



Performance Brief

Achieving Mixed-Use SSD Performance in Virtualization Workloads with Read-Intensive SSDs

Comparing KIOXIA CM7 Series RI and MU SSDs on HPE ProLiant DL385 Gen10 Plus v2 Servers

Introduction

For decades, virtualization in data centers has drastically improved server utilization while reducing hardware, power and cooling costs by running many virtual machines (VMs) on one physical server. The server, desktop, network and storage virtualization workloads, operating systems and processes run inside a VM leveraging system resources (i.e., CPU, memory, storage, networking) from the host server. Benefits of virtualization include efficient and flexible consolidation, isolation and delivery of IT services where actual work gets partitioned and run on a virtualized infrastructure rather than directly on dedicated physical hardware.

VMware ESXi™ and VMware vSAN™ are popular enterprise-grade virtualization platforms developed by VMware®, Inc. VMware ESXi scales compute and memory as needed and provides simple management of large VM clusters. VMware vSAN enables the infrastructure to transition from converged to hyperconverged, delivering incredibly fast performance since storage is local to the servers themselves. Both platforms support a VMware vSAN Express Storage Architecture™ (ESA) that efficiently utilizes NVMe™ SSDs.

Mixed-use drives are prevalently used in virtualized environments as these workloads demand a balance of high-speed reads (for user access of application data) and frequent writes (for VM logs, snapshots and OS activities). These drives are usually intended for higher random write workloads and supported by 3 DWPD¹ endurance and high input/output operations per second (IOPS). From a storage perspective, read-intensive drives are well suited for most other workloads, especially those with large block and sequential data pattern workloads.

However, for many virtualization workloads, 1 DWPD read-intensive drives can provide similar performance to 3 DWPD mixed-use drives, offering higher capacities at lower costs since mixed-use drives are normally more expensive in comparison.

This performance brief presents a performance comparison of NVMe enterprise-class, mixed-use SSDs and read-intensive SSDs in a virtualized environment. It compares twelve 15.36 terabyte² (TB) KIOXIA CM7-R Series read-intensive SSDs with twelve 12.8 TB KIOXIA CM7-V Series mixed-use SSDs. Each drive configuration was deployed in a cluster comprised of three HPE ProLiant DL385 Gen10 Plus v2 servers.

Up to six workloads were performed through HyperConverged Infrastructure Benchmark (HCIBench) and the Flexible IO (FIO) test engine. These workloads included 100% sequential read, 100% sequential write, 100% random read, 100% random write, random 70% read/30% write and one that blended varying block sizes and threads. From these workloads, four metrics were collected – IOPS, throughput, read latency and write latency.

The test results show that there is a minimal performance difference between read-intensive SSDs and mixed-use SSDs for virtualization workloads. Using lower cost read-intensive SSDs can deliver more cost-effectiveness.

The results presented include a brief description of each workload test, a graphical depiction of the test results and analysis. Appendix A covers the hardware/software test configuration. Appendix B covers the configuration setup/test procedures.

Test Results Snapshot

Comparison of read-intensive SSDs versus mixed-use SSDs based on the KIOXIA CM7 Series running virtualization workloads:

IOPS (in IOPS)

Read-Intensive SSDs:

100% Random Read:	1,038,418
100% Random Write:	546,585
Random 70% Read/30% Write:	1,135,189
Blender:	348,826

Mixed-Use SSDs:

100% Random Read:	1,040,146
100% Random Write:	578,906
Random 70% Read/30% Write:	1,109,514
Blender:	341,207

Throughput (in MB/s)

Read-Intensive SSDs:

100% Sequential Read:	4,523
100% Sequential Write:	4,576

Mixed-Use SSDs:

100% Sequential Read:	4,497
100% Sequential Write:	4,587

Read Latency (in ms)

Read-Intensive SSDs:

100% Sequential Read:	85.59
100% Random Read:	47.59
Random 70% Read/30% Write:	37.05
Blender:	1.71

Mixed-Use SSDs:

100% Sequential Read:	86.61
100% Random Read:	47.71
Random 70% Read/30% Write:	38.33
Blender:	1.85

Write Latency (in ms)

Read-Intensive SSDs:

100% Sequential Read:	86.85
100% Random Read:	6.00
Random 70% Read/30% Write:	66.99
Blender:	3.10

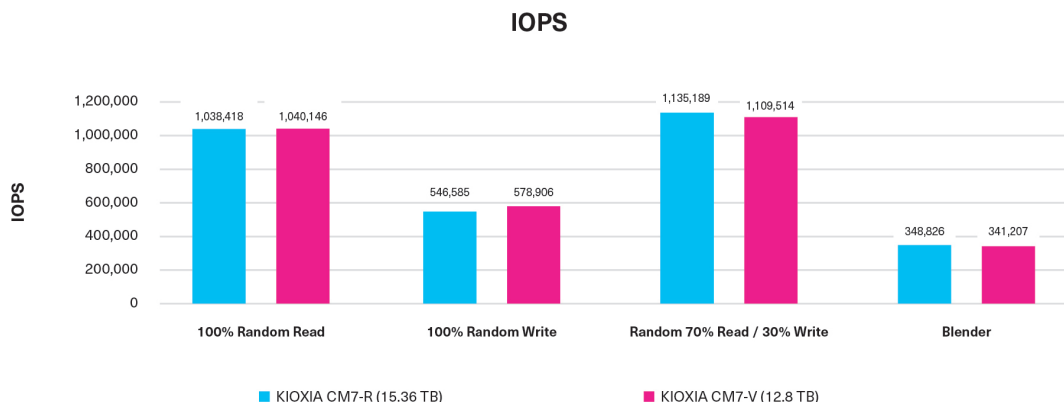
Mixed-Use SSDs:

100% Sequential Read:	85.89
100% Random Read:	5.35
Random 70% Read/30% Write:	65.51
Blender:	2.72

Test Results³

Test 1: IOPS

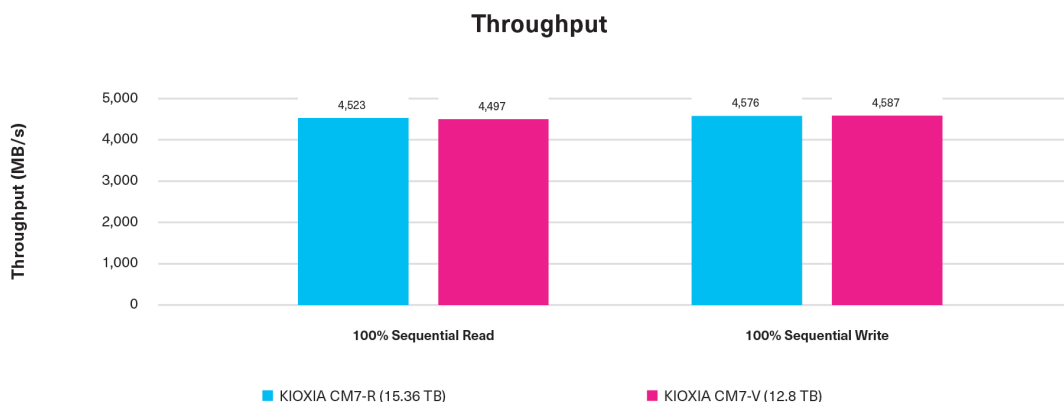
This test measured the number of IOPS that the SSD/server configuration completed and included 100% random read, 100% random write, random 70% read / 30% write and blended workloads. The results are in IOPS.



The above test results show very little difference in IOPS performance between read-intensive 15.36 TB KIOXIA CM7-R Series SSDs and mixed-use 12.8 TB KIOXIA CM7-V Series SSDs.

Test 2: Throughput

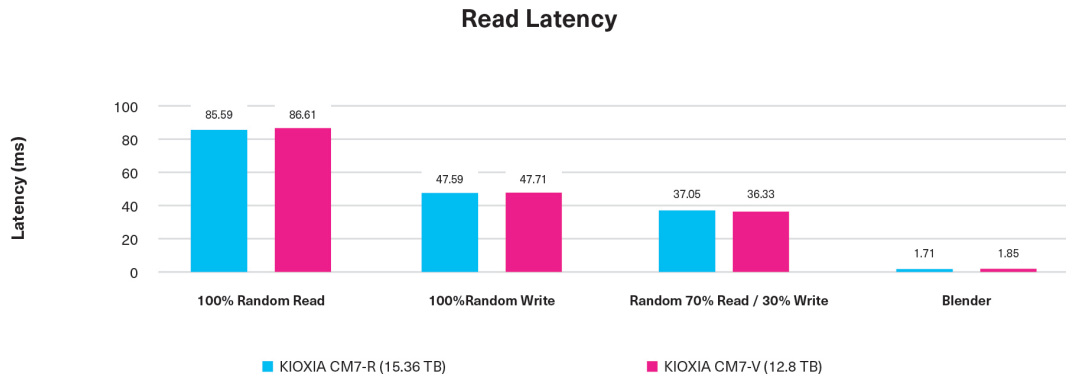
This test measured the amount of data transferred per second to and from the SSDs and included 100% sequential read and 100% sequential write workloads. The results are in megabytes per second (MB/s).



The above test results show very little difference in throughput performance between read-intensive 15.36 TB KIOXIA CM7-R Series SSDs and mixed-use 12.8 TB KIOXIA CM7-V Series SSDs.

Test 3: Read Latency

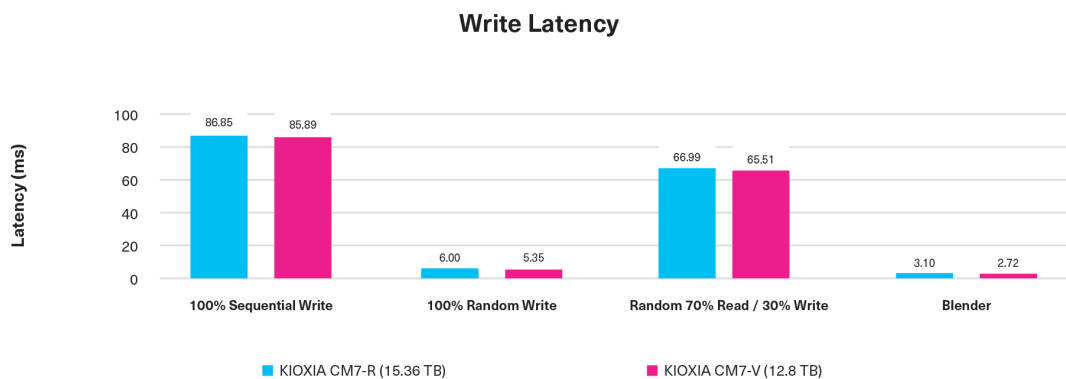
This test measured the time it took to perform a read operation. It included the average time it took for the load generator to not only issue the read operation, but also the time it took to complete the operation and receive a 'successfully completed' acknowledgement. The workloads included 100% sequential read, 100% random read, random 70% read / 30% write and blended. The results are in milliseconds (ms).



The above test results show very little difference in read latency between read-intensive 15.36 TB KIOXIA CM7-R Series SSDs and mixed-use 12.8 TB KIOXIA CM7-V Series SSDs.

Test 4: Write Latency

This test measured the time it took to perform a write operation. It included the average time it took for the load generator to not only issue the write operation, but also the time it took to complete the operation and receive a 'successfully completed' acknowledgement. The workloads included 100% sequential write, 100% random write, random 70% read / 30% write and blended. The results are in milliseconds (ms).

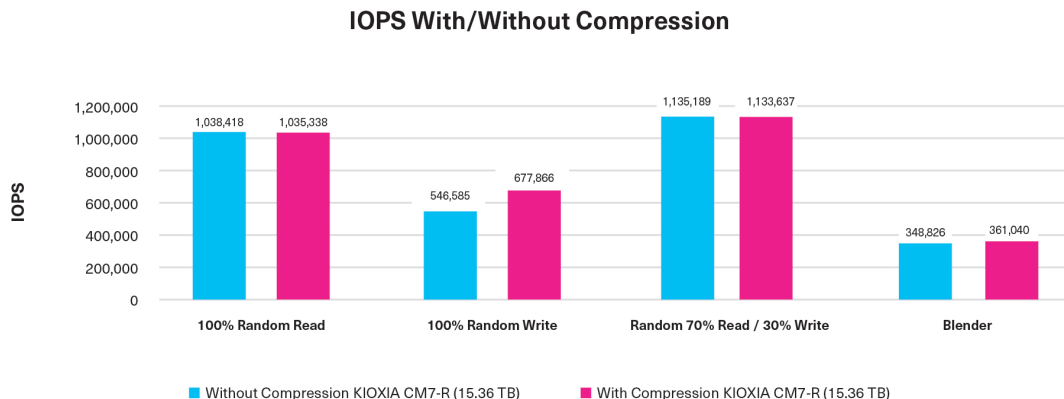


The above test results show very little difference in write latency between read-intensive 15.36 TB KIOXIA CM7-R Series SSDs and mixed-use 12.8 TB KIOXIA CM7-V Series SSDs.

Analysis

Read-intensive KIOXIA CM7-R Series SSDs deployed in HPE ProLiant DL385 Gen10 Plus v2 servers and run on a VMware vSAN™ with HCI Bench/FIO delivered similar IOPS, throughput and latency performance when compared to mixed-use KIOXIA CM7-V Series SSDs in the same server configuration. As mixed-use drives are typically more expensive than read-intensive drives, using read-intensive drives for virtualization workloads provides similar performance and higher capacities at a lower cost.

In addition to the performance tests run on the virtualization workloads, a further test was conducted comparing IOPS performance with and without compression on the read-intensive server/SSD configuration to see its impact. The following results show IOPS performance with and without compression enabled:



Enabling compression for a VMware vSAN reduces the physical storage needs of the VM. The test results show very little impact on storage performance when compression was enabled.

Summary

As read-intensive drives and mixed-use drives have specific purposes, selecting the correct drive for a workload is imperative. For virtualization workloads that are software limited, 1 DWPD drives deliver similar performance versus 3 DWPD drives. As 1 DWPD drives are cheaper, they may be a better choice for virtualized environments.

KIOXIA CM7 Series SSD Product Info

The KIOXIA CM7 Series enterprise NVMe™ SSDs support EDSFF E3.S and 2.5-inch form factors and are compliant with the PCIe® 5.0 and NVMe™ 2.0 specifications. These SSDs are available in two configurations: KIOXIA CM7-R Series for read-intensive applications (1 DWPD, up to 30.72 TB capacities) and KIOXIA CM7-V Series for higher endurance, mixed-use applications (3 DWPD, up to 12.8 TB capacities). Additional features include a dual-port design for high availability applications, flash die failure protection and security options⁴. Additional KIOXIA CM7 Series SSD information is available [here](#).



KIOXIA CM7 Series SSDs⁵

Appendix A

Hardware/Software Test Configuration

Load Generating Server Information		
Server Model	HPE ProLiant DL385 Gen10 Plus v2	
No. of Servers	3	
CPU Information		
CPU Model	AMD EPYC™ 7543	
No. of Sockets	2	
No. of Cores	32	
Frequency (in gigahertz)	2.8 GHz	
Memory Information		
Memory Type	DDR4	
Memory Speed (in megahertz)	3,200 MHz	
Memory Size	256 GB	
SSD Information		
SSD Model	KIOXIA CM7-R Series	KIOXIA CM7-V Series
Form Factor	2.5-inch	2.5-inch
Interface	PCIe® 5.0 x4	PCIe 5.0 x4
No. of SSDs	12	12
SSD Capacity	15.36 TB	12.8 TB
Drive Writes per Day	1	3
Active Power	25 watts	25 watts
Operating System Information		
Operating System (OS)	VMware ESXi™	
OS Version	9	
Storage Type	vSAN ESA	
Software Information		
Database Software	VMware vSphere®	
Database Software Version	9	
Load Generator	HCIBench	
Load Generator Version	2.8.3	
Storage Policy 1		
Name	High Performance RAID 5	
Provisioning	Thick	
Encryption	No	
Space Efficiency	No Space Efficiency	
Storage Tier	All Flash	
Storage Policy 2		
Name	High Performance RAID 5 Compression	
Provisioning	Thick	
Encryption	No	
Space Efficiency	Compression Only	
Storage Tier	All Flash	

Appendix B

Configuration Setup/Test Procedures

Configuration Setup

VMware ESXi™ 9.0 operating system was installed.

VMware vSphere® 9.0 platform was installed.

Two clusters were created in the VMware vCenter™ management interface.

Each of three HPE ProLiant DL385 Gen10 Plus v2 servers were added into the cluster.

VMkernel adapters were set up to have VMware vMotion™ migration, provisioning, management and the VMware vSAN™ platform enabled for both test configurations (read-intensive and mixed-use).

For the read-intensive VMware vSAN configuration, twelve 15.36 TB KIOXIA CM7-R Series SSDs were added to this cluster (four drives per server). For the mixed-use VMware vSAN configuration, twelve 12.8 TB KIOXIA CM7-V Series SSDs were added to this cluster (four drives per server). The default storage policy was set to 'vSAN ESA Default Policy – RAID 5' for both configurations.

The HClBench load generator was then imported and installed.

Test Procedures

Four HClBench/FIO tests were performed on each cluster configuration as follows:

- *Two performance tests: IOPS and throughput*
- *Two latency tests: read latency and write latency*

Up to six workloads were run with the test results recorded:

- *100% sequential read*
- *100% sequential write*
- *100% random read*
- *100% random write*
- *Random 70% read / 30% write*
- *Blender (mix of sequential and random workloads)*

NOTES:

¹ DWPD or Drive Write(s) 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.

² Definition of capacity: KIOXIA 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^{50} 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.

³ Read and write speed may vary depending on the various factors such as host devices, software (drivers, OS, etc.) and read/ write conditions.

⁴ Optional security feature compliant drives are not available in all countries due to export and local regulations.

⁵ The KIOXIA CM7 Series SSD product images shown are representations of each design model and not accurate product depictions.

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