PROWESS

Total Cost of Ownership Study

The Economics of Running SAP HANA®
on Two-Socket and Four-Socket Servers

Research by Prowess Consulting found that Lenovo® ThinkSystem™ SR650 V3 and ThinkSystem SR850 V3 servers provide a lower three-year total cost of ownership (TCO) than competing SAP HANA systems.

Executive Summary

Businesses rely on transactional databases for a single source of truth. Organizations of all sizes need to extract insights from these very large databases. Housing these databases in memory can speed results and increase competitiveness. And while the price of memory continues to decline, single-unit scale-up servers still represent a sizable investment for IT organizations. However, the price of acquisition is only part of the cost; SAP HANA® deployments can be expensive to operate, particularly when labor costs for the specialists to manage them are factored in.

Prowess Consulting evaluated scale-up systems in a variety of memory configurations for SAP HANA solutions running on servers powered by the latest-generation Intel® Xeon® Scalable processors from Dell Technologies, HPE, and Lenovo. Our analysis shows that Lenovo® ThinkSystem™ SR650 V3 servers provide a lower total cost of ownership (TCO) over a three-year period among two-socket servers, compared to Dell™ PowerEdge™ R760 and HPE® ProLiant® DL380 Gen11 servers. For four-socket servers, we found that ThinkSystem SR850 V3 servers provide a lower three-year TCO compared to PowerEdge R860 and ProLiant DL560 Gen11 servers.

Lenovo® solutions for SAP HANA® provide up to

33%

lower three-year TCO than Dell™ solutions.[1]

Lenovo® solutions for SAP HANA® provide up to

40%

lower three-year TCO than HPE® solutions.[2]

This lower TCO stems from both lower capital expenditures (CapEx) and lower operating expenses (OpEx) for the Lenovo® servers—but especially from the latter. In addition to raw TCO advantages, the Lenovo solutions for SAP HANA evaluated in this study also feature faster times to load databases into memory and perform complex queries than their counterparts from Dell Technologies and HPE while providing the same high degree of reliability as other Lenovo servers.

Technology Trends

Real-time analytics is a primary operational requirement for enterprises. In-memory database platforms like the SAP HANA platform are the bedrock for this requirement, and they can also act as transactional databases for business applications, including finance, human resources (HR), order-to-cash, inventory, and forecasting applications. Running large databases in memory—even databases that are several terabytes in size—can keep storage latency from slowing down queries, providing faster, more actionable insights on a single source of truth for analytics and transactions, even as datasets grow increasingly large.

Many kinds of applications beyond traditional line-of-business (LOB) applications build on top of databases to benefit from the in-memory, columnar capabilities of SAP HANA. SAP S/4HANA® software provides enterprise resource planning (ERP) capabilities with the real-time performance of SAP HANA. SAP® BW/4HANA is the SAP® Business Warehouse solution optimized for SAP HANA, and it provides simplified operations and improved performance for business-warehouse applications.

The hardware supporting SAP HANA is crucial to realizing the performance capabilities of the platform; attempting to run SAP HANA on hardware that cannot utilize all of its capabilities constrains overall performance. As one means of avoiding such mismatches between hardware and software, SAP certifies SAP HANA appliances produced by OEMs that successfully integrate with SAP® solutions.[3] In addition, SAP requires that SAP HANA appliances have a valid SAP HANA hardware certification at the time of purchase by customers in order to qualify for SAP support.

The alternative to appliance-based deployment is SAP HANA Tailored Datacenter Integration (TDI). SAP HANA TDI offers organizations greater flexibility for integrating SAP HANA into their data centers, such as by right-sizing CPUs to meet business needs (as opposed to being a single large size for appliances) and by using new types of storage, such as NVM Express® (NVMe®). However, such custom-built SAP HANA solutions must still be assembled using SAP-certified components and deployed with SAP HANA installed by an SAP-certified engineer.

On-Premises Versus Cloud Deployment Considerations

Whether to deploy the SAP HANA® platform in the cloud is a question that many organizations grapple with, and it has no one-size-fits-all answer. SAP HANA in the cloud might save some organizations money while proving more expensive for others.[4] Likewise, cloud-based SAP HANA might provide higher security for some organizations while being untenable for others due to legal or regulatory requirements. This study assumes on-premises deployment of SAP HANA, and it does not consider the ramifications of TCO for deploying SAP HANA in the cloud.

Comparison Motivation and Overview

Because of the centrality of SAP HANA workloads to business operations, Prowess Consulting wanted to explore the differences in three-year TCO when running SAP HANA on x86 servers from the OEMs with the largest market share: Dell Technologies, HPE, and Lenovo.[5] To assess SAP HANA TCO, we examined two-socket and four-socket servers from these OEMs running the latest-generation Intel Xeon processors certified for SAP HANA appliance and TDI deployments (see Figure 1).[6]

Figure 1. Server brands evaluated in this study

This study compares the CapEx to acquire systems that are certified for SAP HANA and that are powered by Intel Xeon Scalable processors,[7] in addition to the OpEx associated with running those solutions over a three-year period. This study only examines TCO considerations for SAP HANA systems in scale-up scenarios.

TCO Findings

Our analysis found that, for two-socket SAP HANA systems, Lenovo ThinkSystem SR650 V3 servers cost $456,238 less (per server) to acquire and operate over a three-year period than Dell PowerEdge R760 servers, or 33 percent lower TCO over three years. The ThinkSystem SR650 V3 servers cost even less to acquire and operate over three years—$641,685 (per server), or 40 percent less—compared to HPE ProLiant DL380 Gen11 servers (see Appendix C: Three-Year Costs). This translates to 49 percent higher three-year TCO for PowerEdge R760 servers and 69 percent higher three-year TCO for ProLiant DL380 Gen11 servers, compared to Lenovo ThinkSystem SR650 V3 servers (see Figure 2).

Three-Year TCO for Two-Socket SAP HANA® Servers
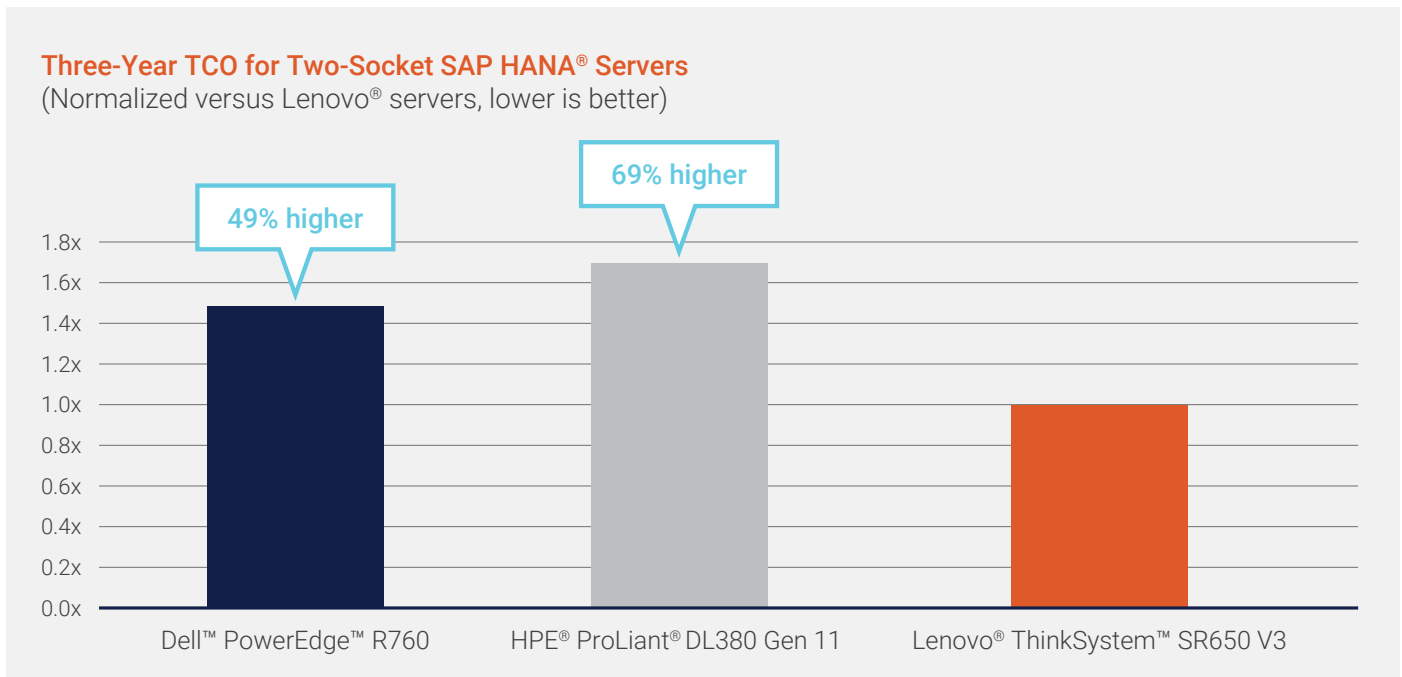(Normalized versus Lenovo® servers, lower is better)

Figure 2. Among two-socket SAP HANA® systems, Lenovo® ThinkSystem™ SR650 V3 servers provide a markedly lower TCO over a three-year period compared to Dell™ PowerEdge™ R760 servers and HPE® ProLiant® DL380 Gen11 servers

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Our examination turned up a similar pattern for the four-socket SAP HANA systems that we analyzed. ThinkSystem SR850 V3 servers cost $560,134 (per server) less to acquire and operate over a three-year period than PowerEdge R860 servers—a 31 percent lower TCO over three years. The ThinkSystem SR850 V3 servers cost even less to acquire and operate over three years compared to HPE ProLiant DL560 Gen11 servers: $684,533 (per server) or 35 percent (see Appendix C: Three-Year Costs). This translates to 45 percent higher three-year TCO for PowerEdge R860 servers and 55 percent higher three-year TCO for ProLiant DL560 Gen11 servers over ThinkSystem SR850 V3 servers (see Figure 3).

Three-Year TCO for Four-Socket SAP HANA® Servers
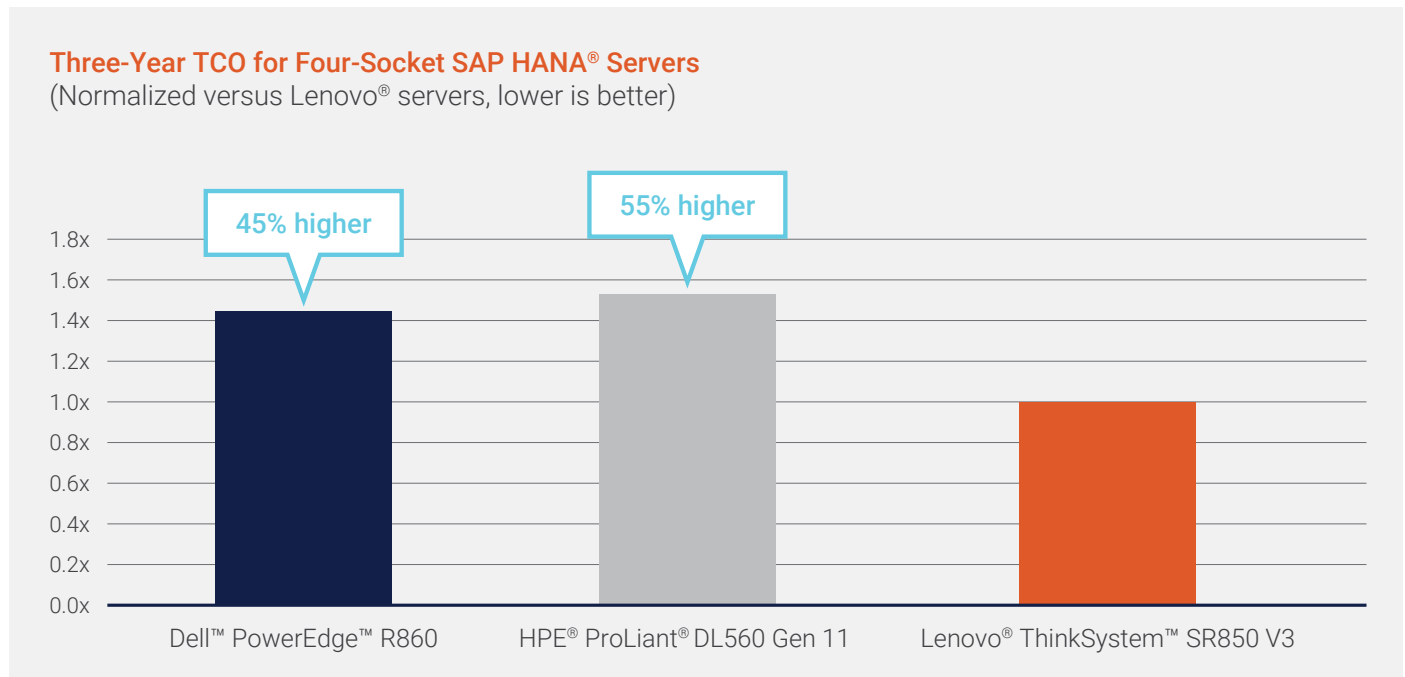(Normalized versus Lenovo® servers, lower is better)

Figure 3. Among four-socket SAP HANA® systems, Lenovo® ThinkSystem™ SR850 V3 servers supply significantly lower TCO over a three-year period compared to Dell™ PowerEdge™ R860 servers and HPE® ProLiant® DL560 Gen11 servers

Study Methodology Details

The TCO examined in this study includes both CapEx and OpEx costs for selected SAP HANA appliances and TDI solutions from three different OEMs. CapEx costs examined include:
- Server hardware
- Storage hardware (integrated)

OpEx can be more nebulous. While power is unarguably an operating cost connected to a particular piece of hardware, other costs—like space in a data center—can be harder to isolate for individual solutions. For this reason, this study limits OpEx costs to the following:
- Management
- Power
- Cooling
- Downtime
- Labor

For specific assumptions about these costs, see Appendix B.

Downtime Costs

After CapEx costs and labor, downtime is the biggest contributor to three-year TCO for all of the servers we analyzed in this study (see Appendix C: Three-Year Costs). Based on the 2022 Information Technology Intelligence Consulting (ITIC) Server Reliability Poll,[8] Prowess Consulting estimated that server downtime costs ThinkSystem users $16,500 (per server) on average over three years, compared to $390,000 for users of PowerEdge servers and $585,000 for organizations using ProLiant servers. See Figure 4 for downtime cost data and Appendix B: Study Assumptions and Methodology for details about our methodology.

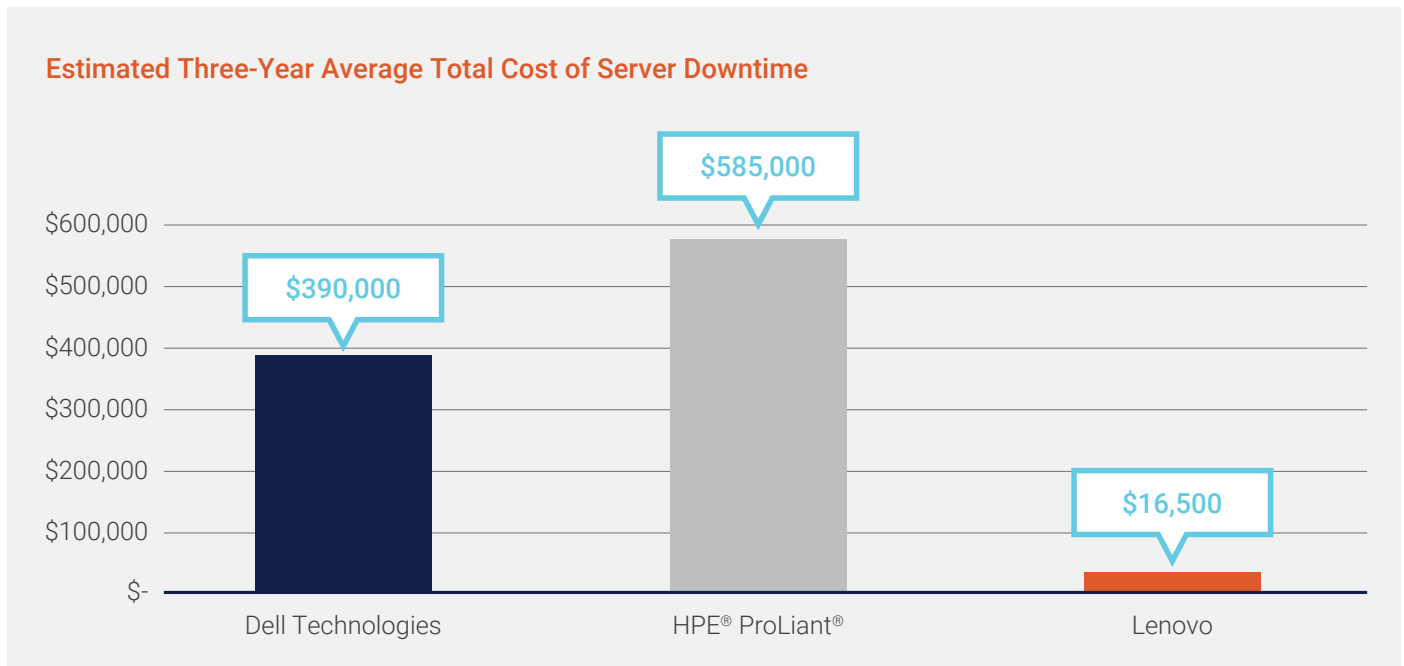### Estimated Three-Year Average Total Cost of Server Downtime

Figure 4. Server downtime is the third-biggest contributor to estimated three-year TCO for all servers examined, behind acquisition and management costs (see Appendix B: Study Assumptions and Methodology for details)

Shared Compute Capabilities

The 4th Gen Intel Xeon Scalable processors that power the servers examined in this study provide a number of benefits over
3rd Gen Intel Xeon Scalable processors:

- 1.53x average generation-on-generation performance improvement[9]
- Up to 1.60x higher input/output operations per second (IOPS) and up to 37 percent latency reduction for large-packet sequential reads using integrated Intel® Data Streaming Accelerator (Intel® DSA) versus 3rd Gen Intel Xeon Scalable processors[10]
- Up to 95 percent fewer cores and 2x higher level-1 compression throughput using integrated Intel® QuickAssist Technology (Intel® QAT) versus 3rd Gen Intel Xeon Scalable processors[11]

4th Gen Intel Xeon Scalable processors are designed to accelerate performance across the fastest-growing workloads in data analytics, networking, and storage.[12] Examples of these accelerators include:

- Intel® In-Memory Analytics Accelerator (Intel® IAA), which improves analytics performance while offloading tasks from CPU cores to accelerate database query throughput and other workloads.[12]
- Intel DSA, which drives high performance for storage, networking, and data-intensive workloads by improving streaming data movement and transformation operations.[12]
- Intel® Advanced Vector Extensions 512 (Intel® AVX-512), which supports up to two fused-multiply add (FMA) units and includes optimizations to accelerate performance for demanding computational tasks.[12]
- Intel QAT, which accelerates encryption, decryption, data compression, and offloading these tasks from the processor core to help reduce system resource consumption.[12]

Qualitative Differentiators

Beyond the TCO benefits highlighted in this study, a number of hard-to-quantify differentiators emerged between the Dell Technologies, HPE, and Lenovo SAP HANA solutions examined. These differentiators span reliability, support, management, and managed services.

Reliability
While Prowess Consulting quantitatively modeled reliability in the TCO figures, qualitative differentiators for reliability stood out from analyzing the SAP HANA solutions in this report. These differentiators can point to lower downtime and improvements for other sources of friction that might otherwise increase operational expenses.

Lenovo® Reliability, Availability, and Serviceability (RAS) Features

Lenovo servers continue to be the industry's most reliable x86 servers for the eighth year in a row.[8] The "ITIC 2022 Global Server Hardware, Server OS Reliability Report" from ITIC noted that 92 percent of Lenovo users surveyed reported between 99.999 percent and 99.9999 percent uptime (less than 5 minutes and 16 seconds of annual downtime and 32 seconds of annual downtime, respectively), a figure that exceeds results reported by PowerEdge and ProLiant users.[7] Specific RAS features in the Lenovo ThinkSystem SR650 V3 server include:

- **Predictive Failure Analysis (PFA)**, which alerts administrators to impending failure of processors, memory, power-supply units (PSUs), system fans, adapter slots, hard-disk drives (HDDs)/solid-state drives (SSDs), and voltage-regulator modules (VRMs); this allows servicers to schedule planned downtime, rather than reacting to sudden failures.
- **Independently powered light-path diagnostic LEDs**, which light up beside a failing component for instant identification in order to facilitate fast servicing and reduced downtime.
- **Machine-Check Architecture (MCA) recovery**, which provides operating system–layer assisted recovery from uncorrectable data errors, helping prevent system resets.
- **Adaptive Double-Device Data Correction (DDDC)**, which protects the system from memory errors while repairing those errors.
- **Fatal-error handling**, which enables override of application shutdown by setting a custom handler of fatal errors.

Support, Management, and as-a-Service

Lenovo provides a range of management options for ThinkSystem servers running SAP HANA, like the ThinkSystem SR650 V3 and ThinkSystem SR850 V3, so that administrators can focus on more strategic tasks. It also provides options to fully manage SAP HANA deployments and provide SAP HANA "as a service" (as described below).

Lenovo® Premier Support

Lenovo® Premier Support includes SAP HANA deployments. This dedicated support from Lenovo provides a single-point-of-contact support service, in addition to one-on-one access to the Lenovo Premier Support team of agents 24/7/365 via a dedicated phone number, online ticket, or live chat; it is available at a variety of service levels. For more information about Lenovo Premier Support, visit www.lenovo.com/us/en/premier-support/.

Lenovo® Managed Services for SAP HANA

With Lenovo® Managed Services for SAP HANA, Lenovo service professionals remotely monitor and manage supported server, storage, and networking devices, in addition to select third-party products sold by Lenovo or Lenovo-authorized resellers. These services enhance the security and reliability of your data center and help ensure high performance and stability for SAP HANA deployments. Continuous monitoring, scheduled health checks, and recommended updates can help control management costs for SAP HANA and provide skills and knowledge that IT organizations might not already possess. For more information about Lenovo Managed Services for SAP HANA, visit www.lenovo.com/us/en/resources/data-center-solutions/brochures/lenovo-managed-services-for-sap-hana/.

As-a-Service

Lenovo® TruScale Infrastructure services enable Lenovo customers to use SAP HANA as a service. These services provide SAP HANA deployments with no up-front capital costs and a flexible, cloud-like consumption model with on-premises security and control. Lenovo TruScale Infrastructure services are all-inclusive offerings that cover the full lifecycle of systems:

- Installation, deployment, and removal
- Comprehensive monitoring and proactive management
- Health checks and updates per customer schedule

Lenovo TruScale Infrastructure services provide a dedicated customer-success manager, quarterly business reviews, support plans, and a customer portal. They can be integrated with the RISE with SAP solution, SAP S/4HANA Cloud, Private Edition, customer data center option. For more information about Lenovo TruScale Infrastructure services, visit https://techtoday.lenovo.com/us/en/solutions/iaas.

Conclusion

Analysis of the TCO for Dell Technologies, HPE, and Lenovo offerings for SAP HANA over three years reveals tangible savings across the board: both for two-socket Lenovo ThinkSystem SR650 V3 servers compared to Dell PowerEdge R760 servers and HPE ProLiant DL380 Gen11 servers and for four-socket ThinkSystem SR850 V3 servers compared to PowerEdge R860 servers and ProLiant DL560 Gen11 servers. In addition to quantitative differences between the solutions, ThinkSystem SR650 V3 and ThinkSystem SR850 V3 servers provide qualitative benefits beyond those supplied by the competing Dell Technologies and HPE servers. Per ITIC, ThinkSystem servers continue to be rated among the most reliable servers in the industry,[7] and both the ThinkSystem SR650 V3 and ThinkSystem SR850 V3 servers host a number of unique RAS capabilities absent from the other systems examined. Finally, our research notes that Lenovo services provide several means to simplify administering complex SAP HANA deployments, including Lenovo Managed Services for SAP HANA.

Appendix A: Hardware Specifications

This section details hardware specifications for each two-socket system included in this study, grouped by OEM:

Dell Technologies

Dell™ PowerEdge™ R760	
Intel® Xeon® Platinum 8470 processor: 2.0 GHz, 52 cores 350 W	2
64 GB RDIMM, 4,800 megatransfers per second (MT/s) quad-rank	32
480 GB Serial ATA (SATA®) read-intensive solid-state drive (SSD), 6 Gbps, 512 2.5-inch hot-plug AG drive, 1 drive write per day (DWPD)	2
3.84 TB NVMe® data center read-intensive AG drive, U2 Gen4 with carrier	4

HPE

HPE® ProLiant® DL380 Gen11	
Intel® Xeon® Platinum 8470 processor: 2.0 GHz, 52 cores, 350 W	2
64 GB (1 x 64 GB) dual-rank x4 DDR5-4800 CAS-40-39-39 EC8	32
480 GB SATA® 6G mixed-use SFF BC multi-vendor SSD	2
3.84 TB Serial Attached SCSI (SAS) read-intensive SSD, 12 Gbps, SFF TLC 2.5-inch SC for Gen10 and 10 Plus server	4

Lenovo

Lenovo® ThinkSystem™ SR650 V3	
Intel® Xeon® Platinum 8470 processor, 2.0 GHz, 52 cores, 350 W	2
64 GB TruDDR5 4,800 MHz (2Rx4) 10x4 RDIMM	32
240 GB read-intensive SATA® SSD, 6 Gb HS 2.5-inch ThinkSystem 5400 PRO	2
3.84 TB read-intensive SAS SSD, 24 Gb HS 2.5-inch ThinkSystem PM1653	4

This section details hardware specifications for each four-socket system included in this study, grouped by OEM:

Dell Technologies

Dell™ PowerEdge™ R860	
Intel® Xeon® Platinum 8490H processor, 1.9 GHz, 60 cores, 350 W	4
128 GB RDIMM, 4800MT/s quad-rank	32
480 GB SATA® read-intensive SSD, 6 Gbps, 512 2.5-inch hot-plug AG Drive, 1 drive write per day (DWPD)	2
3.84 TB NVMe® read-intensive AG drive, U2 Gen4 with carrier	6

Appendix A: Hardware Specifications (cont.)

HPE

HPE® ProLiant® DL560 Gen11	
Intel® Xeon® Platinum 8490H processor, 1.9 GHz, 60 cores, 350 W	4
128 GB (1 x 128 GB) quad-rank x4 DDR5-4800 CAS-46-39-39 EC8	32
480 GB SATA® 6G mixed-use SFF BC multi-vendor SSD	2
3.84 TB SAS read-intensive SSD, 12 Gbps, SFF TLC 2.5-inch SC for Gen10 and 10 Plus server	6

Lenovo

Lenovo® ThinkSystem™ SR850 V3	
Intel® Xeon® Platinum 8490H processor, 1.9 GHz, 60 cores, 350 W	4
ThinkSystem 128 GB TruDDR5 4,800 MHz (4Rx4) 3DS RDIMM	32
240 GB SATA® read-intensive SSD, 6 Gb HS, ThinkSystem 2.5-inch 5400 PRO	2
3.84 TB SAS read-intensive SSD, 24 Gb HS, ThinkSystem 2.5-inch PM1653	6

Appendix B: Study Assumptions and Methodology

This study makes the following assumptions in projecting the three-year TCO for the SAP HANA systems analyzed:

- **Capital costs**—This study uses the manufacturer's suggested retail price (MSRP) for the servers examined and does not include any discounts that customers might receive in actuality.
- **Server utilization**—This study assumes 85 percent average power utilization by the servers examined.
- **Power costs**—This study uses the United States national average commercial cost of USD 0.1277 per kWh.[13]
- **Cooling costs**—This study assumes that the heat dissipated by servers takes exactly its equivalent in the amount of power required to cool at 0.000293 kWh/BTU.
- **Labor costs**—This study uses a uniform fully burdened cost of USD 150,000 per year per full-time employee (FTE) equivalent for both storage and SAP HANA management.
- **FTE equivalents**—This study assumes 1.7 FTE equivalents per management responsibility for each server.

Downtime Cost—Estimate Details

In order to estimate downtime costs for this analysis, Prowess Consulting drew upon the results of the 2022 ITIC Server Reliability Poll. Of respondents to the ITIC poll, 91 percent reported that a single hour of server downtime costs them $301,000 or more, and 44 percent reported that one hour of unplanned server downtime costs them more than $1 million.[7] Based on these results, we used the more conservative figure of $300,000 per hour of unplanned server downtime in this study (although the true figure is likely higher, as the ITIC survey polled organizations about the overall cost of their servers being down; downtime for the kinds of business-critical workloads that organizations run on SAP HANA is likely much more expensive). Table 1 lists the average annual downtime reported in the ITIC poll by server family and the resulting average annual cost of unplanned server downtime.

Table 1. Reported server downtime figures for families of server platforms by OEM; annual cost figures assume $300,000 per hour (per server) of unplanned server downtime

Server Make	Mean of Annual Unplanned Server Downtime	Annual Cost of Unplanned Server Downtime per Server
Dell™ PowerEdge™	26.00 minutes	$130,000
HPE® ProLiant®	39.00 minutes	$585,000
Lenovo® ThinkSystem™	1.10 minutes	$5,500

Appendix C: Three-Year Costs

Three-year estimated TCO for each two-socket server examined in this study breaks down by OEM as follows:

Dell Technologies

	Dell™ PowerEdge™ R760
MSRP (USD)	217,430.94
Power (W)	1,106.00 W
Cooling (BTU/h)	3,773.80 BTU/h
Three-year power and cooling (USD)	7,427.53
Labor (USD)	765,000.00
Downtime (USD)	585,000.00
Three-year TCO (USD)	1,379,858.47

HPE

	HPE® ProLiant® DL380 Gen11
MSRP (USD)	209,092.03
Power (W)	925.20 W
Cooling (BTU/h)	3,157.60 BTU/h
Three-year power and cooling (USD)	6,214.05
Labor (USD)	765,000.00
Downtime (USD)	585,000.00
Three-year TCO (USD)	1,565,306.08

Lenovo

	Lenovo® ThinkSystem™ SR650 V3
MSRP (USD)	136,868.02
Power (W)	782.10 W
Cooling (BTU/h)	2,668.50 BTU/h
Three-year power and cooling (USD)	5,252.21
Labor (USD)	765,000.00
Downtime (USD)	16,500.00
Three-year TCO (USD)	923,620.23

Three-year estimated TCO for each four-socket server examined in this study breaks down by OEM as follows:

Dell Technologies

	Dell™ PowerEdge™ R860
MSRP (USD)	634,992.83
Power (W)	1,986.00 W
Cooling (BTU/h)	6,776.50 BTU/h
Three-year power and cooling (USD)	13,337.36
Labor (USD)	765,000.00
Downtime (USD)	390,000.00
Three-year TCO (USD)	1,803,330.19

HPE

	HPE® ProLiant® DL560 Gen11
MSRP (USD)	566,109.15
Power (W)	*1,474.60 W*
Cooling (BTU/h)	*6,776.50 BTU/h*
Three-year power and cooling (USD)	11,619.84
Labor (USD)	765,000.00
Downtime (USD)	585,000.00
Three-year TCO (USD)	1,927,728.99

Lenovo

	Lenovo® ThinkSystem™ SR850 V3
MSRP (USD)	453,141.02
Power (W)	*1,273.80 W*
Cooling (BTU/h)	*4,346.20 BTU/h*
Three-year power and cooling (USD)	8,554.27
Labor (USD)	765,000.00
Downtime (USD)	16,500.00
Three-year TCO (USD)	1,243,195.29

[1] Calculated from the maximum estimated three-year TCO of a Dell™ PowerEdge™ R760 server being 50 percent higher than a comparable Lenovo® ThinkSystem™ SR650 V3 server. See Appendix C.

[2] Calculated from the maximum estimated three-year TCO of an HPE® ProLiant® DL380 Gen11 server being 69 percent higher than a comparable Lenovo® ThinkSystem™ SR650 V3 server. See Appendix C.

[3] SAP. "Certified and Supported SAP HANA® Hardware." www.sap.com/dmc/exp/2014-09-02-hana-hardware/enEN/index.html.

[4] For example, a recent survey notes that 80 percent of small and medium-sized businesses (SMBs) and 82 percent of enterprises listed managing cloud spend as their number-one priority (the first time that cost has overtaken security as the top priority in the last 10 years). Source: Flexera. "Flexera™ 2023 State of the Cloud Report." 2021. https://info.flexera.com/CM-REPORT-State-of-the-Cloud.

[5] The top server manufacturers in 2022 were (in order of decreasing market share) Dell Technologies, HPE, Inspur, and Lenovo. Because Inspur specializes primarily in white box servers for cloud service providers (CSPs), Prowess Consulting did not assess it as part of this study. Source: Digital Journal. "Servers Market Size 2022 | Top Companies [Dell, HPE, Inspur, Lenovo], long-term Planned Business Strategy up to 2028 | New Report Spread Across 97 Pages." August 2022. www.digitaljournal.com/pr/servers-market-size-2022-top-companies-dell-hpe-inspur-lenovo-long-term-planned-business-strategy-up-to-2028-new-report-spread-across-97-pages.

[6] While some four-socket servers also come in a 4U, 4-socket configuration (such as the Lenovo ThinkSystem SR850 V3), this study evaluated the 2U configurations only.

[7] Intel® Xeon® processors are the only x86 processors certified for SAP HANA®. Source: SAP. "Certified and Supported SAP HANA® Hardware." www.sap.com/dmc/exp/2014-09-02-hana-hardware/enEN/#/solutions?filters=v:deCertified.

[8] Information Technology Intelligence Consulting (ITIC). "ITIC 2022 Global Server Hardware, Server OS Reliability Report." February 2023. www.lenovo.com/us/en/resources/data-center-solutions/analyst-reports/itic-2022-global-server-hardware-server-os-reliability-report-feb-2023/.

[9] Intel. Performance Index (4th Gen Intel Xeon Scalable Processors, G1). Accessed May 12, 2023. www.intel.com/PerformanceIndex.

[10] Intel. Performance Index (4th Gen Intel Xeon Scalable Processors, N18). Accessed May 12, 2023. www.intel.com/PerformanceIndex.

[11] Intel. Performance Index (4th Gen Intel Xeon Scalable Processors, N16). Accessed May 12, 2023. www.intel.com/PerformanceIndex.

[12] Intel. "4th Gen Intel® Xeon® Scalable Processors." December 2022. www.intel.com/content/dam/www/central-libraries/us/en/documents/2022-11/4th-gen-xeon-scalable-processors-brief.pdf.

[13] US Energy Information Administration. "Electric Power Monthly." April 2023. www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a.

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

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

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