KIOXIA

Application Brief

Improve Database Performance and CPU Utilization in a Dell EMC® PowerEdge™ R740xd Server by Switching from SATA to Value SAS SSDs

Flash-based SSDs became an alternative to hard drive storage about 15 years ago and utilized the SATA interface to help propel this transition. As other interface options emerged, SATA-based SSDs were commonplace, providing improved performance and lower latencies over their HDD counterparts. Though SATA-based SSDs have proven to be a successful alternative to HDDs, they can hinder application performance due to limitations in interface speed, half-duplex lane contention and protocol limitations.

For example, when SATA SSDs were first introduced, early architectures were not greatly bottlenecked by the 6 gigabit per second (6Gb/s) speed of the SATA interface. But as NAND flash memory performance improved in each new generation, it outpaced the interface performance limit of SATA. Since performance should continue to improve in NAND flash memory for each new generation, along with SAS improvements, the SATA interface will be more of a bottleneck to SATA SSD performance.

An additional drawback of the SATA interface is its half-duplex data transmission that only uses one lane / one direction at a time to transfer data. With modern-day CPUs getting faster and DRAM bandwidth increasing, the SATA interface can be a bottleneck. These powerful servers, with multicore processors and an abundance of DRAM, could be waiting for data transactions to complete, resulting in underutilized server capabilities and stranded compute resources.

The current SATA interface is SATA III and transfers data at 6Gb/s. Though SATA SSDs have significant penetration in servers, their adoption rate is projected to decline as they are being replaced by higher performing SAS or NVMe® SSDs.

For Online Transaction Processing (OLTP) applications, the half-duplex SATA interface at a 6Gb/s transfer speed can hamper a server's abilities to process the maximum number of new orders and deliver speedy transactions per minute (TPM). These limitations can also affect efficient use of the CPU. IT managers, architects and administrators want to utilize their storage resources to the fullest and not have to purchase additional systems to achieve required performance targets. The objective is to maximize total cost of ownership (TCO) and reduce additional acquisition costs.

Introducing Value SAS SSDs

Recognizing SATA SSD limitations, KIOXIA Corporation introduced a new category of SSD called value SAS SSDs. These SSDs take advantage of the SAS-3 interface that provides full-duplex data transmission and delivers interface speeds up to 12Gb/s. Value SAS SSDs deliver advancements in performance, capacity, reliability and manageability over enterprise SATA SSDs at cost-effective price points. This improvement in storage performance enables a server node to utilize its CPU and DRAM resources more efficiently while servicing I/O-intensive workloads. It also increases the server's load capacity enabling a node to support more users.

Since most servers ship today with a SAS HBA or RAID card, value SAS SSDs and SATA SSDs can be used in the same drive bay. Therefore, replacing SATA SSDs with value SAS SSDs in most cases is an easy transition that requires no changes to the server or existing infrastructure.

To demonstrate the performance benefits and CPU utilization improvements of value SAS SSDs when compared to enterprise SATA SSDs, KIOXIA conducted a series of database benchmark tests comparing its RM Series value SAS SSDs to a leading and currently shipping enterprise SATA SSD.

Test Configuration

KIOXIA conducted tests in a lab environment that compared the system performance and CPU utilization of a Dell EMC PowerEdge 740xd server platform configured with RM Series value SAS SSDs and enterprise SATA SSDs from a leading vendor. The tests utilized an operational, high-performance Microsoft® SQL Server™ database workload based on comparable TPC-C™ tests created by HammerDB software[1].

The testing provides TPM performance and CPU utilization results when running a Microsoft SQL Server database and performing queries against it. In the first test configuration, the PowerEdge 740xd server deployed four KIOXIA RM Series value SAS SSDs, while the second configuration included four enterprise SATA SSDs from a leading vendor.

Test Criteria

The hardware and software equipment used for these tests included:

- **Dell EMC PowerEdge R740xd Server:** One (1) dual socket server with two (2) Intel® Xeon® Platinum 8268 processors featuring 24 processing cores, 2.9 GHz frequency, and 144 gigabytes[2] (GB) of DDR4 DRAM
- **Operating System:** Microsoft Windows® Server 2019 Datacenter, v1809, OS build 17763.1999
- **Application:** Microsoft SQL Server 15.0.2000.5
  Database size of 501GB
- **Test Software:** Comparable TPC-C benchmark tests generated through HammerDB v4.1 test software
- **Storage Devices (Table 1):** Four (4) KIOXIA RM Series SSDs with 3.84 terabyte[2] (TB) capacities
  Four (4) enterprise SATA SSDs (from a leading vendor) with 3.84TB capacities

Specifications / Set-up Parameters	RM6 Series	Vendor A
Interface	12Gb/s SAS	6Gb/s SATA
Capacity	3.84TB	3.84TB
Form Factor	2.5-inch[3] (15mm)	2.5-inch (15mm)
Drive Writes per Day[4] (DWPD)	1 (5 years)	0.8 (5 years)
Power	9W	3.6W
DRAM Allocation	96GB	96GB
Virtual Users	480	480

Table 1: SSD specifications and set-up parameters

Set-up & Test Procedures

Set-up: The PowerEdge 740xd server was first configured to test value SAS SSD performance and CPU utilization. Next, the server was configured for enterprise SATA SSD testing, at which time the same performance and CPU utilization tests were run and results were recorded.

Both server configurations were set-up with the Microsoft Windows Server 2019 Datacenter operating system and Microsoft SQL Server as the database application. Microsoft SQL Server was set to a maximum DRAM allocation of 96GB and the application was loaded using HammerDB test software at a database size of 501GB. For both value SAS and enterprise SATA configurations, a separate storage pool, virtual disk and full capacity volume was created for the four RM Series SSDs and the four enterprise SATA SSDs. Multiple virtual user counts were tested for each configuration and it was determined that 480 virtual users was optimal for both tested set-ups.

Test Procedures: HammerDB software was used to run the comparable TPC-C workload utilizing the four RM6 Series value SAS SSDs and recorded the TPM and CPU utilization results. The same test process for the enterprise SATA SSDs configuration was repeated, with results recorded. *See Test Results section.*

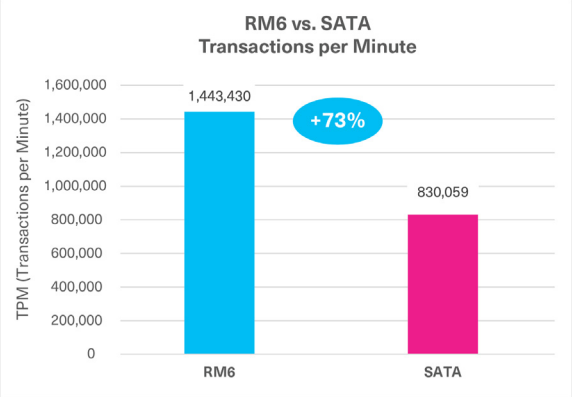
Test Results

TPM and CPU utilization tests were run with the respective result of each recorded. For both TPM and CPU utilization, the higher the value, the better the result.

Transactions Per Minute

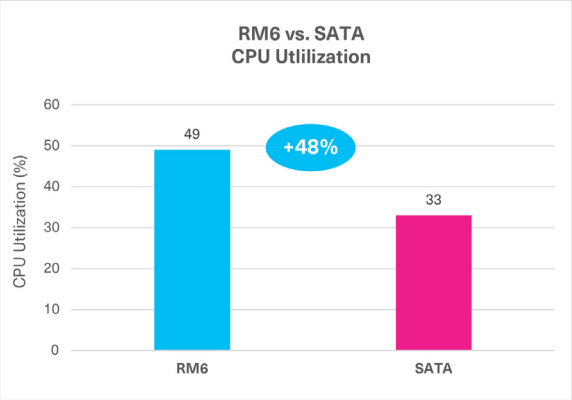
In an OLTP database environment, TPM is a measure of how many transactions in the TPC-C transaction profile that are being executed per minute. The HammerDB software, executing the TPC-C transaction profile, randomly performs new order transactions and randomly executes additional transaction types such as payment, order status, delivery and stock levels. One transaction does not necessarily equate to one new order as a new order can have multiple transactions. The TPM tests conducted simulate an OLTP environment where there are a large number of users that generate simple, yet short transactions that require sub-second response times and return relatively few records.

TPM Test Results:



CPU Utilization
CPU utilization represents a percentage of the total amount of available CPU cycles being used for a given workload and was measured to ensure that the Intel Xeon CPUs were not incurring any extra processing for OLTP applications such as database workloads. Low utilization means that the CPUs are not being used efficiently and could result in an underutilization of server capabilities and stranded compute resources.

CPU Utilization Test Results:



Test Analysis

The test results demonstrate that KIOXIA value SAS SSDs enabled the Dell EMC PowerEdge 740xd server to deliver 73% more transactions per minute than enterprise SATA SSDs from a leading vendor. Additionally, the value SAS configuration also utilized the Intel Xeon processors 48% more when compared to enterprise SATA. Value SAS SSD performance enables IT managers, architects and administrators to better utilize their server resources versus enterprise SATA SSD, and could result in increased user capacity for an existing infrastructure or TCO savings as a result of not having to purchase more servers to achieve the required performance targets.

RM6 Series SSD Overview

The RM6 Series is KIOXIA's 2nd generation value SAS SSD product line that delivers improved performance over previous RM Series generations. The series is based on the 12Gb/s SAS interface and features 7.68TB maximum capacities, single-port interfaces, 1 DWPD for read-intensive applications (RM6-R Series) and 3 DWPD for mixed use applications (RM6-V Series), up to a 9-watt power envelope, and a host of supported security capabilities – all of which support a wide variety of workloads.

RM6 Series SSDs
12Gb/s SAS

High-Performance[5]
SeqRead = up to 840MB/s
RanRead = up to 160K IOPS
SeqWrite = up to 710MB/s
RanWrite = up to 50K IOPS

Configurable Flexibility
1 and 3 DWPD options
960GB – 7,680GB capacities

Summary

Enterprise SATA SSDs have proven to be sufficient replacements for traditional spinning disk drives, but they encounter performance challenges for some of today's modern workloads. These are mostly due to the 6Gb/s performance limitation of the SATA III interface, the use of traditional hard drive processes, and a single half-duplex path to move data.

Value SAS SSDs are a better option than enterprise SATA SSDs as they deliver increased application performance and better CPU utilization at very competitive price points. They also provide an easy enterprise SATA SSD replacement path as SAS and SATA SSDs can be used in the same drive bay typically resulting in no changes to the server or existing infrastructure.

For IT managers, architects, database administrators and storage engineers, the increased transactional database performance delivered by value SAS SSDs is a welcomed addition to achieve the required performance targets without having to add cost to the server or system infrastructure. At the same time, end customers and users have a better experience.

Bottom line: Value SAS SSDs delivered 73% more transactions per minute and 48% better CPU utilization when compared to leading enterprise SATA SSDs.

NOTES:

[1] HammerDB is benchmarking and load testing software that is used to test popular databases. It simulates the stored workloads of multiple virtual users against specific databases to identify transactional scenarios and derive meaningful information about the data environment, such as performance comparisons. TPC Benchmark C is a supported OLTP benchmark that includes a mix of five concurrent transactions of different types, and nine types of tables with a wide range of record and population sizes and where results are measured in transactions per minute.

[2] Definition of capacity - KIOXIA Corporation defines a kilobyte (KB) as 1,000 bytes, a megabyte (MB) as 1,000,000 bytes, a gigabyte (GB) as 1,000,000,000 bytes and a terabyte (TB) as 1,000,000,000,000 bytes. A computer operating system, however, reports storage capacity using powers of 2 for the definition of 1Gbit = 2^{30} bits = 1,073,741,824 bits, 1GB = 2^{30} bytes = 1,073,741,824 bytes and 1TB = 2^{40} bytes = 1,099,511,627,776 bytes and therefore shows less storage capacity. Available storage capacity (including examples of various media files) will vary based on file size, formatting, settings, software and operating system, and/or pre-installed software applications, or media content. Actual formatted capacity may vary.

[3] 2.5-inch indicates the form factor of the SSD and not the drive's physical size.

[4] Drive Write(s) per Day: One full drive write per day means the drive can be written and re-written to full capacity once a day, every day, for the specified lifetime. Actual results may vary due to system configuration, usage, and other factors.

[5] Read and write speed may vary depending on the host device, read and write conditions, and the file size.

TRADEMARKS:

DISCLAIMERS: