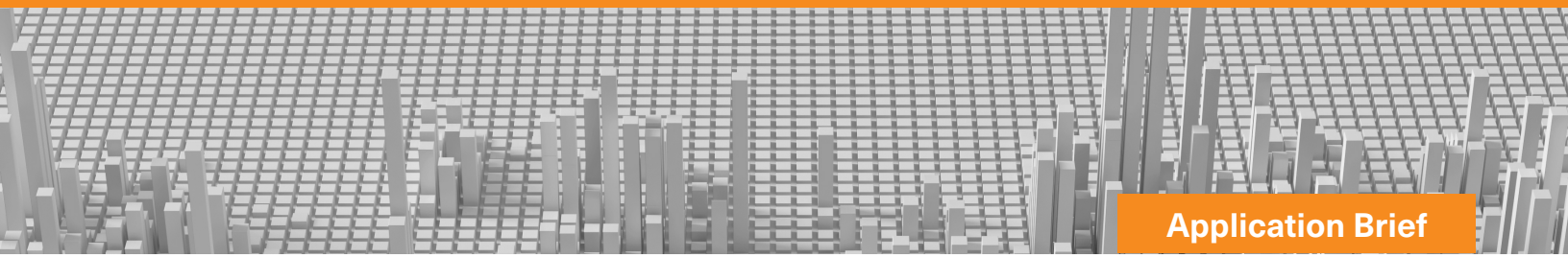
KIOXIA



Accelerate NoSQL Database Storage Performance with PCIe® 5.0 Servers and SSDs

Featuring KIOXIA CD8P Series PCIe 5.0 Data Center NVMe™ SSDs in a Supermicro® Hyper A+ Server AS -2125HS-TNR, running Aerospike® Database Software

Databases enable large amounts of data – both structured and unstructured - to be stored, analyzed and/or managed within an organization. The role of database management systems is to provide this data quickly, accurately and securely across an organization. Required data needs to be accessible in real time and provide the high Quality of Service (QoS) experiences that users expect. However, the abundance of data generated in modern day data centers has become difficult to manage and access quickly. The need for database technologies to be faster and keep up with the increase in data generation is an architectural priority for many data centers worldwide.

The latest available PCIe 5.0 interface can help meet database objectives for higher data storage performance as it enables SSDs to communicate with system CPUs faster than previous PCIe generations and has the ability to transfer data at lower latency. The PCIe 5.0 interface increases data transfer speeds from 16 gigatransfers per second (GT/s) to 32 GT/s and can move data at approximately 4 gigabytes per second (GB/s) per lane versus about 2 GB/s per lane when compared with the PCIe 4.0 interface. As a result, NVMe SSDs with PCIe 5.0 support can deliver bandwidth performances up to 14,000 megabytes per second (MB/s).

This application brief presents a performance comparison of database operations executed on a PCIe 5.0 server/SSD configuration versus a PCIe 4.0 server/SSD configuration. The PCIe 5.0 configuration included a Supermicro Hyper A+ Server AS -2125HS-TNR deployed with eight 3.84 terabyte[1] (TB) KIOXIA CD8P-R Series PCIe 5.0 data center NVMe SSDs[2]. The PCIe 4.0 configuration included a Supermicro A+ AS -2124US-TNRP server deployed with PCIe 4.0 SSDs from a competing vendor using comparable capacities. Both systems ran an Aerospike NoSQL[3] database driven by synthetic tests from Yahoo!™ Cloud Serving Benchmark (YCSB) software. There are eight workload tests in the comparison covering specific database tests. Appendix A covers the database tests – Appendix B covers the hardware and software configuration – Appendix C covers the configuration set-up and test procedures.

The tests measured: (1) Runtime; (2) Database Throughput; (3) 100% Insert Latency; (4) 50% Read / 50% Update Latency; (5) 95% Read / 5% Update Latency; (6) 100% Read Latency; (7) 95% Read / 5% Insert Latency; and (8) 50% Read / 50% Read-Modify-Write Latency. The test database created on the Aerospike database consisted of 300,000,000 records and 200,000,000 operations (regarded as the 100% insert[4]).

Aerospike is a NoSQL key-value database[5] capable of delivering very fast runtime performance for all-sized read and write workloads as its architecture is flash-optimized. It features direct device access that enables high throughput and low latency delivered directly from the storage device itself. In order to take advantage of this capability, the underlying SSDs must be fast enough to support it.

Test results show that the PCIe 5.0 configuration demonstrated a faster runtime, higher throughput and lower latencies of NoSQL database workloads when compared with the PCIe 4.0 configuration. The test results presented include a brief description of each workload test, a graphical depiction of the test results and a brief analysis.

Test Results Snapshot

The PCIe 5.0 configuration (KIOXIA CD8P Series SSDs / Supermicro Hyper A+ Server AS -2125HS-TNR) delivers exceptional NoSQL database performance when compared with the PCIe 4.0 test configuration as depicted by the test results:

Runtime
up to 43% Lower

Database Throughput
up to 77% Higher

100% Insert Latency
up to 15% Lower

50% Read / 50% Update Latency
up to 46% Lower

95% Read / 5% Update Latency
up to 60% Lower

100% Read Latency
up to 54% Lower

95% Read / 5% Insert Latency
up to 50% Lower

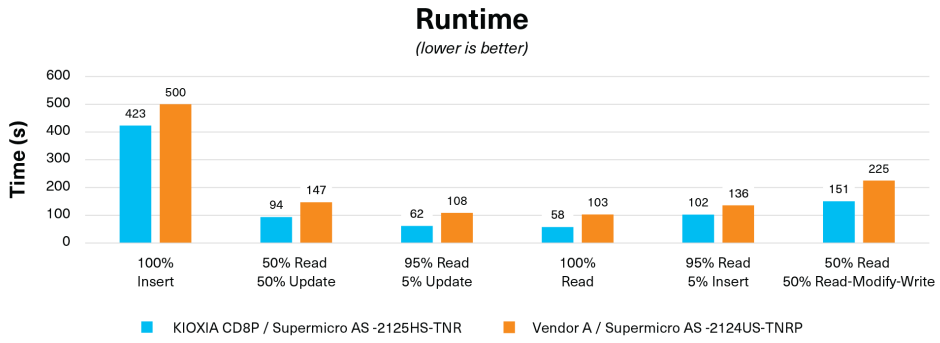
50% Read / 50% Read-Modify-Write Latency
up to 38% Lower

TEST RESULTS

The Aerospike® application performed six database workloads (see Appendix A) where the workloads were run using YCSB software against the Aerospike database. Metrics were recorded for total runtime, database throughput and individual database operational latencies.

Metric 1: Runtime

This metric measured the total time required in seconds to complete each of the six Aerospike database workloads. For this metric, the lower result is better.



Runtime Tests *(in seconds)*	PCIe 5.0 Configuration *(KIOXIA CD8P / SMC AS -2125HS-TNR)*	PCIe 4.0 Configuration *(Vendor A / SMC AS -2124US-TNRP)*	PCIe 5.0 Configuration Gains
100% Insert	423	500	15%
50% Read / 50% Update	94	147	36%
95% Read / 5% Update	62	108	42%
100% Read	58	103	43%
95% Read / 5% Insert	102	136	25%
50% Read / 50% Read-Modify-Write	151	225	32%

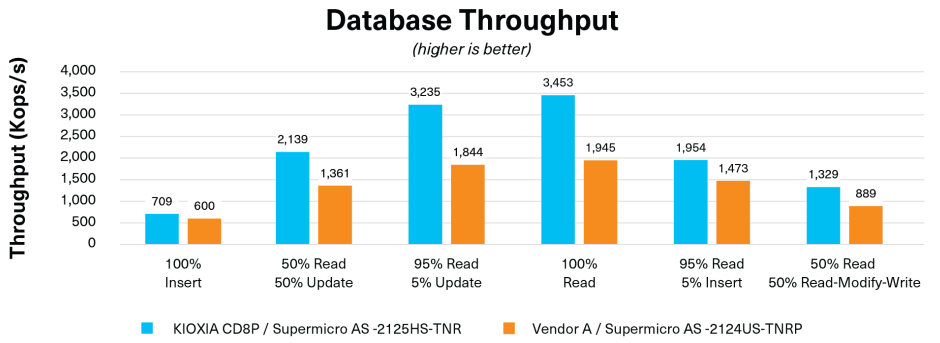
Figure 1: Database runtime results

Analysis:

The test results show that the PCIe 5.0 configuration delivered a lower query time across the six database workloads versus the PCIe 4.0 configuration. Faster completion time of an individual operation or workload allows the database to handle high volume requests and more users concurrently. The PCIe 5.0 configuration was able to show increased performance and versatility when required to speed up various types of user workloads.

Metric 2: Database Throughput

This metric measured the number of operations per second (Kops/s) a system can complete on average for each of the six database workloads. For this workload, the higher result is better.



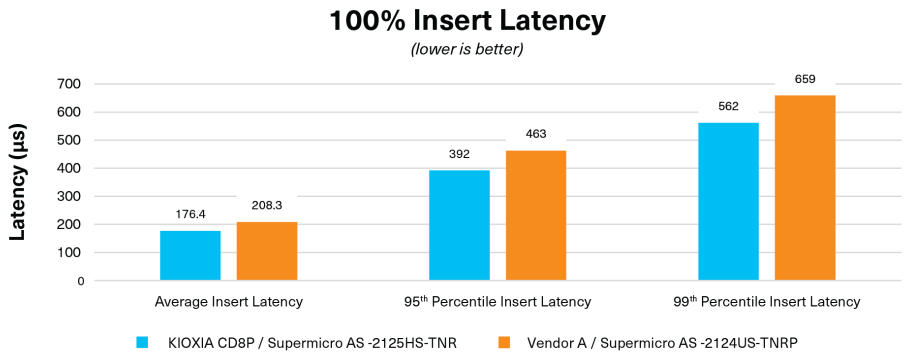
Database Throughput Tests *(in Kops/s)*	PCIe 5.0 Configuration *(KIOXIA CD8P /SMC AS -2125HS-TNR)*	PCIe 4.0 Configuration *(Vendor A / SMC AS -2124US-TNRP)*	PCIe 5.0 Configuration Gains
100% Insert	709	600	18%
50% Read / 50% Update	2,139	1,361	57%
95% Read / 5% Update	3,235	1,844	75%
100% Read	3,453	1,945	77%
95% Read / 5% Insert	1,954	1,473	32%
50% Read / 50% Read-Modify-Write	1,329	889	49%

Figure 2: Database throughput results

Analysis:
The test results show that the PCIe 5.0 configuration completed more operations per second across the six database throughput tests than the PCIe 4.0 configuration. One scenario that can occur is when the number of incoming operations from concurrent users is higher than the achievable database throughput supported by the hardware and software configuration. If this occurs, the server could overload and create longer waiting times per query that could negatively affect application performance and user experience. The PCIe 5.0 configuration was able to achieve higher database throughput and did not encounter this scenario as often as the PCIe 4.0 configuration. This performance was a result of shorter waiting times per query and more database operations that were performed simultaneously from multiple users.

Metric 3: 100% Insert Latency

This metric measured the time it took in microseconds (µs) to perform an insert database operation. It includes the time it took for the YCSB workload generator to not only issue the insert operation, but also the time it took to complete the operation and receive a 'successfully completed' acknowledgement. For this workload, the lower result is better.



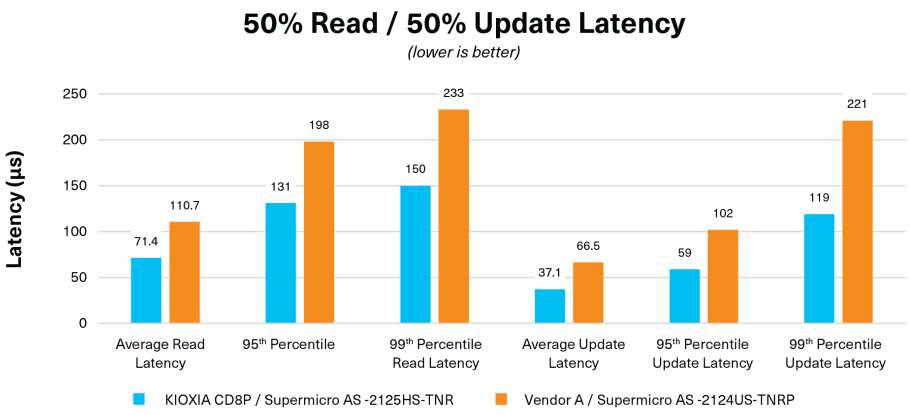
100% Insert Latency Tests *(in microseconds)*	PCIe 5.0 Configuration *(KIOXIA CD8P / SMC AS -2125HS-TNR)*	PCIe 4.0 Configuration *(Vendor A / SMC AS -2124US-TNRP)*	PCIe 5.0 Configuration Gains
Average Insert Latency	176.4	208.3	15%
95th Percentile Insert Latency	392	463	15%
99th Percentile Insert Latency	562	659	14%

Figure 3: 100% insert latency results

Analysis:
The test results show that the PCIe 5.0 configuration completed insert operations in less time than the PCIe 4.0 configuration. One example of an application that benefits from this performance uses databases to store logs and quickly write new records. It is an important capability for database backup systems as they use logs to rebuild databases in the case of corruption or failure.

Metric 4: 50% Read / 50% Update Latency

This metric measured the time it took in microseconds to perform a read or update database operation. It includes the time it took for the YCSB workload generator to not only issue the read or update operation, but also the time it took to complete the operation and receive a 'successfully completed' acknowledgement. For this workload, the lower result is better.



50% Read / 50% Update Latency Tests *(in microseconds)*	PCIe 5.0 Configuration *(KIOXIA CD8P / SMC AS -2125HS-TNR)*	PCIe 4.0 Configuration *(Vendor A / SMC AS -2124US-TNRP)*	PCIe 5.0 Configuration Gains
Average Read Latency	71.4	110.7	35%
95th Percentile Read Latency	131	198	33%
99th Percentile Read Latency	150	233	35%
Average Update Latency	37.1	66.5	44%
95th Percentile Update Latency	59	102	42%
99th Percentile Update Latency	119	221	46%

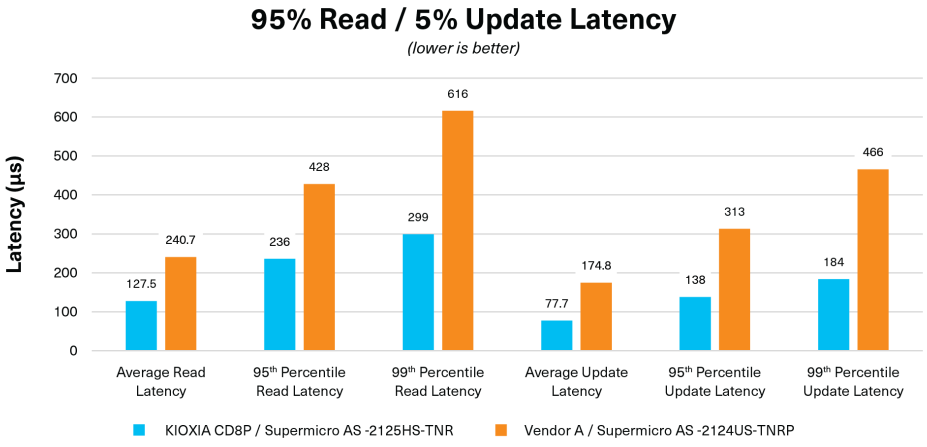
Figure 4: 50% read / 50% update latency results

Analysis:

The test results show that the PCIe 5.0 configuration completed read and update operations in less time than the PCIe 4.0 configuration. One example of an application use case that benefits from this performance is key-value storage for social media sites where fast data streaming represents the 50% read and posting the data represents the 50% update. Machine learning and data analytics are use cases that can also benefit from these results where algorithms can be accessed quickly to run against the data represents the 50% read and updating the data to detect behavioral pattern changes or fraud represents the 50% update.

Metric 5: 95% Read / 5% Update Latency

This metric measured the time it took in microseconds to perform a read or update database operation. It includes the time it took for the YCSB workload generator to not only issue the read or update operation, but also the time it took to complete the operation and receive a 'successfully completed' acknowledgement. For this workload, the lower result is better.



95% Read / 5% Update Latency Tests *(in microseconds)*	PCIe 5.0 Configuration *(KIOXIA CD8P / SMC AS -2125HS-TNR)*	PCIe 4.0 Configuration *(Vendor A / SMC AS -2124US-TNRP)*	PCIe 5.0 Configuration Gains
Average Read Latency	127.5	240.7	47%
95th Percentile Read Latency	236	428	44%
99th Percentile Read Latency	299	616	51%
Average Update Latency	77.7	174.8	55%
95th Percentile Update Latency	138	313	55%
99th Percentile Update Latency	184	466	60%

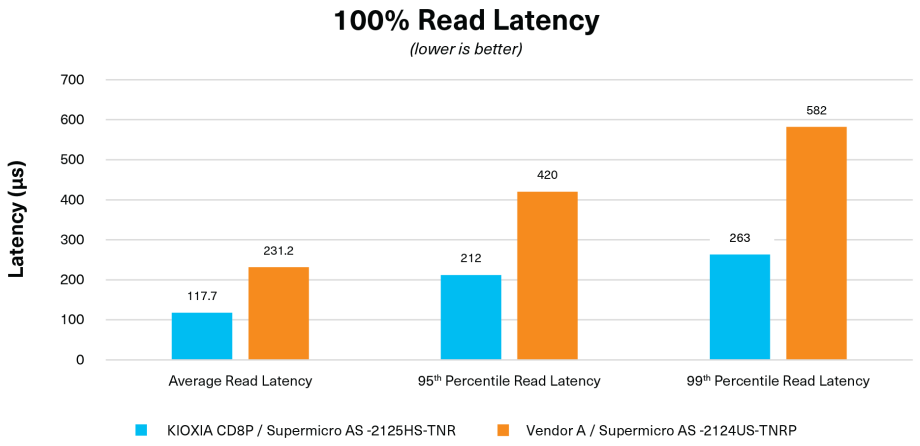
Figure 5: 95% read / 5% update latency results

Analysis:

The test results show that the PCIe 5.0 configuration completed read and update operations in less time than the PCIe 4.0 configuration. One example of an application use case that benefits from this performance are those that need to tag and label records stored in a database so that a filtering system can be used to sort through them. Applications that utilize these filters show increased performance when reading and sorting through records, then updating a page with relevant records.

Metric 6: 100% Read Latency

This metric measured the time it took in microseconds to perform a read database operation. It includes the average time it took for the YCSB workload generator to not only issue the read operation, but also the time it took to complete the operation and receive a 'successfully completed' acknowledgement. For this workload, the lower result is better.



100% Read Latency Tests *(in microseconds)*	PCIe 5.0 Configuration *(KIOXIA CD8P / SMC AS -2125HS-TNR)*	PCIe 4.0 Configuration *(Vendor A / SMC AS -2124US-TNRP)*	PCIe 5.0 Configuration Gains
Average Read Latency	117.7	231.2	49%
95th Percentile Read Latency	212	420	49%
99th Percentile Read Latency	263	582	54%

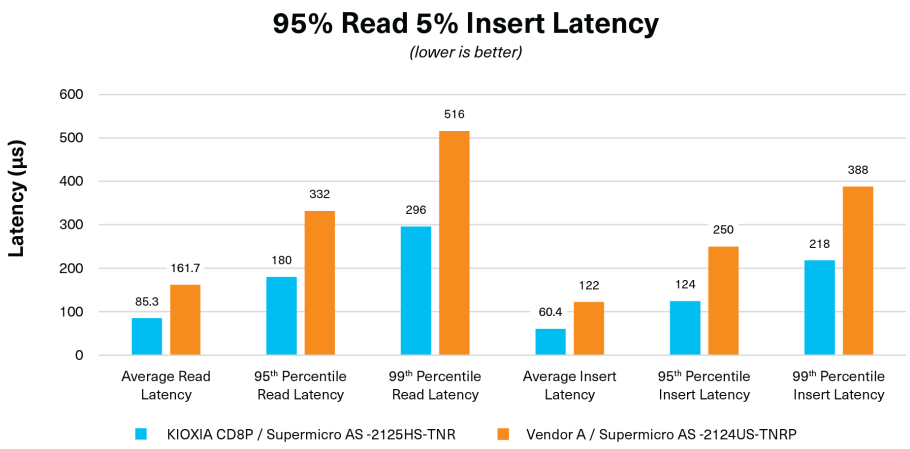
Figure 6: 100% read latency results

Analysis:

The test results show that the PCIe 5.0 configuration completed read operations in less time than the PCIe 4.0 configuration. This performance can replace memcached[6] distributed caching systems where the low latency cache layer requires persistence. High performance workloads, such as data analytics, represent an application use case that can benefit from low 100% read latency.

Metric 7: 95% Read / 5% Insert Latency

This metric measured the time it took in microseconds to perform read and insert database operations. It includes the average time it took for the YCSB workload generator to not only issue the read or insert operation, but also the time it took to complete the operation and receive a 'successfully completed' acknowledgement. For this workload, the lower result is better.



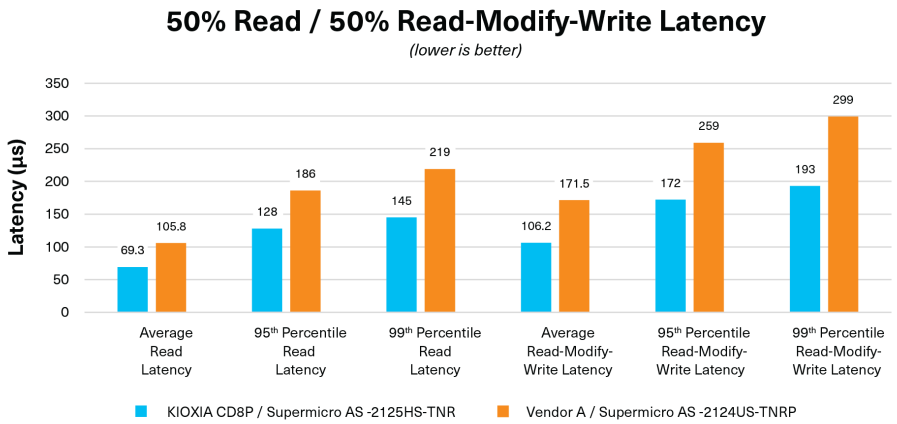
95% Read / 5% Insert Latency Tests *(in microseconds)*	PCIe 5.0 Configuration *(KIOXIA CD8P / SMC AS -2125HS-TNR)*	PCIe 4.0 Configuration *(Vendor A / SMC AS -2124US-TNRP)*	PCIe 5.0 Configuration Gains
Average Read Latency	85.3	161.7	47%
95th Percentile Read Latency	180	332	45%
99th Percentile Read Latency	296	516	42%
Average Insert Latency	60.4	122	50%
95th Percentile Insert Latency	124	250	50%
99th Percentile Insert Latency	218	388	43%

Figure 7: 95% read / 5% insert latency results

Analysis:
The test results show that the PCIe 5.0 configuration completed more read and insert operations across the six database tests than the PCIe 4.0 configuration. One example of an application use case that benefits from this performance is when users post new content to a database and other users read and load that content within their application. The database enables users to have the most updated feeds while enabling other users to post new content faster.

Metric 8: 50% Read / 50% Read-Modify-Write Latency

This metric measured the time it took in microseconds to perform a read or read-modify-write database operation. It includes the average time it took for the YCSB workload generator to not only issue the read or read-modify-write operation, but also the time it took to complete the operation and receive a 'successfully completed' acknowledgement. For this workload, the lower result is better.



50% Read / 50% Read-Modify-Write Latency Tests *(in microseconds)*	PCIe 5.0 Configuration *(KIOXIA CD8P / SMC AS -2125HS-TNR)*	PCIe 4.0 Configuration *(Vendor A / SMC AS -2124US-TNRP)*	PCIe 5.0 Configuration Gains
Average Read Latency	69.3	105.8	34%
95th Percentile Read Latency	128	186	31%
99th Percentile Read Latency	145	219	33%
Average Read-Modify-Write Latency	106.2	171.5	38%
95th Percentile Read-Modify-Write Latency	172	259	33%
99th Percentile Read-Modify-Write Latency	193	299	35%

Figure 8: 50% read / 50% read-modify-write latency results

Analysis:
The test results show that the PCIe 5.0 configuration completed more read and read-modify-write operations across the six database tests than the PCIe 4.0 configuration. One example of an application use case that benefits from this performance is when concurrent users read and modify records, which are then written into a user activity log. When concurrent users try to read and then modify the same record, potential stalls can occur especially when operations require locks to perform any modification to the record. Since various read-modify-write operations can interleave, in worst case an operation can be lost if another client updates the record without reading the update operations. By increasing the speed at which these operations occur, applications can perform faster and operations are less likely to be lost.

Summary

Query completion time and throughput are important database performance metrics that determine how fast a system/SSD configuration can complete the database workload and its operations. High performance for these metrics is important to support large concurrent user databases for applications, and becomes even more important as the hardware configurations horizontally scale.

Latency performance is another important database metric used to determine the end user experience. Since many NoSQL databases are the backend for web services, faster responses from the database make the application appear snappier. The end user experience is a critical measure as a key revenue component for purchase-based websites.

KIOXIA and Supermicro are advancing database applications by enabling lower runtimes, higher throughputs and lower operational latencies. IT users can upgrade their prior PCIe generation systems with the latest PCIe 5.0 interface, experience improved database speed with faster response times for end users and reduce the number of servers needed to meet existing workload and service level agreement requirements.

Products Tested

KIOXIA CD8P-R Series SSD

The award-winning KIOXIA CD8P-R Series read intensive data center NVMe SSDs include optimizations to support a broad range of scale-out and cloud applications. These SSDs use the PCIe 5.0 x4 interface at 32 GT/s delivering significant performance that includes up to 12,000 MB/s for sequential reads, up to 5,500 MB/s for sequential writes, up to 2,000,000 IOPS for random reads and up to 200,000 IOPS for random writes[7].

KIOXIA CD8P Series SSD[10]

Featuring KIOXIA BiCS FLASH™ generation 5 TLC flash memory, the KIOXIA CD8P-R Series is available in a 2.5-inch[8] and E3.S form factor. They deliver 1 Drive Write Per Day[9] (DWPD) endurance with storage capacities up to 30.72 TB, making them well-suited for hyperscale data centers and virtualized environments and for big data, IoT and online transaction processing applications, to name a few. Additional KIOXIA CD8P Series SSD specifications and information available here.

Supermicro Hyper A+ Server AS -2125HS-TNR

The Supermicro® Hyper A+ Server AS -2125HS-TNR supports the PCIe 5.0 interface and 2.5-inch SSDs - four PCIe 5.0 x16 slots or eight PCIe 5.0 x8 slots. It features 4th generation AMD EPYC™ 9004 Series processors, 24x DIMM slots supporting up to 6 TB of DDR5-4,800 megahertz (MHz) memory. Additional specifications and information available here.

Supermicro® Hyper A+ Server AS -2125HS-TNR[10]
(used with permission from Super Micro Computer, Inc.)

Appendix A
Database Tests

Metric 1: Runtime Metric 2: Database Throughput	
Workload Tests	**Test Description**
100% Insert	This test measures the time it takes to perform a database insert operation.
50% Read / 50% Update	This test measures the time it takes to read recent database actions and updates them (50% / 50% ratio).
95% Read / 5% Update	This test measures the time it takes to read recent database actions and updates them (95% / 5% ratio).
100% Read	This test measures the time it takes to perform a database read operation.
95% Read / 5% Insert	This test measures the time it takes to read recent database actions and inserts new data (95% / 5% ratio).
50% Read / 50% Read-Modify-Write	This test measures the time it takes to read recent database actions and perform a database read-modify-write operation (50% / 50% ratio).

Metric 3: 100% Insert Latency	
Workload Tests	**Test Description**
Average Insert Latency	This test measures the average time it takes to perform a database insert operation.
Average Insert Latency: 95th Percentile	This test measures the average time it takes to perform a database insert operation at the 95th percentile (5% of the database traffic is experiencing out of range values).
Average Insert Latency: 99th Percentile	This test measures the average time it takes to perform a database insert operation at the 99th percentile (1% of the database traffic is experiencing out of range values).

Metric 4: 50% Read / 50% Update Latency Metric 5: 95% Read / 5% Update Latency	
Workload Tests	**Test Description**
Average Read Latency	This test measures the time it takes to perform a database read operation.
Average Read Latency: 95th Percentile	This test measures the average time it takes to perform a database read operation at the 95th percentile (5% of the database traffic is experiencing out of range values).
Average Read Latency: 99th Percentile	This test measures the average time it takes to perform a database read operation at the 99th percentile (1% of the database traffic is experiencing out of range values).
Average Update Latency	This test measures the time it takes to perform a database update operation.
Average Update Latency: 95th Percentile	This test measures the average time it takes to perform a database update operation at the 95th percentile (5% of the database traffic is experiencing out of range values).
Average Update Latency: 99th Percentile	This test measures the average time it takes to perform a database update operation at the 99th percentile (1% of the database traffic is experiencing out of range values).

Metric 6: 100% Read Latency	
Workload Tests	**Test Description**
Average Read Latency	This test measures the average time it takes to perform a database read operation.
Average Read Latency: 95th Percentile	This test measures the average time it takes to perform a database read operation at the 95th percentile (5% of the database traffic is experiencing out of range values).
Average Read Latency: 99th Percentile	This test measures the average time it takes to perform a database read operation at the 99th percentile (1% of the database traffic is experiencing out of range values).

Appendix A
Database Tests (continued)

Metric 7: 95% Read / 5% Insert Latency	
Workload Tests	**Test Description**
Average Read Latency	This test measures the time it takes to perform a database read operation.
Average Read Latency: 95th Percentile	This test measures the average time it takes to perform a database read operation at the 95th percentile (5% of the database traffic is experiencing out of range values).
Average Read Latency: 99th Percentile	This test measures the average time it takes to perform a database read operation at the 99th percentile (1% of the database traffic is experiencing out of range values).
Average Update Latency	This test measures the time it takes to perform a database insert operation.
Average Update Latency: 95th Percentile	This test measures the average time it takes to perform a database insert operation at the 95th percentile (5% of the database traffic is experiencing out of range values).
Average Update Latency: 99th Percentile	This test measures the average time it takes to perform a database insert operation at the 99th percentile (1% of the database traffic is experiencing out of range values).

Metric 8: 50% Read / 50% Read-Modify-Write Latency	
Workload Tests	**Test Description**
Average Read Latency	This test measures the time it takes to perform a database read operation.
Average Read Latency: 95th Percentile	This test measures the average time it takes to perform a database read operation at the 95thpercentile (5% of the database traffic is experiencing out of range values).
Average Read Latency: 99th Percentile	This test measures the average time it takes to perform a database read operation at the 99thpercentile (1% of the database traffic is experiencing out of range values).
Average Read-Modify-Write Latency	This test measures the time it takes to perform a database read-modify-write operation.
Average Read-Modify-Write Latency: 95th Percentile	This test measures the average time it takes to perform a database read-modify-write operation at the 95thpercentile (5% of the database traffic is experiencing out of range values).
Average Read-Modify-Write Latency: 99th Percentile	This test measures the average time it takes to perform a database read-modify-write operation at the 99thpercentile (1% of the database traffic is experiencing out of range values).

Appendix B
Hardware / Software Test Configuration

Server Information		
Server Model	Supermicro® Hyper A+ Server AS -2125HS-TNR	Supermicro A+ Server AS -2124US-TNRP
No. of Servers	1	1
No. of CPU Sockets	2	2
CPU	AMD EPYC™ 9534	AMD EPYC 7702
No. of CPU Cores	64	64
CPU Frequency	2.45 gigahertz (GHz)	2.0 GHz
Total Memory	768 GB DDR5 DRAM	512 GB DDR4 DRAM
Memory Frequency	4,800 megatransfers per second (MT/s)	3,200 MT/s

Operating System Information		
Operating System	Ubuntu®	Ubuntu
Version	22.04.3	22.04.3
Kernel	5.15.0-78-generic	5.15.0-78-generic

SSD Information		
Model	KIOXIA CD8P-R Series[2]	Vendor A
Interface	PCIe® 5.0 x4	PCIe 4.0 x4
No. of Devices	8	8
Form Factor	2.5-inch (U.2)	2.5-inch (U.2)
Capacity	3.84 TB	3.84 TB
Drive Write(s) Per Day	1 (5 years)	1 (5 years)
Active Power	up to 19 W	up to 16.6 W

Application Information	
Application	Aerospike® Enterprise
Version	6.3.0.6

Load Generator Information	
Software	YCSB
Version	0.18.0
Record Count	300,000,000
Operation Count	200,000,000

Appendix C
Configuration Set-up / Test Procedures

Configuration Set-up

A Supermicro® Hyper A+ server (AS -2125HS-TNR) was set-up with the Ubuntu® 22.04.3 operating system.

Eight KIOXIA CD8P-R Series SSDs were installed in the server.

The Aerospike® Enterprise database application was installed.

YCSB software was installed and a database of 300,000,000 records was created on the KIOXIA CD8P-R Series drives.

Test Procedures

Eight YCSB workloads and associated tests (see Appendix A) were run where each workload consisted of 200,000,000 operations to complete as follows:

- Runtime
- Database Throughput
- 100% Insert Latency
- 50% Read / 50% Update Latency
- 95% Read / 5% Update Latency
- 100% Read Latency
- 95% Read / 5% Insert Latency
- 50% Read / 50% Read-Modify-Write Latency

The test results for each of the eight YCSB workloads was recorded.

A Supermicro A+ server (AS -2124US-TNRP) was set-up with the Ubuntu 22.04.3 operating system.

Eight Vendor A SSDs were installed in the server.

The same eight KIOXIA CD8P-R Series YCSB workloads and associated tests were run on the Supermicro A+ server (AS -2124US-TNRP) and Vendor A SSD configuration where each workload also consisted of 300,000,000 records and 200,000,000 operations to complete.

The test results for each of the eight YCSB workloads were recorded.

The PCIe 5.0 configuration results consisting of the Supermicro Hyper A+ server (AS -2125HS-TNR) and KIOXIA CD8P Series SSDs were compared with the PCIe 4.0 configuration consisting of the Supermicro A+ server (AS -2124US-TNRP) and Vendor A SSDs (see Test Results).

NOTES:

[1] 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.

[2] KIOXIA CD8P-R Series PCIe 5.0 data center NVMe SSD performance specifications are subject to change.

[3] A NoSQL database is a non-tabular database that stores data differently than traditional relational tables and provide flexible schemas that scale easily with large amounts of data and high user loads.

[4] A 100% insert workload is common for such use cases as transaction logging, tracking systems, logistics, asset management, and others.

[5] A key-value database is a type of non-relational database that uses a simple key-value method to store data as a collection of key-value pairs in which a key serves as a unique identifier.

[6] Memcached is an open source, general-purpose, distributed memory-caching system used to speed up dynamic database-driven websites by caching data and objects in RAM to reduce the number of times a storage device needs to be read.

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

[8] 2.5-inch indicates the form factor of the SSD and not its physical size.

[9] Drive Write Per Day (DWPD): 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.

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

TRADEMARKS:

Aerospike is a registered trademark of Aerospike, Inc. AMD EPYC and combinations thereof are trademarks of Advanced Micro Devices, Inc. NVMe and NVM Express are registered or unregistered trademarks of NVM Express, Inc. in the United States and other countries. PCIe and PCI Express are registered trademarks of PCI-SIG. Supermicro is a registered trademark of Super Micro Computer, Inc. or its subsidiaries in the United States and other countries. Ubuntu is a registered trademark of Canonical Ltd. Yahoo! Is a trademark of Yahoo, Inc. All other company names, product names and service names may be trademarks or registered trademarks of their respective companies.

DISCLAIMERS:

KIOXIA America, Inc. may make changes to specifications and product descriptions at any time. The information presented in this application brief is for informational purposes only and may contain technical inaccuracies, omissions and typographical errors. Any performance tests and ratings are measured using systems that reflect the approximate performance of KIOXIA America, Inc. products as measured by those tests. Any differences in software or hardware configuration may affect actual performance, and KIOXIA America, Inc. does not control the design or implementation of third party benchmarks or websites referenced in this document. The information contained herein is subject to change and may render inaccuracies for many reasons, including but not limited to any changes in product and/or roadmap, component and hardware revision changes, new model and/or product releases, software changes, firmware changes, or the like. KIOXIA America, Inc. assumes no obligation to update or otherwise correct or revise this information.

KIOXIA America, Inc. makes no representations or warranties with respect to the contents herein and assumes no responsibility for any inaccuracies, errors or omissions that may appear in this information.

KIOXIA America, Inc. specifically disclaims any implied warranties of merchantability or fitness for any particular purpose. In no event will KIOXIA America, Inc. be liable to any person for any direct, indirect, special or other consequential damages arising from the use of any information contained herein, even if KIOXIA America, Inc. are advised of the possibility of such damages.