Improving Oracle Database performance: Moving from older servers to 16th Generation Dell PowerEdge R960 servers with Intel Xeon Scalable processors

Bare metal Dell PowerEdge R960 servers running Oracle Enterprise Linux 8.8 handled more Oracle Database 19c transactions than legacy PowerEdge R940 and R920 virtualized solutions running Windows Server 2019

16th Gen Dell PowerEdge R960 bare metal solution running Oracle Enterprise Linux 8.8:

7.9x the Oracle Database 19c transactions per minute*

vs. a legacy Dell PowerEdge R920 virtualized solution running Windows Server 2019

2.4x the Oracle Database 19c transactions per minute*

vs. a legacy Dell PowerEdge R940 virtualized solution running Windows Server 2019

Up to 7.9x the performance/rack U for consolidation*

vs. a legacy Dell PowerEdge R920 virtualized solution running Windows Server 2019

Overview

Aging servers can become progressively costlier to maintain and can negatively impact business productivity, due to a higher demand for IT staff time and the increased risk of unplanned downtime. Older servers hosting virtualized Oracle® Database applications may begin to struggle to meet growing usage demands, leading to slower operations that, for example, could deter customers from searching a website for products and making online purchases. Aging hardware also faces an increased risk of data loss or corruption and could introduce security issues and higher maintenance and repair costs.

Moving Oracle Database workloads from older servers onto new ones, such as the 16th Generation Dell™ PowerEdge™ R960 with 4th Gen Intel® Xeon® Scalable processors, could address those concerns. Upgrading to the latest-generation PowerEdge R960 could also help pave the way for additional IT improvements and help achieve business goals, such as improved customer responsiveness and accelerated time to market. Additionally, moving workloads from virtualized to bare metal solutions could increase transactional database performance, especially for those databases that come with high-performance service-level agreements (SLAs).

*Due to EULA restrictions, we normalized performance between the platforms.

To see how upgrading to 16th Generation Dell PowerEdge R960 servers can boost Oracle Database 19c workloads specifically, we compared the performance of a bare metal solution running Oracle Enterprise Linux® 8.8 against the performance of two older generations—the PowerEdge R940 and PowerEdge R920—running Windows Server 2019. We found that the latest-gen solution delivered significantly better performance, demonstrating a sizable transactional database performance divide between a new solution and aging legacy solutions. The results, as seen in Figure 1 on page 7, show that your organization might wish to consider upgrading to the Dell PowerEdge R960.

Oracle Database in today's businesses

Of the numerous relational database management systems (RDBMS) available, Oracle Database continues to stand as a market leader across enterprises of various sizes in many industries. Recent estimates position Oracle with approximately 30.2 percent of the RDBMS market share,[1] reigning as one of the database systems of choice for large enterprises and organizations including Netflix®, LinkedIn®, eBay®, intuit®, Massachusetts Institute of Technology, and more.[2]

Oracle Database offers the following features that organizations might find appealing for their critical data:

- A single database application to handle a wide variety of data types: Oracle offers a "converged, multi-model database management system."[3]
- Scalability: Oracle Database handles databases of many sizes and offers the Oracle Multitenant feature that "allows you to consolidate small databases under a single Container Database for improved scalability and reduced system overhead. Multitenant also reduces CPU use, memory, and I/O compared to databases running individually."[4]
- Built-in security: Oracle Database includes security features such as granular access controls, activity monitoring, flexible data masking, and encryption and key management to help guard against data breaches.[5]
- Multitenancy: Oracle databases can function in a multitenant architecture, which enables organizations to consolidate data and code without altering existing schemas or applications while keeping individual databases separate.[6]

The benefits of moving Oracle databases back to bare metal

While virtualized servers can maximize scalability and cost-effectiveness depending on your desired workload(s), hosting bare metal servers can be a solid option for many organizations—especially those with workloads for which maximum performance is paramount.

Performance improvements on bare metal servers stem from the removal of the virtualization layer that typically separates the host from the applications and libraries. This allows the server to use all its resources for the database application, without using processing power and memory for the hypervisor.[7]

Bare metal servers offer additional advantages, too, including reliable processing power and consistent input/output operations per second (IOPS). Such characteristics enable them to handle demanding tasks without sharing resources. Lastly, bare metal servers can provide organizations with better control over both the server's hardware and software stack and help applications avoid resource contention from competing software on different VMs.

How each server component plays a role in Oracle Database performance levels

Optimizing database performance requires tuning the database to your needs and efficiently using available server resources, from CPU power to memory allocation and even the database traffic of users accessing stored data. Troubleshooting performance issues can often involve solving a problem in one area and creating another in a different area, meaning that organizations must take a complex, comprehensive approach to mitigating dips in performance. The Oracle Database platform itself provides functional solutions that can help you optimize resource utilization, but even with this software-level aid, hardware improvements via the latest technology still offer significant performance enhancements and help optimize database performance.[8]

Processors

Because Oracle Database workloads rely heavily on the processor and tend to favor single-threaded operations, organizations running those workloads on aging servers with older processor technology could see degradation in performance. When older servers are underperforming, the impulse may be to expand and simply add new servers to the environment to cover user demands. This approach has drawbacks, including potentially excessive data center expansion and increases in power and cooling costs. Instead, replacing the underperforming servers with the latest technology can drive Oracle Database performance to levels that can handle peak demands while avoiding data center expansion challenges.

Networking

Network optimization can also play a key role in database performance, ensuring that connecting users can swiftly access the application servers. Updated servers leverage newer networking hardware, which can improve bandwidth.

Storage

Another aging server component that can hamstring Oracle Database performance is storage. Improving disk input/output (I/O) efficiency can dramatically enhance transactional database performance. Because organizations typically place busy files and tablespaces, such as log files, rollback segments, and certain indexes, on the fastest accessible disks for this purpose, newer and better internal drives and updated controllers that support those drives can improve Oracle Database performance.[9]

Memory

Maximizing physical memory utilization is also an important concern and can help you avoid swapping. Because moving memory to disk is slow, it may be more efficient to invest in additional memory if the system's requirements exceed its current capacity. Physical memory plays a crucial role in the functioning of the System Global Area (SGA) and has a direct impact on its performance. It is important to ensure that the SGA does not exceed the available physical memory, as swapping it to disk can significantly impair Oracle Database performance.

Allocating memory properly for sort operations also ensures stronger database performance. Oracle assigns memory for data sorting through the SORT_AREA_SIZE parameter. If the sorting process cannot complete within the allocated memory, Oracle resorts to using temporary segments in the database, which leads to slower performance. Larger sizes can improve performance by reducing I/O operations but could also consume more memory, potentially causing paging issues.

Comparing old versus new: The servers we tested

To show the benefits of moving Oracle Databases 19c to bare metal 16th Generation Dell PowerEdge servers from older virtualized Dell PowerEdge R940 and PowerEdge R920 servers, we compared the transactional performance of the systems. Table 1 shows key configuration details of the servers.

For this study, we tested the latest-generation PowerEdge R960, and our comparison points are results from a previous study for the PowerEdge R940 and PowerEdge R920 servers. You can read the report for that study and see the results at https://facts.pt/fhvcwjm.

Table 1: Key server specifications. Source: Principled Technologies.

Server model	Dell PowerEdge R960	Dell PowerEdge R940	Dell PowerEdge R920
Processor	4x Intel Xeon Gold 6418H (24 cores/2.10 GHz)	4x Intel Xeon Gold 6240 (18 cores/2.60 GHz)	4x Intel Xeon E7-4890 v2 (15 cores/2.80 GHz)
Total memory in system (GB)	2,048	768	512
Memory speed (MHz)	4,800	2,933	1,333
Storage	8x Dell Ent NVMe™ P5600 MU U.2 1.6TB	12x Intel SSDSC2KB019T8R 1.92TB 6Gbps SATA SSD 12x Dell Express Flash NVMe P4610 1.6TB PCIe NVMe SSD	8x Seagate® ST9300653SS 300GB 15K SAS HDD 4x Seagate ST9900805SS 900GB 15K SAS HDD 12x Intel SSDSA2CW60 600GB 3Gbps SATA SSD
Network adapter	Broadcom® NetXtreme E-Series	Intel 2P XXV710	Intel 2P XXV710
Solution	Bare metal	Virtualized	Virtualized

How we tested the Dell PowerEdge R960

We set up a single Dell PowerEdge R960 in a bare metal configuration using Oracle Enterprise Linux 8.8 for the operating system. We then installed Oracle Database 19c and used Oracle ASM to manage the storage for our data and redo logs. See the section Oracle parameters – spfile in the science behind this report for the Oracle parameters we used to configure our Oracle Database environment.

What is Oracle ASM?

Oracle Automatic Storage Management (ASM) serves as a dual-purpose file system and volume manager explicitly crafted for Oracle database files. ASM appears to operate on the premise that the database itself should manage database storage, in the hopes of eradicating the need for administrators to oversee numerous Oracle database files.[10]

At the heart of ASM are disk groups. These are clusters of disks that ASM manages collectively. Inside these disk groups, ASM offers a file system interface for Oracle database files and tries to distribute file contents evenly across all disks within a disk group.[11]

A major potential advantage of ASM is that it allows the addition or removal of disks from a disk group while the database remains accessible. This ability comes with an automatic file content redistribution feature that can help during content reorganization.[12]

In summary, ASM strives to simplify disk management, enhance redundancy within a disk group, provide strong I/O balancing with no manual tuning, and enable database object management without the need to specify mount points and filenames.[13]

To compare the performance of the Oracle Database solutions, we used the HammerDB TPROC-C workload. HammerDB TRPOC-C reports a transactions-per-minute (TPM) rate of performance, with a higher rate meaning better performance. For our Dell PowerEdge R960 testing, we used the same 400 warehouse TPROC-C database configuration for the target dataset from our previous virtualized PowerEdge R940 and PowerEdge R920 testing. In the testing of those now legacy solutions, we used multiple small Oracle databases each running in its own VM. Similarly, we used multiple small Oracle Pluggable Databases (PDBs) for our latest-gen PowerEdge R960 testing. We scaled the same 400-warehouse database, which we ran in VMs in our PowerEdge R940 and PowerEdge R920 environments, to multiple databases using four Oracle PDBs. Using multiple datasets in each testing scenario resulted in a large aggregate TPM performance.

What are Oracle pluggable databases?

The Oracle database, operating as a multitenant container database (CDB), potentially can incorporate multiple PDBs. In essence, these PDBs serve as movable assemblies of schemas, schema objects, and non-schema objects that appear as an Oracle Database. PDBs function akin to a standard database for applications.[14]

The multitenant feature of PDBs allows database admins to assign a PDB to one PDB-using group. Then they can configure access and security to the PDB so that no other PDB-using group can access it, or the database admins can configure the PDB so that another group can see only subsets of data and actions.

Multiple benefits can arise from using CDBs and PDBs, including potentially a more efficient use of resources. Compared to VMs, which duplicate the operating system, or separate databases that don't share processes, PDBs and CDBs may help you manage resources more effectively. Furthermore, these databases can facilitate an easier transfer of data and code. If admins need to move a PDB from one CDB to another, the process should be straightforward.[15]

Other notable potential advantages include the simplified separation of data and code, ease of performance tuning, support for Oracle Database Resource Manager, quicker and easier cloning, and more straightforward database upgrades.[16]

On a separate infrastructure host, we deployed HammerDB client VMs to drive the TPROC-C workload. We deployed them in a one-to-one relationship to the number of PDBs with each client targeting a single PDB. We ran each test for 20 mins with a 10-min warmup and targeted each PDB with 128 virtual users. We ran each test three times to ensure repeatability, and we report the median run.

Given that we were comparing between virtualized and bare metal environments, there are inevitably some differences in how we tuned each environment. We made the best decisions possible at the time of testing for each server, with a goal of coaxing the most possible performance out of each. This meant more virtualized databases and HammerDB clients in that earlier testing. For our bare metal testing, we were able to tune for higher TPM performance with only four PDBs and HammerDB clients with higher virtual user counts.

Our results: Achieve better Oracle Database performance and consolidate your data center

In our testing with the HammerDB TPROC-C benchmarking tool, the 16th Generation Dell PowerEdge R960 with 4th Generation Intel Xeon Scalable processors running Oracle Enterprise Linux 8.8 handled more Oracle Database 19*c* transactions than both the Dell PowerEdge R940 and the legacy Dell PowerEdge R920 servers running Windows Server 2019—up to 7.9 times the TPM. Please note that the Oracle Database EULA does not permit us to publish specific results, so we have normalized performance between the platforms. Figure 1 shows the normalized performance for each solution.

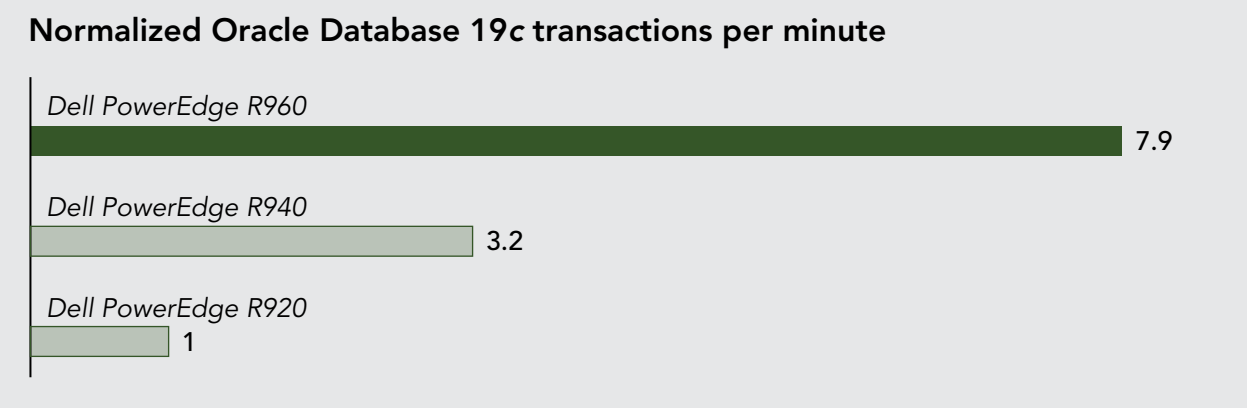

Figure 1: Normalized Oracle Database 19c results for the three Dell PowerEdge solutions we tested. Source: Principled Technologies.

Based on this data, your organization could handle 7.9 times the transactions by replacing a Dell PowerEdge R920 with a 16th Generation Dell PowerEdge R960. Additionally, you could handle 2.4 times the transactions of a PowerEdge R940 with a PowerEdge R960. This also means you could reduce your server inventory if you upgraded to the 16th Generation Dell PowerEdge R960 server for Oracle Database 19*c* workloads. A single PowerEdge R960 could replace seven PowerEdge R920 servers or two PowerEdge R940 servers and still have additional head room. Using fewer servers could reduce your operating expenses, including costs associated with power and cooling, management, and more.

In addition, consolidating systems could significantly lower database and OS licensing costs for products that use a per-core pricing model. Oracle Database and Microsoft Windows Server both license products based on core count, so fewer cores could translate to lower licensing costs if you downsized your data center. We calculated the performance per rack unit (U) of each solution and found that the 4U PowerEdge R960 delivered 7.9 times the TPM per rack unit than the 4U PowerEdge R920 and 1.8 times the TPM per rack unit than the 3U PowerEdge R940. These numbers, which we calculated by taking each solution's TPM and dividing them by the server's U count, could help you assess rack space in your data center occupied by the legacy servers. Based on this performance-per-rack unit ratio, you potentially could consolidate the workloads of seven legacy 4U PowerEdge R920 servers or two 3U PowerEdge R940 servers to just one 4U Dell PowerEdge R960.

These performance and consolidation advantages do not factor in the impact of aging legacy hardware. When legacy solutions begin to fail, they can require more time and effort from your admins to keep critical workloads running. New hardware restarts the aging clock and incorporates the latest management and storage technologies, which could save admin time and drive performance even higher.

About the workload we used: HammerDB 4.6

HammerDB is an open-source benchmarking tool that lets you test the performance of many leading databases. The benchmark tool includes two built-in workloads derived from industry standards: a transactional (TPROC-C) workload and an analytics (TPROC-H) workload. We chose the TPROC-C (TPC-C-like) workload to demonstrate the online transaction processing performance capabilities of each server; those workloads benefit from high core counts, fast memory, and fast drives. TPROC-C runs a transaction processing workload that simulates an ecommerce business with five types of transactions: receiving a customer order, recording a payment, delivering an order, checking an order's status, and checking stock in inventory.[17] Note that our test results do not represent official TPC results and are not comparable to official TPC-audited results. To learn more about HammerDB, visit https://www.hammerdb.com/.

The benefits of upgrading to new servers for enterprise

The quality of experiences for users making purchases or otherwise accessing Oracle Database data relies on the efficiency of the underlying Oracle Database application. Using newer hardware to increase responsiveness of Oracle databases can foster user engagement and retention. Reducing latency, or the wait times between data access, speeds time to data and can thus help anyone trying to make purchases, for example. Organizations historically have believed that servers are more likely to experience issues as they age, including more frequent breakdowns,[18] which could lead to downtime in turn. There is a common link between downtime and revenue loss, with older estimates suggesting losses at a rate of $5,600 to $9K per minute.[19] Although organizations likely incorporate high availability into their data center architecture, upgrading servers could help reduce the potential for downtime.

Additionally, failing databases have implications for SLAs. SLAs are contracts with clients regarding the standard of service those clients can expect. Failure to adhere to those standards, such as one resulting from a database outage, may result in SLA violations that can cause fines or other severe repercussions for a business.

Client satisfaction—the cornerstone of many organizations—can also suffer significantly in the event of a database outage. If customers cannot quickly access data, make purchases, or confirm reservations, they might simply move on to a competitor.

Which leads to our final potential negative outcome from aging servers: Your brand's reputation may be at stake. Database outages can considerably mar a brand's standing in the market. Customers expect reliability and uptime from the services they pay for, and any shortcomings in delivering on these assurances can adversely affect the perception of the brand and potentially send customers to competitors.

About the Dell PowerEdge R960 rack server

The Dell PowerEdge R960 is a 4U, four-socket server powered by 4th Generation Intel Xeon Scalable processors with up to 60 cores per processor. It features 64 DDR5 RDIMM slots, up to 16 TB of storage, and up to 24 NVMe SSDs. According to Dell, the PowerEdge R960 "boosts business-critical operations with unprecedented scale-up capabilities in a 4U air-cooled form factor with four (4) Intel Xeon® Scalable Processors to empower business and drive data-driven initiatives."[20] To learn more about the Dell PowerEdge R960, visit https://www.dell.com/en-us/shop/dell-poweredge-servers/new-poweredge-r960-rack-server/spd/poweredge-r960/pe_r960_16718_vi_vp.

About 4th Generation Intel Xeon Scalable processors

According to Intel, its strategy for 4th Gen Intel Xeon Scalable processors "aligns CPU cores with built-in accelerators optimized for specific workloads and delivers increased performance at higher efficiency for optimal total cost of ownership."[21] Intel claims the processors deliver "a range of features for managing power and performance, making the best use of CPU resources to achieve key sustainability goals. In addition, the Xeon CPU Max and the Max Series GPU add high-bandwidth memory and maximum compute density to solve the world's most challenging problems faster."[22]

Conclusion

Upgrading to latest-gen servers could be a performance boon for your business-critical applications. In addition to the better transactional database performance that newer servers typically deliver, switching from virtualization to bare metal for Oracle Database could increase that performance gain. We found that the latest-gen Dell PowerEdge R960 powered by 4th Gen Intel Xeon Scalable processors processed up to 7.9 times the Oracle Database 19*c* transactions per minute that the legacy PowerEdge R920 server handled and up to 2.4 times the TPM the PowerEdge 940 produced. With those levels of improvement, organizations using Oracle Database for ecommerce or inventory workloads could grow their user base, generate more revenue, or improve inventory control.

In addition, data center architects and others could appreciate the space saving that comes from consolidating workloads from the new server upgrade. Our results show that the bare metal PowerEdge R960 server delivered 7.9 times the TPM per rack unit than the legacy PowerEdge R920 virtualized solution and 1.8 times the TPM per rack unit than the legacy PowerEdge R940 virtualized solution. Based on this performance-per-rack unit ratio, organizations potentially could consolidate the work of seven PowerEdge R920 servers or two legacy PowerEdge R940 servers to just one Dell PowerEdge R960.

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Read the science behind this report at https://facts.pt/3XIzWJB ►

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