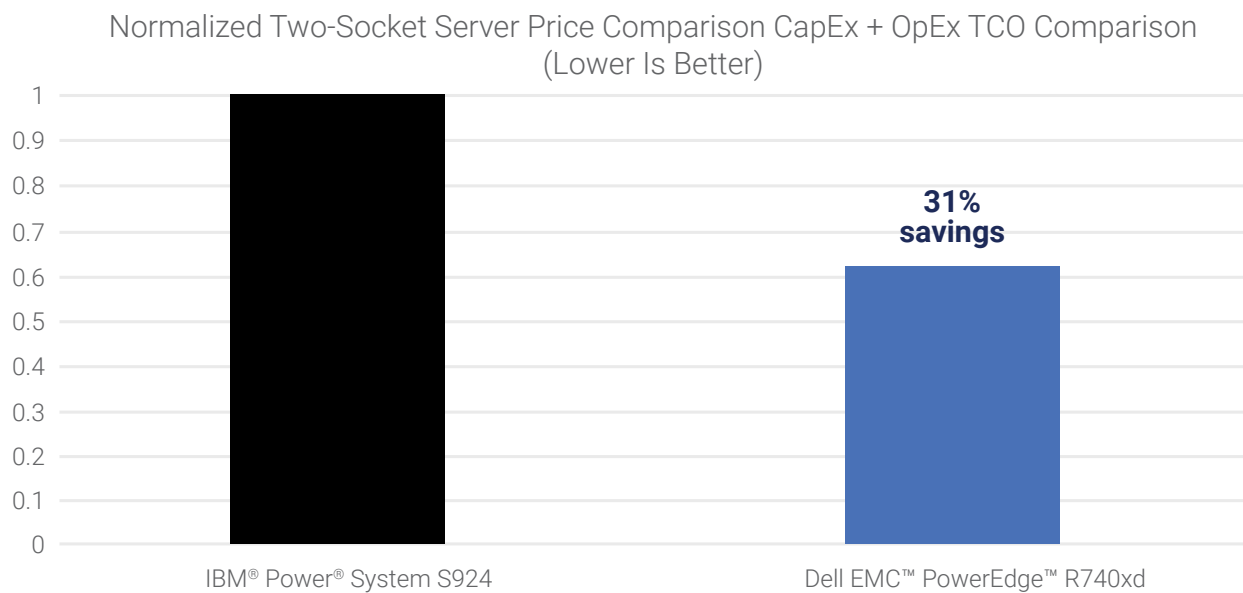

Figure 3. Normalized comparisons of three-year TCO for two-socket IBM® Power® Systems and Dell Technologies™ servers (lower is better)
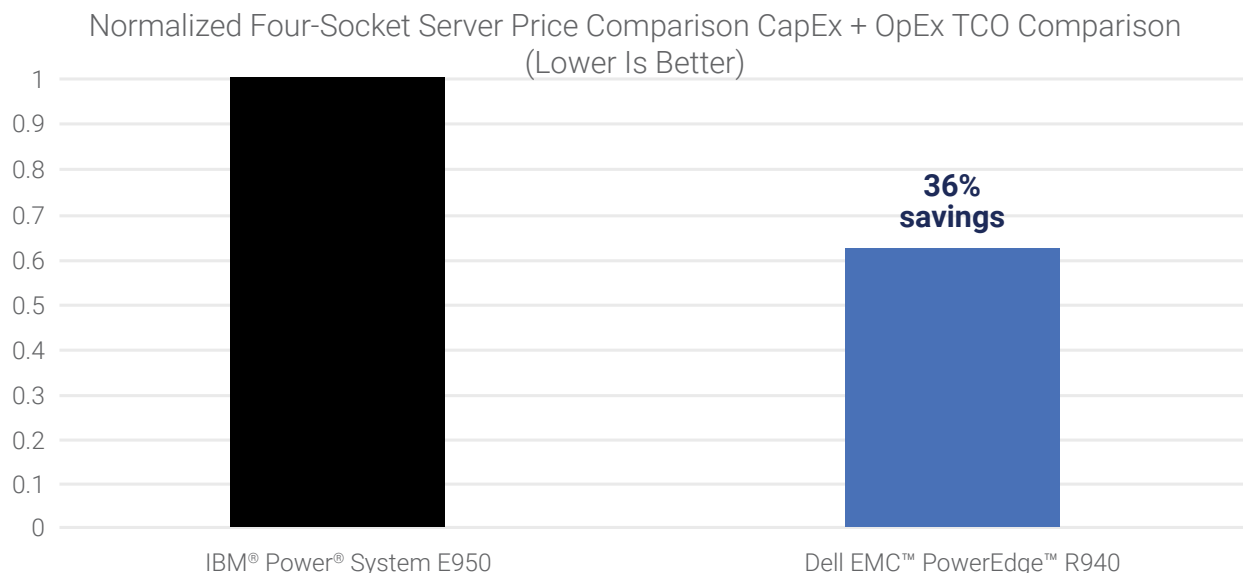

Figure 4. Normalized comparisons of three-year TCO for four-socket IBM® Power® Systems and Dell Technologies™ servers (lower is better)

Four-socket server versus two-server cluster

Prowess was also interested in whether a four-socket Dell Technologies server could provide lower TCO for enterprise businesses over a three-year period compared to a two-server, two-socket Dell Technologies cluster. As shown in Figure 5, the four-socket system offered nearly identical TCO, because the Oracle licensing cost outweighed hardware and other software expenses. That suggests, however, that the Dell EMC PowerEdge R940 offers a better long-term value, because it provides scale-up capabilities to support changing business needs over time. In addition, administrators would need to manage fewer servers with a four-socket system compared to a 2 x two-socket cluster.
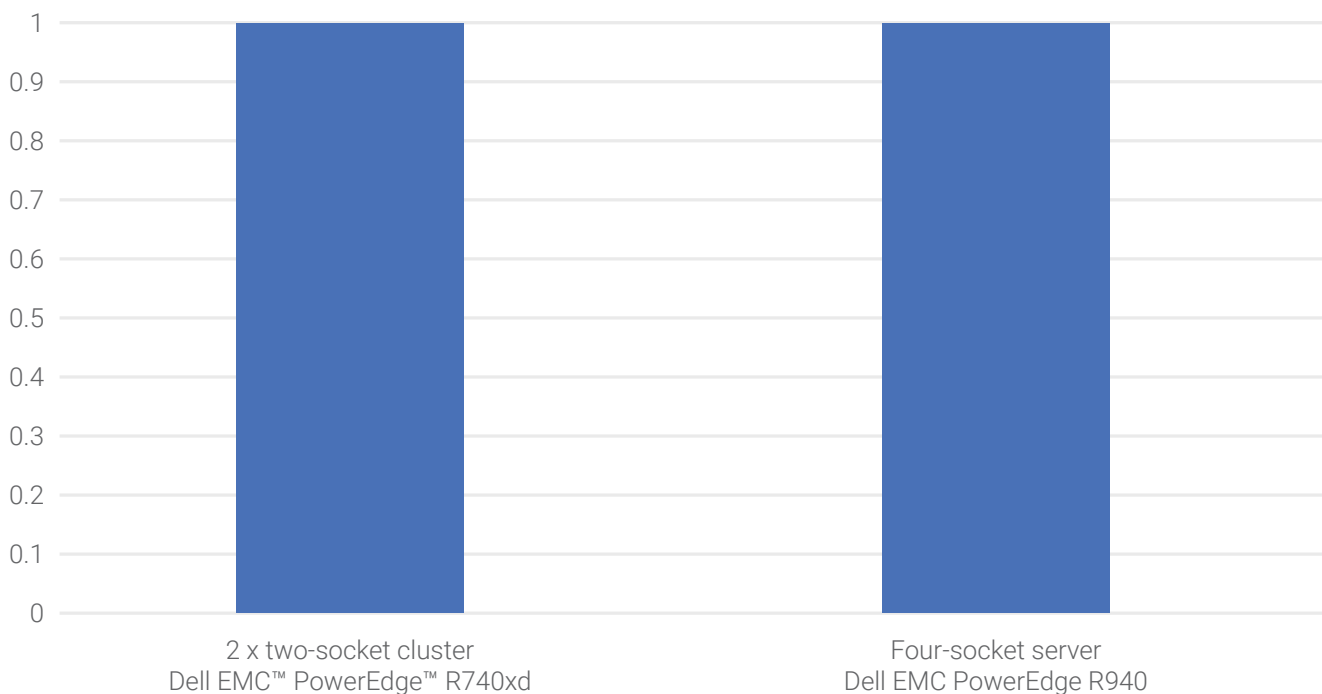

Figure 5. Normalized three-year TCO comparison of a two-server cluster of two-socket Dell EMC™ PowerEdge™ servers and a single four-socket Dell EMC PowerEdge server

For organizations looking to achieve both scale-up and scale-out capabilities, the TCO gains for a 2 x four-socket Dell Technologies platform would essentially be the same as the single four-socket server comparison in Figure 1. This assumes that the hardware, software, and support costs would roughly double from the single-server scenario. A four-socket Dell Technologies cluster offers organizations the higher reliability of an Oracle RAC configuration at a much lower hardware, software, and Oracle licensing cost than a comparable IBM Power Systems four-socket cluster.

Performance

Prowess ran HammerDB performance tests on Oracle Database to determine how well performance scaled from a single two-socket Dell EMC PowerEdge R740xd server to a single four-socket Dell EMC PowerEdge R940 server. TPM results are based on the median of three runs with 750 warehouses for both 433 and 505 users and are normalized to show relative performance against the single two-socket Dell EMC PowerEdge R740xd system.

As Figure 6 shows, performance for the four-socket system was essentially double the performance of the single two-socket system for both the 433- and 505-user test scenarios.

Comparison of Oracle® Database Performance on Two and Four-Socket Dell Technologies™ Platforms (Higher Is Better)
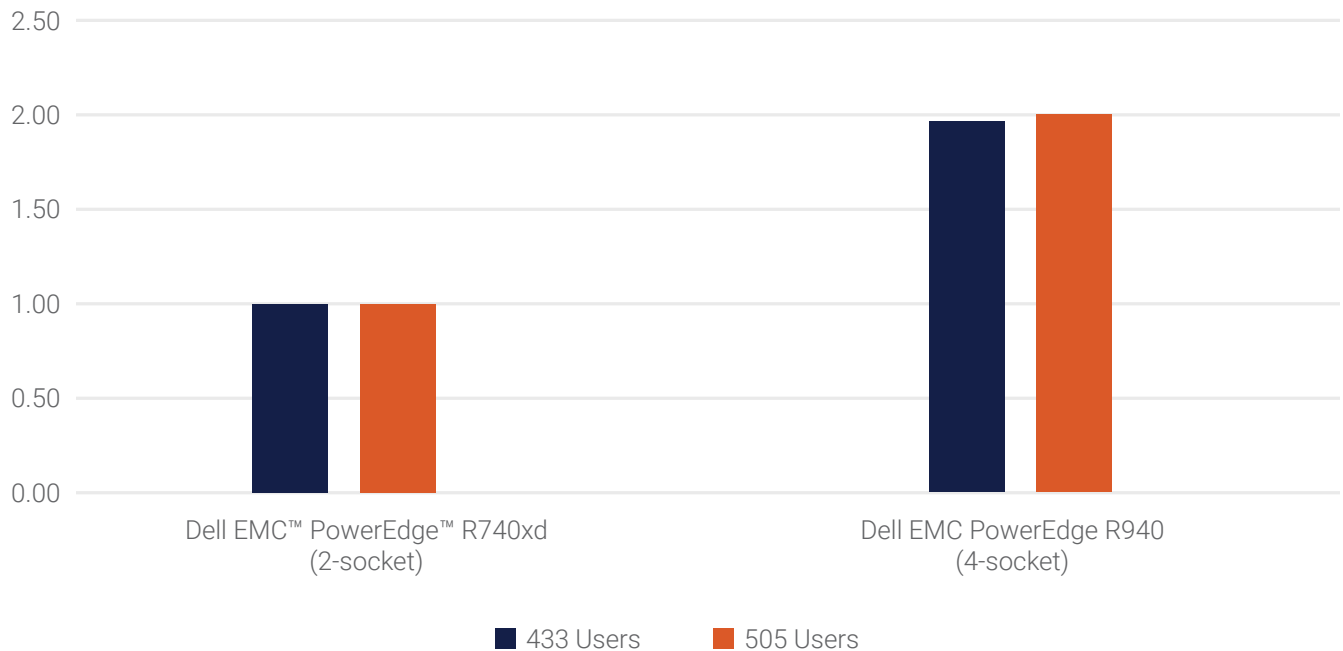

Figure 6. Relative performance of a four-socket Dell EMC™ PowerEdge™ R940 system to a two-socket Dell EMC PowerEdge R740xd

For users looking to reduce management complexity and costs, the Dell EMC PowerEdge four-socket system offers a compelling value for both performance and TCO.

Dell EMC PowerEdge Server Overview and Competitive Differentiators

Our analysis uncovered several additional benefits to running Oracle Database on Dell EMC PowerEdge servers, compared to IBM Power Systems. In addition to performance and TCO, IT administrators should take the following storage and management considerations into account when evaluating platforms.

Dell EMC™ PowerStore

Oracle Database requires reliable, performant storage. As part of our research for this study, we found the Dell EMC™ PowerStore appliance to be a compelling option for providing scalable storage infrastructure. PowerStore supports NVMe solid-state drives (SSDs), NVMe NVRAM for system cache, storage-class memory (SCM), up to 32 Gb Fibre Channel (FC), and 25 Gb Ethernet. The appliance offers several features that would be of interest to Oracle Database IT administrators, including intelligent scale-up and scale-out capabilities for appliance clusters, automated management of resources, and simplified administration. PowerStore also supports thin provisioning, and it provides always-on data compression and deduplication to help lower costs and improve efficiency without compromising performance. PowerStore uses patented technology built from the ground up, called Dynamic Resiliency Engine (DRE), to help protect data and improve the reliability of the appliance. Because of this, Oracle ASM mirroring is not needed, which reduces storage usage and increases overall performance.

PowerStore comes in two different models, PowerStore T and PowerStore X. PowerStore T models serve block services, or both block and file services. PowerStore T models can also be grouped into a cluster of up to four appliances.

A PowerStore cluster enables scaling the storage and connectivity of the PowerStore solution, while managing multiple appliances from a single HTML5 interface. In addition, a cluster can migrate resources between appliances and intelligently load-balance new applications based on storage metrics.

PowerStore X models serve block services and include a VMware vSphere® hypervisor on the system, which allows applications to run directly on the appliance alongside the PowerStore operating system. This feature (called "AppsOn") is intended for storage-heavy applications and for providing additional compute and high-performance storage to an existing environment. One of the benefits of AppsOn is that it helps IT organizations consolidate IT infrastructure and applications on PowerStore X models.

Both models offer data protection using the DRE, thin-provisioning volumes, snapshots, clones, always-on data reduction, replication, and deep integration with VMware vSphere.

A Deeper Look at PowerStore Snapshots

For most workloads, including relational databases like Oracle Database, PowerStore is a good fit for providing scalable, efficient storage with data-protection features. In fact, Dell Technologies plays up the speed, simplicity, and space-efficiency of PowerStore snapshots for point-in-time database copies or for quickly spinning up full-size, non-production environments for testing. Because these capabilities would be highly beneficial to organizations running Oracle Database workloads, Prowess decided to put PowerStore to the test to gauge the performance of creating and using snapshots.

To perform this testing, Prowess engineers used a two-socket Dell EMC PowerEdge 740xd server and added a PowerStore 7000T appliance, configured in block-optimized mode, for database storage infrastructure. Our engineers ran HammerDB against a 750-warehouse database running 1 billion transactions for 433 users. After several runs, we took snapshots of the database, and then we ran the HammerDB tests again to determine if there was performance degradation from running the database on the same storage volume containing the large snapshot (see Figure 7). Performance was within 3 percent after taking the snapshots.
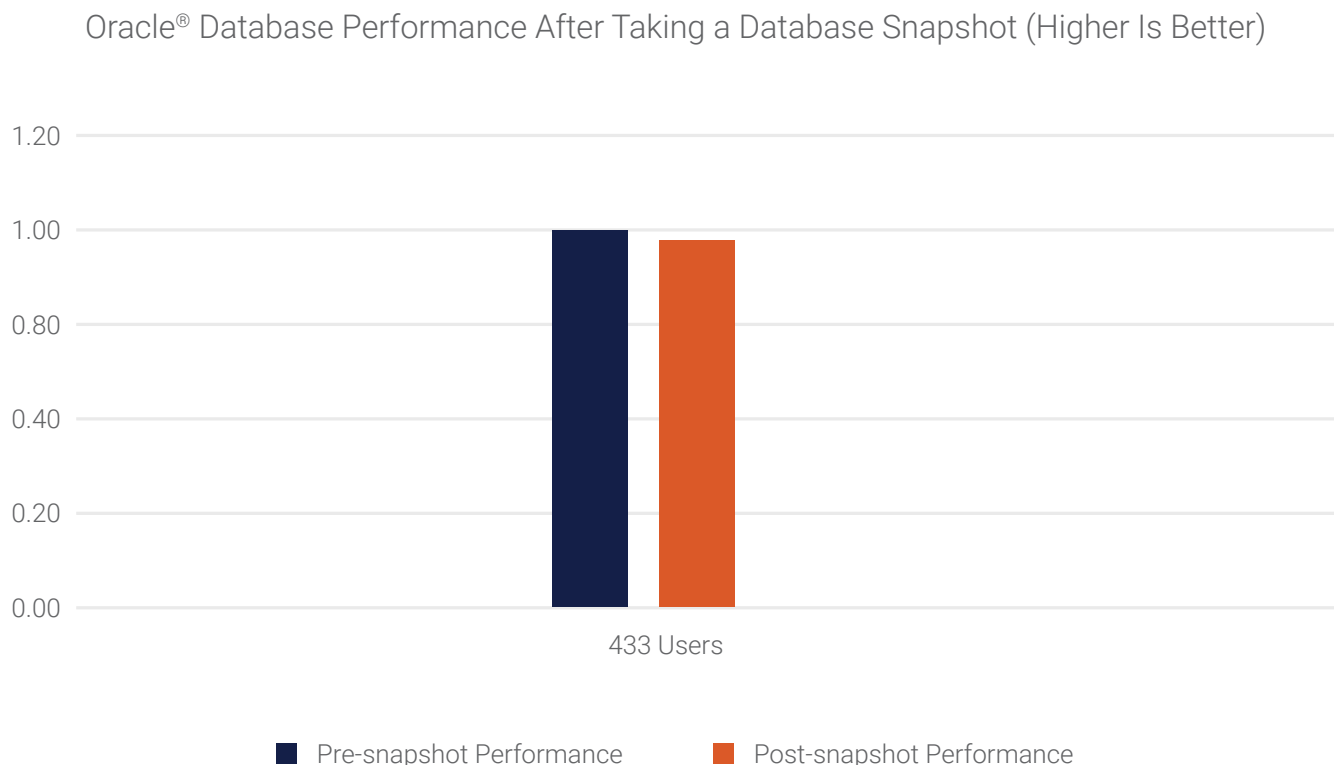
Oracle® Database Performance After Taking a Database Snapshot (Higher Is Better)

Figure 7. Oracle® Database performance on a Dell EMC™ PowerEdge™ R740xd two-socket system after taking a snapshot, relative to pre-snapshot performance

Finally, our engineers created cloned volumes from the snapshots, mapped the cloned volumes to a two-socket Dell EMC PowerEdge 740xd server, and then re-ran the HammerDB tests to compare performance between the original and snapshot volumes. As shown in Figure 8, performance of the cloned volume actually increased by 16 percent.

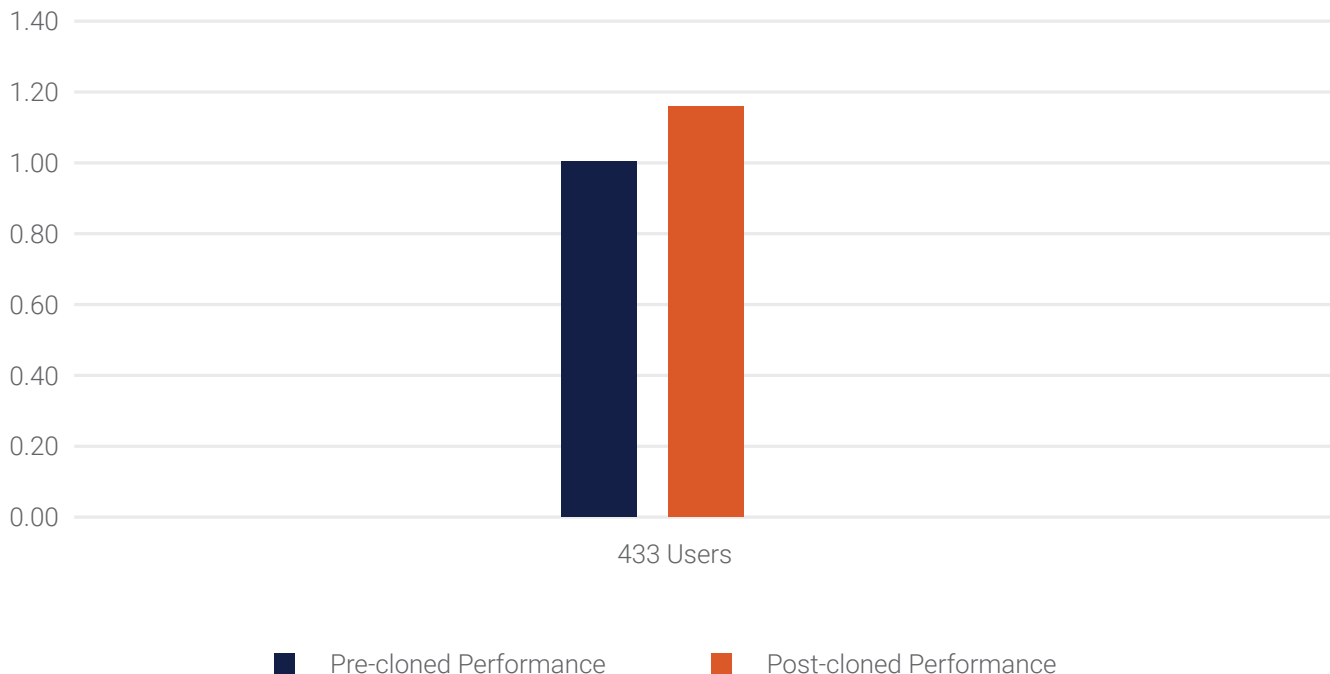Oracle® Database Performance on a Cloned Volume (Higher Is Better)

Figure 8. Oracle® Database performance on a Dell EMC™ PowerEdge™ R740xd two-socket system mapped to a cloned volume, relative to performance on the original volume

Dell EMC™ PowerEdge™ Server Advantages

Dell EMC PowerEdge R740xd
The Dell EMC PowerEdge R740xd 2U two-socket platform is ideal for advanced application environments where performance and reliability are key requirements. With support for up to 24 NVM Express® (NVMe®) drives, the flexible system architecture behind the PowerEdge R740xd offers an attractive balance between scalability and performance. In addition, administrators can mix any drive type to create the optimum configuration of NVMe drives, Serial-Attached SCSI (SAS)/Serial ATA (SATA) SSDs, and hard-disk drives (HDDs) for performance, capacity, or both. For more information on the Dell EMC PowerEdge R740xd, visit: **https://i.dell.com/sites/csdocuments/Shared-Content_data-Sheets_ Documents/en/poweredge-r740xd-spec-sheet.pdf**.

Dell EMC PowerEdge R940
The Dell EMC PowerEdge R940 is designed to power mission-critical applications that provide data for real-time decisions. With four sockets and up to 12 NVMe drives, the scalable business architecture of the Dell EMC PowerEdge R940 can support demanding, critical workloads. This server also minimizes configuration time by providing automatic tuning for many workloads. With support for up to 15.36 TB of memory and 13 PCIe® Gen 3 slots, the Dell EMC PowerEdge R940 has significant resources to improve application performance and scale to meet future demands. For more information, visit: **https://i.dell.com/sites/csdocuments/Shared-Content_data-Sheets_Documents/en/aa/ poweredge-r940-spec-sheet.pdf**.

Dell Technologies Management, Automation, and Services

IT administrators can typically reduce complexity by deploying infrastructure from a single vendor. Dell Technologies offers several software tools and services that go beyond simple consolidation to simplify management and support. For example, the Dell EMC OpenManage Enterprise console provides a comprehensive view of Dell Technologies servers, chassis, storage, and network switches on the enterprise network. It also supports plugins to automate installation of firmware and drivers for streamlined updates, includes hands-free infrastructure deployment and discovery, and generates customized reports.

Organizations that standardize on Dell Technologies hardware, software, and services can benefit from increased utilization and simplified management and support, which, in turn, can lower TCO over a three-year period and beyond.

Conclusion

Testing by Prowess shows that the Dell EMC PowerEdge servers examined provide a better investment for organizations looking to optimize their Oracle Database deployments than the IBM Power Systems examined. In addition, performance testing demonstrated that organizations can double their Oracle Database transactions with a four-socket Dell EMC PowerEdge R940 server compared to a two-socket Dell EMC PowerEdge R740xd, while achieving similar or greater TCO.

The Dell EMC PowerEdge systems that we evaluated offer several benefits to organizations over the proprietary IBM offerings, which can be expensive and harder to administer. In addition to lower TCO, the Dell Technologies servers provide greater flexibility and utilization, along with easier management and support, particularly when deployed as part of a more homogeneous Dell Technologies infrastructure–based data center. In addition, IT administrators can make use of integrated tools, services, and hardware, such as Dell EMC PowerStore, to further reduce complexity and add greater value to an already compelling investment.

Note: System configurations and TCO calculations are provided in Appendices A and B. For full descriptions of the configurations and our performance testing, see **Oracle Database on Dell PowerEdge Servers: Methodologies Report**.

Appendix A: System Configurations for TCO Study

	Dell EMC™ PowerEdge™ R740xd	Dell EMC PowerEdge R940	IBM® Power® System S924	IBM Power System E950
Processor/Cores	2 x 18-core Intel® Xeon® Gold 6240 processors	4 x 18-core Intel Xeon Gold 6240 processors	2 x 12-core IBM® POWER9™ processors	4 x 12-core IBM POWER9 processors
Total Cores	36	72	24	48
Total Memory	576 GB	1,152 GB	1,536 GB	3,072 GB
Storage	2 x 1.92 TB SATA SSD	2 x 1.92 TB SATA SSD	300 GB SAS SSD 387 GB SAS SSD	800 GB NVM Express® (NVMe®) SSD 1.6 TB NVMe SSD 3.2 TB NVMe SSD
Network	Dual-port 10 gigabit Ethernet (GbE) Base-T + dual-port 1 GbE Base-T adapter Dual-port 10/25 GbE SFP28 adapter	Dual-port 10 GbE Base-T and dual-port 1 GbE Base-T adapter Dual-port 10/25 GbE SFP28 adapter	4-port 10 GbE + 1 GbE SR + RJ45 adapter	4-port 10 GbE + 1 GbE SR + RJ45 adapter 4-port 10 GbE SR adapter

	Dell EMC™ PowerEdge™ R740xd	Dell EMC PowerEdge R940	IBM® Power® System S924	IBM Power System E950
Fibre	Dual-port 32 Gb QLogic® QLE2742 Fibre Channel controller	Dual-port 32 Gb QLogic QLE2742 Fibre Channel controller	2 x dual-port PCIe® 3.0 32 Gb Fibre Channel adapter	Dual-port PCIe 3.0 32 Gb Fibre Channel adapter Dual-port PCIe 3.0 16 Gb Fibre Channel adapter
Operating System	Red Hat® Enterprise Linux® (RHEL) 8	RHEL 8	IBM® AIX® 7.2 Enterprise Edition	AIX 7.2 Enterprise Edition
Oracle® Database	Oracle Database 19c (19.3 RU 19.9)	Oracle Database 19c (19.3 RU 19.9)	Oracle Database 19c	Oracle Database 19c

Appendix B: TCO Comparisons

Three-year TCO comparison of two-socket systems (see Figures 1–3 and Table 1); all hardware costs were provided by Dell Technologies in November 2020 and IBM in May 2020 and are based on retail pricing without discounts.

	Dell EMC™ PowerEdge™ R740xd (36 Cores)	IBM® Power® System S924 (24 Cores)
Hardware	$28,024	$158,079
Purchase price difference for hardware	*$130,055 less*	–
Support (3 years)	$2,338	$12,528
Operating system: IBM® AIX® 7.2 Enterprise Edition (48 cores, 3 years)	–	$29,952
Operating system: Red Hat® Enterprise Linux® (3 years)	$6,144	–
Oracle® Database licensing[8]	$1,269,000	$1,692,000
Purchase price difference for software and support	*$456,998 less*	–
Maximum system power consumption (watts)[9,10]	300	1,222
Power consumption total cost (3 years [8,766 hours] at $0.1004/kWh)[11]	$264	$1,075
Power consumption cost difference	*$811 less*	–
Grand total	$1,305,770	$1,893,634
Grand total difference	*$587,864 less*	–
Relative difference	31 percent lower TCO	

Three-year TCO comparison of four-socket systems (see Figures 1–3 and Table 1); all hardware costs were provided by Dell Technologies in November 2020 and IBM in May 2020 and are based on retail pricing without discounts.

	Dell EMC™ PowerEdge™ R940 (72 Cores)	IBM® Power® System S950 (48 Cores)
Hardware	$57,619	$608,422
Purchase price difference for hardware	*$564,569 less*	–
Support (3 years)	$3,865	$26,676
IBM® AIX® 7.2 Enterprise Edition (48 cores, 3 years)	–	$59,904
Red Hat® Enterprise Linux® (3 years)	$6,144	–
Oracle® Database licensing[8]	$2,538,000	$3,384,000
Purchase price difference for software and support	*$922,571 less*	–
Maximum system power consumption (watts)[12,13]	600	2,016
Power consumption total cost (3 years [8,766 hours] at $0.1004/kWh)[11]	$528	$1,774
Power consumption cost difference	*$1,246 less*	–
Grand total	$2,606,156	$4,080,776
Grand total difference	$1,474,620 less	–
Relative difference	36 percent lower TCO	

DELLTechnologies

1 DB-Engines. "DB-Engines Ranking." December 2020. **https://db-engines.com/en/ranking**.

2 Oracle. "Oracle Processor Core Factor Table." October 2019. **www.oracle.com/us/corporate/contracts/processor-core-factor-table-070634.pdf**.

3 DataCenterNews. "HPE, Dell tops worldwide server market – IDC." September 2020. **https://datacenternews.us/story/hpe-dell-tops-worldwide-server-market-idc**.

4 $158,079 for the IBM® Power® System S924 versus $28,024 for the Dell EMC™ PowerEdge™ R740xd. IBM price provided to Prowess Consulting May 6, 2020, and is for an IBM Power System S924 running 2 x 12-core IBM® POWER9™ processors and 6 x 64 GB DDR4 memory. Dell pricing provided to Prowess Consulting December 4, 2020, and is for 2 x 18-core Intel® Xeon® Gold 6240 processors and 12 x 16 GB plus 12 x 32 GB DRAM..

5 $608,422 for the IBM® Power® System E950 versus $57,619 for Dell EMC™ PowerEdge™ R940. IBM price provided to Prowess Consulting May 6, 2020, and is for an IBM Power System E950 running 4 x 12-core IBM® POWER9™ processors and 48 x 64 GB DDR4 memory. Dell pricing provided to Prowess Consulting December 4, 2020 and is for 4 x 24-core Intel® Xeon® Gold 6240 processors with 24 x 16 GB plus 24 x 32 GB DRAM.

6 IBM® AIX® systems administrator average base pay was $64,892 per year as of September 29, 2020. Source: Glassdoor. "AIX Systems Administrator Salaries." **www.glassdoor.com/Salaries/aix-systems-administrator-salary-SRCH_KO0,25.htm**.

7 Average IT administrator base pay was $56,396 per year as of December 3, 2020. Source: Glassdoor. "IT Administrator Salaries." **www.glassdoor.com/Salaries/it-administrator-salary-SRCH_KO0,16.htm**.

8 Source: Oracle Technology Global Price List. September 2020. Accessed December 21, 2020. Pricing covers Oracle® Database Enterprise Edition, processor license, and the Oracle® Real Application Clusters (RAC) add-on. Licensing subject to the Oracle core factor (number of cores times 0.5 for Intel® Xeon® processors and times 1.0 for IBM® AIX® processors).

9 Source for maximum system power, 300 watts, for Dell EMC™ PowerEdge™ R740xd running 2 x 18-core Intel® Xeon® Gold 6240 processors was Dell Technologies. "Dell EMC Technical Guide: PowerEdge R740740xd." 2017. **https://i.dell.com/sites/csdocuments/Merchandizing_Docs/ja/poweredge-r740-r740xd-technical-guide-190712.pdf**.

10 Source for maximum system power, 1,222 watts, for IBM® Power® System S924 running 2 x 12-core IBM® POWER9™ processors, 24 x 64 GB DDR4 memory was the IBM Energy Estimator tool: **https://see.au-syd.mybluemix.net/see/EnergyEstimator**. Accessed December 4, 2020. Redbooks. "IBM Power System S924." 2018. **www.redbooks.ibm.com/redpapers/pdfs/redp5509.pdf**.

11 United States Energy Information Administration. "Electric Power Monthly." September 2020. **www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a**.

12 Source for maximum system power, 600 watts, for Dell EMC™ PowerEdge™ R940 running 4 x 18-core Intel® Xeon® Gold 6240 processors with 24 x 16 GB DRAM was Intel. "Product Specifications: Intel® Xeon® Gold 6240 Processor" **https://ark.intel.com/content/www/us/en/ark/products/192443/intel-xeon-gold-6240-processor-24-75m-cache-2-60-ghz.html**.

13 Source for maximum system power, 2,016 watts, for IBM® Power® System E950 running 4 x 12-core IBM® POWER9™ processors, 48 x 64 GB DDR4 memory was the IBM Energy Estimator tool: **https://see.au-syd.mybluemix.net/see/EnergyEstimator**. Accessed December 4, 2020.