KIOXIA

Performance Brief

Accelerating Transactional Database Workloads Using KIOXIA RM7 Series Value SAS SSDs Compared with Enterprise SATA SSDs

Introduction

Transactional databases represent one of the most important workloads run in today's data centers. They handle a broad scope of transactional applications throughout many industries (i.e., e-commerce sites, banks, stock exchanges, retail stores, etc.). These databases excel at reading and writing individual rows of data very quickly with a focus on data integrity.

Many data centers require solutions that can better address large transactional datasets, as well as the expected future growth of data intensive workloads. Since transactional databases are dependent on fast underlying storage for performance, SATA SSD performance can become a bottleneck for these workloads. The SATA interface is up to 6 gigabits per second (Gb/s) with no planned performance improvements. Most servers with SATA SSDs utilize a SAS interface card to connect SSDs to the motherboard. IT personnel are seeking alternative and cost-effective interface options for deploying SSDs so they can maximize value from their flash investments.

Recognizing the limitations of SATA SSDs, KIOXIA Corporation developed Value SAS SSDs - a unique class of SAS SSD that delivers advancements in performance, capacity, reliability, manageability and data security over enterprise SATA SSDs, at a price designed to replace them. When Value SAS SSDs are deployed in servers, applications have access to higher performing and lower latency storage and no longer have to contend with a 6 Gb/s performance ceiling. This improvement in storage performance enables a server to efficiently utilize its CPU and DRAM resources while servicing data intensive workloads.

This performance brief presents an SSD performance and system utilization comparison using Microsoft® SQL Server™ transactional database workloads. It compares KIOXIA RM7-R Series Value SAS SSDs with SATA SSDs from a leading provider (Vendor A). A Dell® PowerEdge™ R660 rack server was used for the tests.

The database tests were performed on both SSD configurations and several metrics were collected to show performance improvements. The storage metrics collected were average database throughput, average read throughput and average write throughput. The system level metrics collected were average power utilization, average CPU utilization and total memory utilization. The tests included three total runs. The average of the three runs were calculated and compared with each SSD configuration. HammerDB[1] test software was used for both SSD configurations, which enabled the TPROC-C[2] online transaction processing (OLTP) workloads to run against the Microsoft SQL Server database.

The test results show that with a maximum SAS interface throughput of 12 Gb/s, the KIOXIA RM7-R Series Value SAS SSDs delivered more than twice the performance of the SATA SSDs that were limited by the 6 Gb/s SATA interface. Additionally, the exceptional performance delivered by Value SAS SSDs was achieved without any significant increases in system power, CPU or memory utilization.

The results include a brief description of each workload test, a graphical depiction of the test results and an analysis. Appendix A covers the hardware and software test configuration. Appendix B covers the configuration set-up and test procedures.

Test Results Snapshot

KIOXIA RM7-R Series Value SAS SSDs delivered the following results when compared with SATA SSDs:

SSD Performance Tests

Average Database Throughput
(higher is better)
146% Higher

Average Read Throughput
(higher is better)
110% Higher

Average Write Throughput
(higher is better)
106% Higher

System Utilization Tests

Average Power Utilization
Similar Utilization

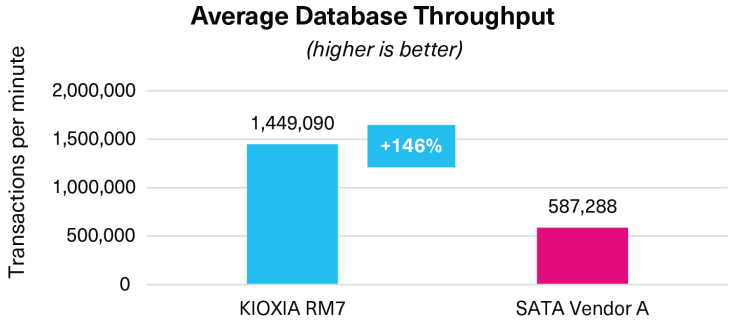
Average CPU Utilization
Similar Utilization

Total Memory Utilization
Similar Utilization

Test Results[3]

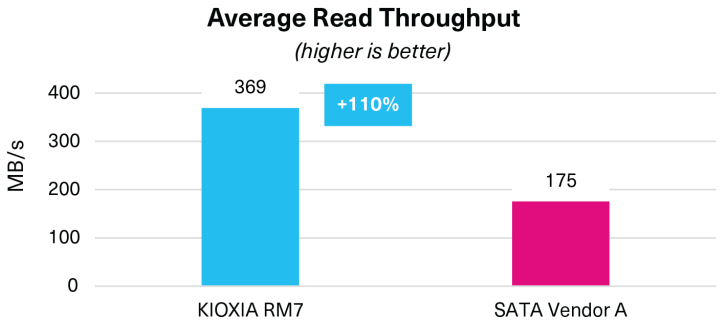
Test 1: Average Database Throughput

This test measured how many transactions in the TPROC-C workload were executed per minute. The HammerDB software, executing the TPROC-C transaction profile, randomly performed new order, payment, order status, delivery and stock level transactions. The test simulated an OLTP environment with a large number of users conducting simple and short transactions (that require sub-second response times and return relatively few records). The following results show the average database throughput from three test runs for each SSD configuration. The results are in transactions per minute. The higher result is better.



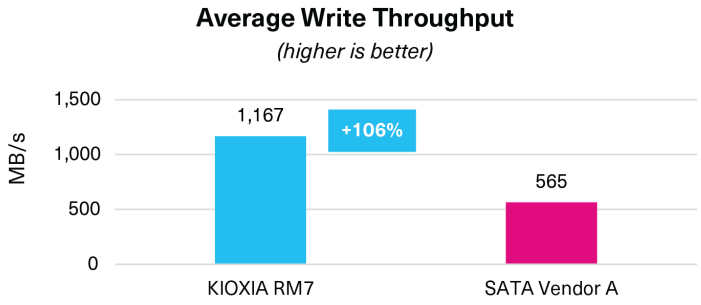
Test 2: Average Read Throughput

With Test 1 running, the average read throughput of each SSD configuration was recorded. It shows read transaction throughput and how the test server responded to incoming database queries. If the number of incoming queries is much higher than the achievable database throughput, the server can overload creating longer wait times per query that can negatively affect application performance and user experience. The following results show the average read throughput from three test runs for each SSD configuration. The results are in megabytes per second (MB/s). The higher result is better.



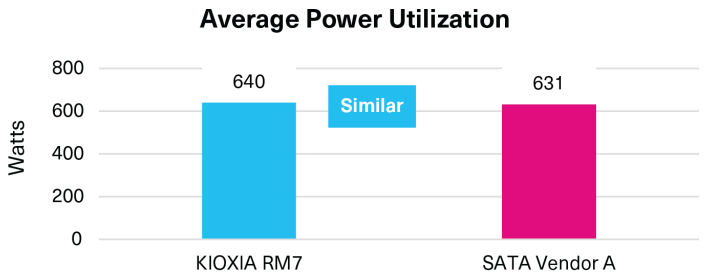
Test 3: Average Write Throughput

With Test 1 running, the average write throughput of each SSD configuration was recorded. It shows the number of incoming database inserts processed by the test server. If the number of incoming queries is much higher than the achievable database throughput, the server can overload creating longer wait times per query that can negatively affect application performance and user experience. The following results show the average write throughput from three test runs for each SSD configuration. The results are in megabytes per second (MB/s). The higher result is better.



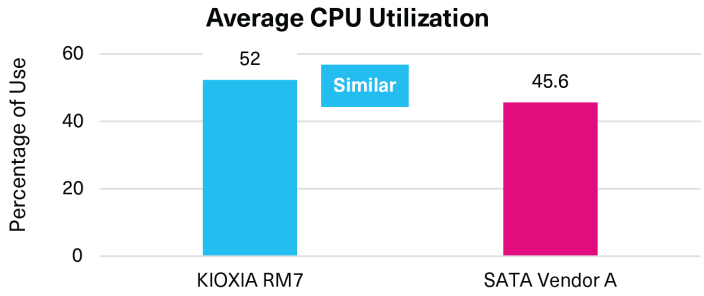
Test 4: Average Power Utilization

This test measured the average power drawn by the test system when the tests were run and included the individual components that operate from the power supply unit. The following results show the average power utilization from three test runs for each SSD configuration. The results are in watts. For these tests, similar power draw positions the KIOXIA RM7 Series Value SAS SSDs as a drop-in replacement for enterprise SATA SSDs.



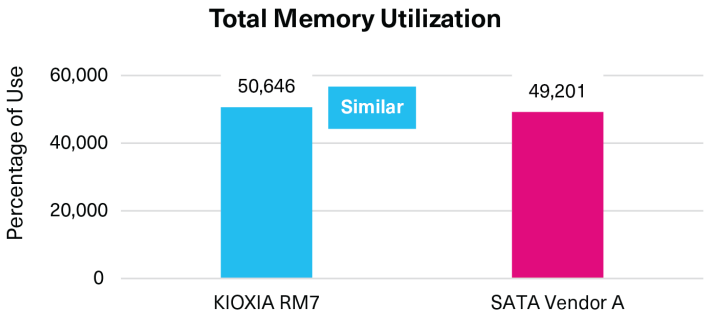
Test 5: Average CPU Utilization

This test measured the average test system CPU utilization when the tests were run. A lower percent of utilization is ideal. However, similar CPU utilization with high database transactional throughput demonstrates that the CPU is able to service more transactions. The following results show the average CPU utilization from three test runs for each SSD configuration. The results are in percentage of use. Similar CPU utilization was the goal.



Test 6: Total Memory Utilization

This test measured the average total DRAM that the system used when the tests were run. Microsoft® SQL Server™ was provided 40.96 gigabytes (GB) of DRAM. The following results show the total memory utilization on average from three test runs for each SSD configuration. The results are in percentage of use. For these tests, similar system memory utilization was the objective.



Test Analysis

KIOXIA RM7-R Series Value SAS SSDs deployed in the Dell® PowerEdge™ R660 server showed more than twice the database performance when compared with a leading SATA SSD configuration. The KIOXIA RM7 Series Value SAS SSD configuration delivered 146% more transactions per minute, 110% higher read throughput and 106% higher write throughput while reducing the footprint of servers needed to service these workloads.

Although the overall system power draw was slightly higher than the SATA SSD configuration by 9 watts, the KIOXIA RM7-R Series Value SAS SSDs were able to deliver significant performance gains without utilizing significant CPU or system memory resources when compared with the SATA SSD configuration. At the data center level, these results enable administrators to use the same number of servers for more than twice the performance, or conversely, scale the number of servers to lower power consumption and total cost of ownership without sacrificing performance.

Summary

This performance brief presented an SSD performance and system utilization comparison using Microsoft® SQL Server™ database workloads with KIOXIA RM7-R Series Value SAS SSDs and SATA SSDs from a leading provider (Vendor A). A Dell® PowerEdge™ R660 rack server and HammerDB test software were used for the tests. Testing showed that KIOXIA RM7 Series SSDs were able to deliver more than twice the performance when compared with the SATA SSD configuration with only utilizing minimal additional system resources. KIOXIA RM7 Series SSDs deliver a compelling value proposition and are an excellent drop-in replacement for existing SATA SSD deployments and for new or existing SAS servers.

KIOXIA RM7 Series Value SAS SSD Product Info

The latest generation KIOXIA RM7 Series Value SAS SSDs support 12 Gb/s SAS-3 interfaces and are available in two 2.5-inch[4] configurations: RM7-R Series for read intensive applications (1 DWPD[5], up to 7.68 terabyte[6] (TB) capacities) and RM7-V Series for higher endurance mixed use applications (3 DWPD, up to 3.84 TB capacities). Security options[7] are available for both configurations.

Additional KIOXIA RM7 Series Value SAS SSD information is available at the KIOXIA 'Life After SATA' site.

KIOXIA RM7 Series SSD[8]

Appendix A

Hardware/Software Test Configuration

Server Information		
Server Model	Dell® PowerEdge™ R660	
No. of Servers	1	
BIOS Version	1.3.2	

CPU Information	
CPU Model	Intel® Xeon® Gold 6430
No. of Sockets	2
No. of Cores	32
Frequency (in gigahertz)	2.1 GHz

Memory Information	
Memory Type	DDR5
Memory Speed	DDR5-4400
Memory Size	32 GB[6]
No. of DIMMs	4
Total Memory Size	128 GB

SSD Information		
SSD Model	KIOXIA RM7-R Series	Vendor A
Form Factor	2.5-inch	2.5-inch
Interface	SAS-3	SATA-3
Interface Speed	12 Gb/s	6 Gb/s
No. of SSDs	4	4
SSD Capacity	3.84 TB	3.84 TB
Drive Writes per Day	1	1
Active Power	up to 9 watts	up to 3.2 watts

Operating System Information	
Operating System (OS)	Microsoft® Windows® Server® 2022 Datacenter
OS Version	8.0.1, 21813344
Database Model	Microsoft SQL Server™
Database Version	16.0.1000.6

Test Software Information	
Test Software Model	HammerDB
Benchmark	TPROC-C
Version	4.9
No. of Virtual Users	176

Appendix B

Configuration Set-up/Test Procedures

Configuration Set-up

The Dell® PowerEdge™ R660 server was installed with the Microsoft® Windows® Server® 2022 Datacenter operating system.

Four 3.84 TB[6] KIOXIA RM7-R Series Value SAS SSDs were placed in a hardware RAID 10[9] set to hold the Microsoft SQL Server™ database in the server.

Disk Management on the Microsoft Windows Server 2022 Datacenter operating system was initialized and a new volume was created by the RAID 10 hardware set.

Microsoft SQL Server was installed on the newly created volume.

HammerDB test software was installed on the same volume that Microsoft SQL Server resided enabling the TPROC-C online transaction processing (OLTP) workloads to run against the database. To build a schema, 1,000 was entered for the number of warehouses. For the number of virtual users, 128 was entered. With 1,000 warehouses, the size of the database was 126 GB[6].

Once the schema was built, the Driver Script was edited by changing 'Minutes for Test Duration' to 15 minutes and selecting 'Use All Warehouses.' For virtual users, 'Options' must be opened and 'Virtual Users' changed to 176, 'User Delay' to 1, and 'Repeat Delay' to 1. Once completed, select 'Run' to initiate the schema.

The HammerDB TPROC-C workload tests were started.

Test Procedures

The results were recorded when the TPROC-C workload was run against each SSD configuration covering:

- *Average Database Throughput (in transactions per minute)*
- *Average Read Throughput (in MB/s)*
- *Average Write Throughput (in MB/s)*
- *Average Power Utilization (in watts)*
- *Average CPU Utilization (in percentage of use)*
- *Total Memory Utilization (in percentage of use)*

For each individual test, three total runs were performed and the average of the three runs were calculated and compared with each SSD configuration.

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.

[2] TPROC-C is the OLTP workload implemented in HammerDB derived from the TPC-C™ specification with modification to make running HammerDB straightforward and cost-effective on any of the supported database environments. The HammerDB TPROC-C workload is an open source workload derived from the TPC-C Benchmark Standard and as such is not comparable to published TPC-C results, as the results comply with a subset rather than the full TPC-C Benchmark Standard. TPROC-C means Transaction Processing Benchmark derived from the TPC "C" specification.

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

[4] 2.5-inch indicates the form factor of the SSD and not the drive's physical size.

[5] DWPD or Drive Write(s) Per Day (DWPD): One full drive write 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.

[6] Definition of capacity: KIOXIA Corporation defines a megabyte (MB) as 1,000,000 bytes, a gigabyte (GB) as 1,000,000,000 bytes, a terabyte (TB) as 1,000,000,000,000 bytes and a petabyte (PB) as 1,000,000,000,000,000 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, 1TB = 2^{40} bytes = 1,099,511,627,776 bytes and 1PB = 2^{40} bytes = 1,125,899,906,842,624 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.

[7] Optional security feature compliant drives are not available in all countries due to export and local regulations.

[8] The product image shown is a representation of the design model and not an accurate product depiction.

[9] RAID 10 is a redundant array of independent disks configuration that combines disk mirroring and disk striping to protect data.

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