

# Cisco UCS C245 M8 Rack Server Disk I/O Characterization

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## Executive summary

The Cisco® UCS C245 M8 Rack Server is perfectly suited for a wide range of storage and I/O-intensive applications such as big data analytics, databases, collaboration, virtualization, consolidation, AI/ML, and high-performance computing, supporting up to two AMD CPUs in a 2RU form factor.

The Cisco UCS C245 M8 Rack Server extends the capabilities of the Cisco UCS rack server portfolio. It powers 5<sup>th</sup> Gen and 4<sup>th</sup> Gen AMD EPYC™ processors with up to 160 cores per socket designed using AMD's chiplet architecture. With advanced feature like AMD Infinity Guard, compute-intensive applications will see significant performance improvements and will reap other benefits such as power and cost efficiencies.

You can deploy the Cisco UCS C-Series rack servers as part of the Cisco Unified Computing System™ (UCS) managed by Cisco Intersight® or Cisco UCS Manager to take advantage of Cisco standards-based unified computing innovations that can help reduce your Total Cost of Ownership (TCO) and increase your business agility. You can also use the Cisco UCS C-Series rack servers as standalone servers.

The Cisco UCS C245 M8 Rack Server brings many innovations to the UCS AMD rack server line. With the introduction of Peripheral Component Interconnect Express (PCIe) Gen 5.0 expansion slots for high-speed I/O, a Double Data Rate 5 (DDR5) memory bus, and expanded storage capabilities, the server delivers significant performance and efficiency gains that will greatly enhance application performance.

This document outlines the I/O performance characteristics of the Cisco UCS C245 M8 Rack Server using the new Cisco 24G Tri-Mode SAS Redundant Array of Independent Disks (RAID) Controller with cache backup to control SAS/Serial Advanced Technology Attachment/Non-Volatile Memory Express (SAS/SATA/NVMe) drives. The goal of this document is to help customers make well-informed decisions in choosing the right internal disk types and configuring the right controller options to meet their individual I/O workload needs.

Performance data was obtained using the Flexible I/O Tester (FIO) measurement tool, with analysis based on the number of I/O Operations Per Second (IOPS) for random I/O workloads and Megabytes-per-second (MBps) throughput for sequential I/O workloads. From this analysis, specific recommendations are made for storage configuration parameters.

Many combinations of drive types and RAID levels are possible. For these characterization tests, performance evaluations were limited to Small-Form-Factor (SFF) Solid State Drives (SSDs) with RAID 0, 5, and 10 virtual drives.

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## Introduction

The widespread adoption of virtualization and data-center consolidation technologies has profoundly affected the efficiency of the data center. Virtualization brings new challenges for storage technology, requiring the multiplexing of distinct I/O workloads across a single I/O “pipe.” From a storage perspective, this approach results in a sharp increase in random IOPS. For spinning-media disks, random I/O operations are the most difficult to handle, requiring costly seek operations and rotations between microsecond transfers, and they also constitute the critical performance components in the server environment. Therefore, it is important that data centers bundle the performance of these components through intelligent technology so that they do not cause a system bottleneck as well as ensuring they compensate for any failure of an individual component. RAID technology offers a solution by arranging several hard disks in an array so that any disk failure can be accommodated.

Data-center I/O workloads are either random (many concurrent accesses to relatively small blocks of data) or sequential (a modest number of large sequential data transfers). Currently, data centers are dominated by random and sequential workloads resulting from the scale-out architecture requirements in the data center. Historically, random access has been associated with transactional workloads, which are the most common workload types for an enterprise.

## I/O challenges

The rise of technologies such as virtualization, cloud computing, and data consolidation poses new challenges for the data center and requires enhanced I/O requests. These enhanced requests lead to increased I/O performance requirements. They also require that data centers fully use available resources so that they can support the newest requirements of the data center and reduce the performance gap observed industrywide.

The following are the major factors leading to an I/O crisis:

- **Increasing CPU usage and I/O:** Multicore processors with virtualized server and desktop architectures increase processor usage, thereby increasing the I/O demand per server. In a virtualized data center, it is the I/O performance that limits the server consolidation ratio, not the CPU or memory.
- **Randomization:** Virtualization has the effect of multiplexing multiple logical workloads across a single physical I/O path. The greater the degree of virtualization achieved, the more random the physical I/O requests.

## Scope of this document

For the I/O performance characterization tests, performance was evaluated using SSDs with configurations of RAID 0, 5, and RAID10 virtual drives to achieve maximum performance for NVMe, SAS, and SATA SSDs for the Cisco UCS C245 M8 Rack Server. The Cisco UCS C245 M8 Server used for the I/O performance characterization tests supports up to 28 SSDs configured on dual storage controllers (14 drives on each controller). The performance tests described here were performed with a 28-disk configuration for SFF NVMe/SAS/SATA SSDs with dual Cisco 24G Tri-Mode SAS RAID Controllers.

**Note:** Just a Bunch of Disks (JBOD) config testing with Host Bust Adapter (HBA) adapter is not covered in this document.

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## Cisco UCS C245 M8 server model

### Overview

Cisco UCS C245 M8 Rack Servers can be deployed as part of a Cisco UCS-managed environment, through Cisco Intersight, or standalone. When used in combination with Cisco Intersight, the C245 M8 brings the power and automation of unified computing to enterprise applications, including Cisco SingleConnect technology, drastically reducing switching and cabling requirements.

Cisco Intersight leverages the familiar capabilities of Cisco UCS Manager with service profiles, templates, and policy-based management to enable rapid deployment and help ensure deployment consistency. It also enables end-to-end server visibility, management, and control in both virtualized and bare-metal environments. Below are the details of the product:

- Support for up to two 5<sup>th</sup> Gen or up to two 4<sup>th</sup> Gen AMD EPYC™ CPUs in a server designed to drive as much as 320 CPU cores (160 cores per socket)
- Up to 24 DDR5 Dual In-line Memory Module (DIMM) slots, yielding up to 6 TB of capacity, using 256 GB DIMMs (12 DIMMs per socket)
- Up to 6000 MT/s DDR5 memory plus other speeds depending on the CPU installed
- Up to 8 x PCIe Gen 4.0 slots or up to 4 x PCIe Gen 5.0 slots, plus a hybrid modular LAN on motherboard (mLOM) /OCP 3.0 slot (details below)
- Support for Cisco UCS Virtual Interface Card (VIC) 15000 Series adapters as well as a host of third-party Network Interface Card (NIC) options
- Up to 28 hot-swappable Small-Form-Factor (SFF) SAS/SATA or NVMe drives (with up to 8 direct-attach NVMe drives)
- New tri-mode RAID controller supports SAS4 plus NVMe hardware RAID
- M.2 boot options
- Up to two 960GB SATA M.2 drives with hardware RAID support
- Up to two 960GB NVMe M.2 drives with NVMe hardware RAID
- Support for up to 8 GPUs
- Modular LAN on motherboard (LOM)/OCP 3.0

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The Cisco UCS C245 M8 SFF Server can be used standalone, or as part of the Cisco Unified Computing System, which unifies computing, networking, management, virtualization, and storage access into a single integrated architecture enabling end-to-end server visibility, management, and control in both bare metal and virtualized environments.



**Figure 1.**  
Front view of server

A specifications sheet for the C245 M8 is available at:

<https://www.cisco.com/c/dam/en/us/products/collateral/servers-unified-computing/ucs-c-series-rack-servers/ucs-c245-m8-sff-rack-server.pdf>

## SSDs and NVMe drives used

The SSDs selected for the tests were based on the following factors:

- 1.9 TB enterprise value 12G SAS SSD
- 960 GB enterprise value 6G SATA SSD
- 3.2 TB U.3 high performance high endurance NVMe SSD

## Performance

When considering price, it is important to differentiate between enterprise performance SSDs and enterprise value SSDs. The differences between the two in performance, cost, reliability, and targeted applications are significant. Although it can be appealing to integrate SSDs with NAND flash technology in an enterprise storage solution to improve performance, the cost of doing so on a large scale may be prohibitive.

## Virtual disk options

You can configure the following controller options with virtual disks to accelerate write and read performance and provide data integrity:

- RAID level
- Strip (block) size
- Access policy
- Disk cache policy
- Read policy

- Write policy
- RAID levels

Table 1 summarizes the supported RAID levels and their characteristics.

**Table 1.** RAID levels and characteristics

RAID level	Characteristics	Parity	Redundancy
<b>RAID 0</b>	Striping of two or more disks to achieve optimal performance	No	No
<b>RAID 1</b>	Data mirroring on two disks for redundancy with slight performance improvement	No	Yes
<b>RAID 5</b>	Data striping with distributed parity for improved fault tolerance	Yes	Yes
<b>RAID 6</b>	Data striping with dual parity with dual fault tolerance	Yes	Yes
<b>RAID 10</b>	Data mirroring and striping for redundancy and performance improvement	No	Yes
<b>RAID 50</b>	Block striping with distributed parity for high fault tolerance	Yes	Yes
<b>RAID 60</b>	Block striping with dual parity for performance improvement	Yes	Yes

To avoid poor write performance, full initialization is always recommended when creating a RAID 5 or RAID 6 virtual drive. Depending on the virtual disk size, the full initialization process can take a long time based on the drive capacity. Fast initialization is not recommended for RAID 5 and RAID 6 virtual disks.

## Stripe size

Stripe size specifies the length of the data segments that the controller writes across multiple drives, not including parity drives. You can configure stripe size as 64, 128, 256, or 512 KB, or 1 MB. The default stripe size is 64 KB. The performance characterization tests in this paper used a stripe size of 64 KB. With random I/O workloads, no significant difference in I/O performance was observed by varying the stripe size. Stripe size of 64 KB was used for all the random and sequential workloads in the tests.

## Strip (block) size versus stripe size

A virtual disk consists of two or more physical drives that are configured together through a RAID controller to appear as a single logical drive. To improve overall performance, RAID controllers break data into discrete chunks called strips that are distributed one after the other across the physical drives in a virtual disk. A stripe is the collection of one set of strips across the physical drives in a virtual disk.

## Access policy

You can set access policy as follows:

- **RW:** Read and write access is permitted.
- **Read Only:** Read access is permitted, but write access is denied.
- **Blocked:** No access is permitted.

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## Disk cache policy

You can set disk cache policy as follows:

- **Disabled:** The disk cache is disabled. The drive sends a data transfer completion signal to the controller when the disk media has actually received all the data in a transaction. This process helps ensure data integrity if a power failure occurs.
- **Enabled:** The disk cache is enabled. The drive sends a data transfer completion signal to the controller when the drive cache has received all the data in a transaction. However, the data has not actually been transferred to the disk media, so data may be permanently lost if a power failure occurs. Although disk caching can accelerate I/O performance, it is not recommended for enterprise deployments.

## I/O cache policy

You can set I/O cache policy as follows:

- **Direct:** All read data is transferred directly to host memory, bypassing the RAID controller cache. Any read-ahead data is cached. All write data is transferred directly from host memory, bypassing the RAID controller cache if write-through cache mode is set. The direct policy is recommended for all configurations.

## Read policy

You can set the read policy as follows:

- **No read ahead (normal read):** Only the requested data is read, and the controller does not read any data ahead.
- **Always read ahead:** The controller reads sequentially ahead of requested data and stores the additional data in cache memory, anticipating that the data will be needed soon.

## Write policy

You can set the write policy as follows:

- **Write through:** Data is written directly to the disks. The controller sends a data transfer completion signal to the host when the drive subsystem has received all the data in a transaction.
- **Write back:** Data is first written to the controller cache memory, and then the acknowledgment is sent to the host. Data is written to the disks when the commit operation occurs at the controller cache. The controller sends a data transfer completion signal to the host when the controller cache has received all the data in a transaction.
- **Write back with Battery Backup Unit (BBU):** Battery backup is used to provide data integrity protection if a power failure occurs. Battery backup is always recommended for enterprise deployments.



## Workload characterization

This section provides an overview of the specific access patterns used in the performance tests.

Table 2 lists the workload types tested.

**Table 2.** Workload types

Workload type	RAID type	Access pattern type	Read:write (%)
Online Transaction Processing (OLTP)	5	Random	70:30
Decision-support system (DSS), business intelligence, and Video on Demand (VoD)	5	Sequential	100:0
Database logging	10	Sequential	0:100
High-Performance Computing (HPC)	5	Random and sequential	50:50
Digital video surveillance	10	Sequential	10:90
Big data: Hadoop	0	Sequential	90:10
Apache Cassandra	0	Sequential	60:40
Virtual Desktop Infrastructure (VDI): Boot process	5	Random	80:20
VDI: Steady state	5	Random	20:80

Tables 3 and 4 list the I/O mix ratios chosen for the sequential access and random access patterns, respectively.

**Table 3.** I/O mix ratio for sequential access pattern

I/O mode	I/O mix ratio (read:write)	
Sequential	100:0	0:100
	RAID 0, 10	RAID 0, 10

**Table 4.** I/O mix ratio for random access pattern

I/O mode	I/O mix ratio (read:write)			
Random	100:0	0:100	70:30	50:50
	RAID 0	RAID 0	RAID 0, 5	RAID 5

Tables 5 and 6 show the recommended virtual drive configuration for SSDs and HDDs, respectively.

**Table 5.** Recommended virtual drive configuration for SSDs

Access pattern	RAID level	Strip size	Disk cache policy	Read policy	Write policy
Random I/O	RAID 0	64 KB	Disabled	No read ahead	Write back good BBU
Random I/O	RAID 5	64 KB	Disabled	No read ahead	Write back good BBU
Sequential I/O	RAID 0	64 KB	Disabled	No read ahead	Write back good BBU
Sequential I/O	RAID 10	64 KB	Disabled	No read ahead	Write back good BBU

**Table 6.** Recommended virtual drive configuration for NVMe SSDs

Access pattern	RAID level	Strip size	Disk cache policy	Read policy	Write policy
Random I/O	RAID 0	64 KB	Disabled	No read ahead	Write through
Random I/O	RAID 5	64 KB	Disabled	No read ahead	Write through
Sequential I/O	RAID 0	64 KB	Disabled	No read ahead	Write through
Sequential I/O	RAID 10	64 KB	Disabled	No read ahead	Write through

**Table 7.** Recommended virtual drive configuration for HDDs

Access pattern	RAID level	Strip size	Disk cache policy	Read policy	Write policy
Random I/O	RAID 0	1 MB	Disabled	Always read ahead	Write back good BBU
Random I/O	RAID 5	1 MB	Disabled	Always read ahead	Write back good BBU
Sequential I/O	RAID 0	1 MB	Disabled	Always read ahead	Write back good BBU
Sequential I/O	RAID 10	1 MB	Disabled	Always read ahead	Write back good BBU

## Test configuration

The test configuration was as follows for SAS/SATA/NVMe SSDs:

- 28 RAID 0 virtual drives were created with 28 disks for the SFF SSDs (14 virtual drives configured on each tri-mode controllers).
- 4 RAID 5 virtual drives were created with 7 disks in each virtual drive (2 virtual drives configured on each tri-mode controllers).
- 4 RAID 10 virtual drives were created with 8 disks in one virtual drive and 6 disks in second virtual drive (2 virtual drives configured on each tri-mode controllers).
- The RAID configuration was tested with the Cisco 24G tri-mode RAID controller with SuperCap and a 4 GB cache module with 28 disks for the SFF SSDs. The server is configured with dual RAID controllers, and 14 disks are configured on each controller (28 disks on two controllers).
- Random workload tests were performed using SAS/SATA/NVMe SSDs for
  - 100-percent random read for 4- and 8-KB block sizes
  - 100-percent random write for 4- and 8-KB block sizes
  - 70:30-percent random read:write for 4- and 8-KB block sizes
- Sequential workload tests were performed using SAS/SATA/NVMe SSDs for
  - 100-percent sequential read for 256-KB and 1-MB block sizes
  - 100-percent sequential write for 256-KB and 1-MB block sizes

Table 8 lists the recommended FIO settings.

**Table 8.** Recommended FIO settings

Name	Value
<b>FIO version</b>	Fio-3.19
<b>Filename</b>	Device name on which FIO tests should run
<b>Direct</b>	For direct I/O, page cache is bypassed
<b>Type of test</b>	Random I/O or sequential I/O, read, write, or mix of read:write
<b>Block size</b>	I/O block size: 4, 8, or 256K, or 1M
<b>I/O engine</b>	FIO engine – libaio
<b>I/O depth</b>	Number of outstanding I/O instances
<b>Number of jobs</b>	Number of parallel threads to be run
<b>Run time</b>	Test run time
<b>Name</b>	Name for the test

Name	Value
Ramp-up time	Ramp-up time before the test starts
Time-based	To limit the run time of test

**Note:** The SSDs were tested with various combinations of outstanding I/O and number of jobs to get the best performance within acceptable response time.

## SSD performance results

Performance data was obtained using the FIO measurement tool on Red Hat Enterprise Linux (RHEL) with analysis based on the IOPS rate for random I/O workloads and MBps throughput for sequential I/O workloads. From this analysis, specific recommendations can be made for storage configuration parameters.

The I/O performance test results capture the maximum IOPS and bandwidth achieved with the SAS and SATA SSDs within the acceptable response time (latency) of 2 milliseconds (ms).

The RAID controller (UCSC-RAID-HP) used in this testing is Broadcom 9670W-16i controller. The performance specifications for this controller is around 6+ million IOPS for Random Read I/O and 28GB for Sequential Read I/O when used with high-performing SAS/NVMe SSDs. Refer to Broadcom 9670W-16i product brief (<https://www.broadcom.com/products/storage/raid-controllers/megaraid-9670w-16i>) for more information.

During our testing, results showed that for random I/O (reads) performance with SAS drives, 5+ million IOPS was achieved with 14 SAS drives populated on single controller of the server. This was achieved per the maximum performance of SAS SSDs that was configured on the server. However, given that the C245 M8 Server allows 28 disks populated on two controllers in the server, performance will be cumulative of two storage controllers, and random read was measured at 10+ million IOPS.

Similarly, for random I/O (reads) performance with SATA drives, 2.3M IOPS was achieved with 28 SATA drives, a fully populated disk scenario with two storage controllers. This result aligns with the IOPS specifications of the SATA drives configured in the server (refer to Figure 6 later in this document).

For sequential I/O (reads) workloads (both with SAS and SATA drives), results showed that an adapter maximum of 58,000 MBps was achieved in the case of SAS with 28 drives, and 15,000 MBps was achieved in the case of SATA as per the drive maximum with 28 drives, and captured in this document (refer to Figure 3 for SAS and Figure 7 for SATA).

There is a significant improvement in performance on Cisco UCS C245 M8 compared to earlier generations of servers and this is observed for both random I/O and sequential I/O workloads. This is mainly due to improved server architecture, storage controller design, and SAS4 drives.

This dual adapter configuration is for performance, not for any fault tolerance between adapters.

**Note:** Performance data for HBA adapter configuration (JBOD) is not included in this document as the supported HBA adapter on C245 M8 server is from a different vendor. This testing is planned in a separate configuration for SAS/SATA drives.

SAS SSD (1.9 TB enterprise value 12G SAS SSD) performance for 28-disk configuration

SAS SSD RAID 0 performance

Figure 2 shows the performance of the SSDs under test for RAID 0 configuration with a 100-percent random read, 100-percent random write, and 70:30-percent random read:write access pattern. The graph shows the comparative performance values achieved for enterprise value SAS SSD drives to help customers understand the performance. The graph shows that the 1.9 TB SAS drive provides performance of more than 10M IOPS with latency of 0.3 milliseconds for random read, performance of 2.3M IOPS with latency of 0.3 milliseconds for random write, and performance of 5.3M IOPS with latency of 0.4 milliseconds for random read:write 70:30 percent with a 4 KB block size. The result shows the maximum performance achievable from the C245 M8 RAID controller. Latency is the time taken to complete a single I/O request from the viewpoint of the application.

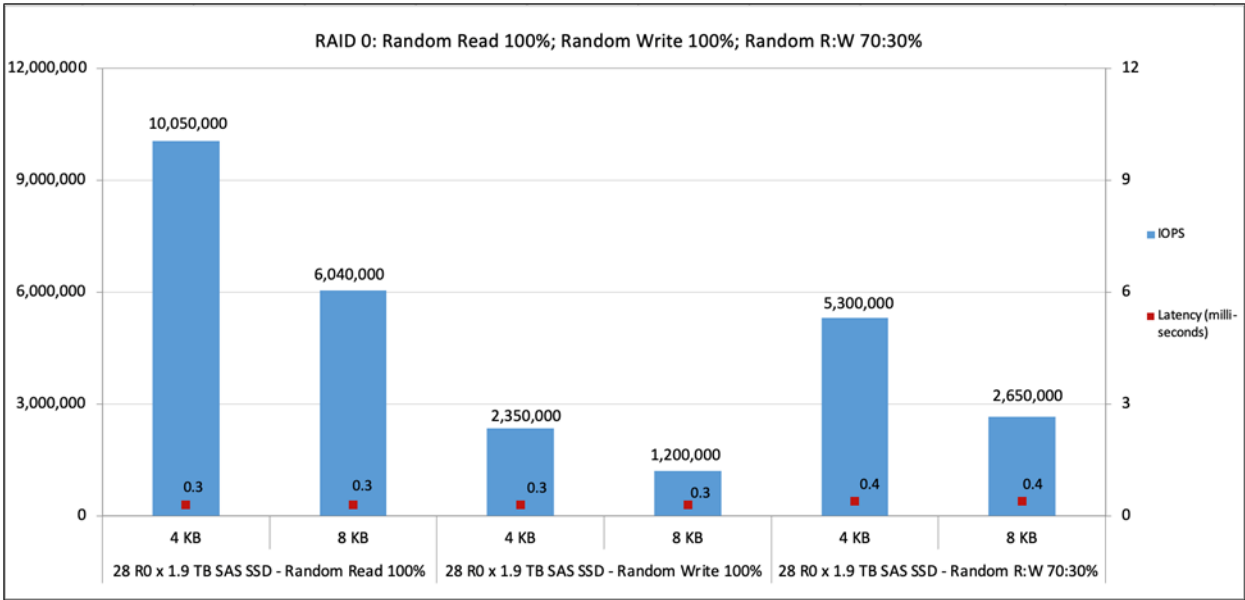
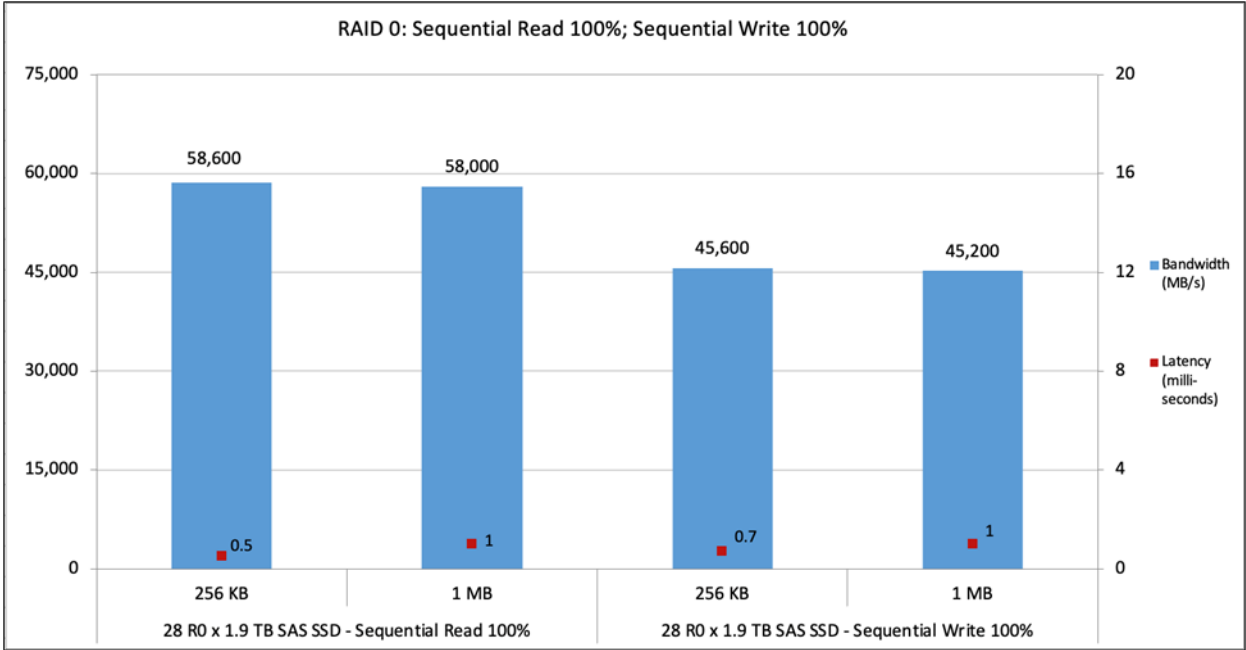


Figure 2. Cisco UCS C245 M8 RAID 0 100-percent random read; 100-percent random write; 70:30-percent random read:write

Figure 3 shows the performance of the SSDs under test for the RAID 0 configuration with a 100-percent sequential read and write access pattern. The graph shows that the 1.9 TB enterprise value SAS SSD drive provides performance of more than 58,000 MBps for sequential read and more than 45,000 MBps for sequential write, with 256 KB and 1 MB block sizes within a latency of 1 millisecond.

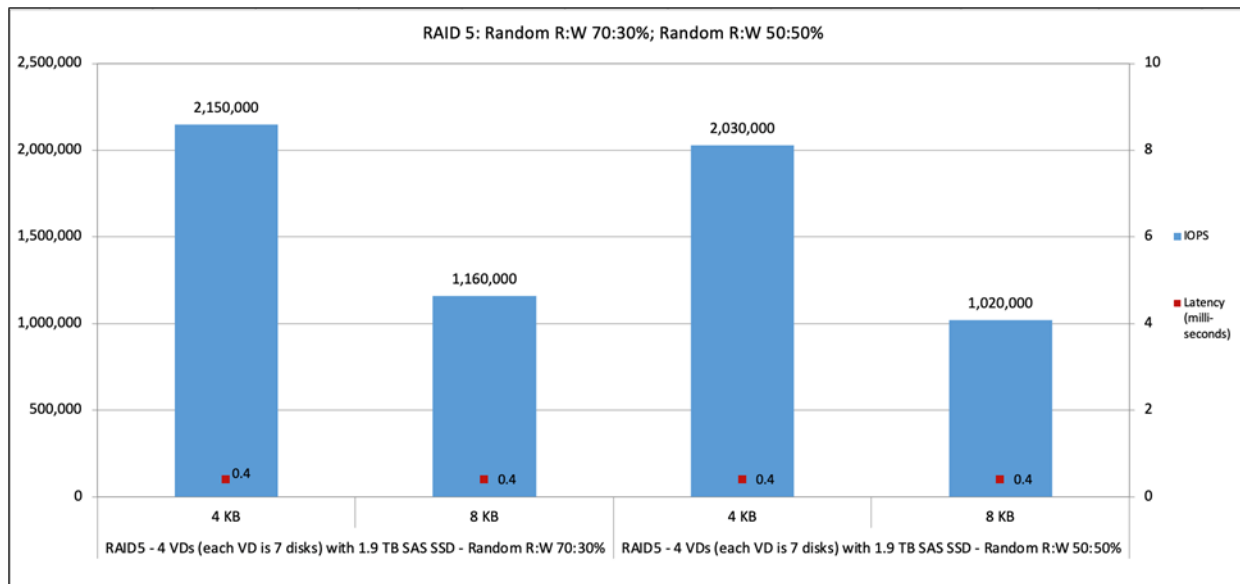


**Figure 3.**  
Cisco UCS C245 M8 RAID 0 100-percent sequential read; 100-percent sequential write

**SAS SSD RAID 5 performance**

Figure 4 shows the performance of the SSDs under test for the RAID 5 configuration with a 70:30- and 50:50-percent random read:write access pattern. The graph shows the comparative performance values achieved for enterprise value SAS SSD drives to help customers understand the performance for the RAID 5 configuration. The graph shows that the 1.9 TB SAS drive provides performance of 2.1M IOPS with latency of 0.4 milliseconds for random read:write 70:30 percent and 2M IOPS with latency of 0.4 milliseconds for random read:write 50:50 percent with a 4 KB block size.

Each RAID 5 virtual drive was carved out using 7 disks, and a total of 4 virtual drives were created using 28 disks on dual RAID controllers (14 disks are configured on each controller). The performance data shown in the graph is cumulative data by running tests on all four virtual drives in parallel.

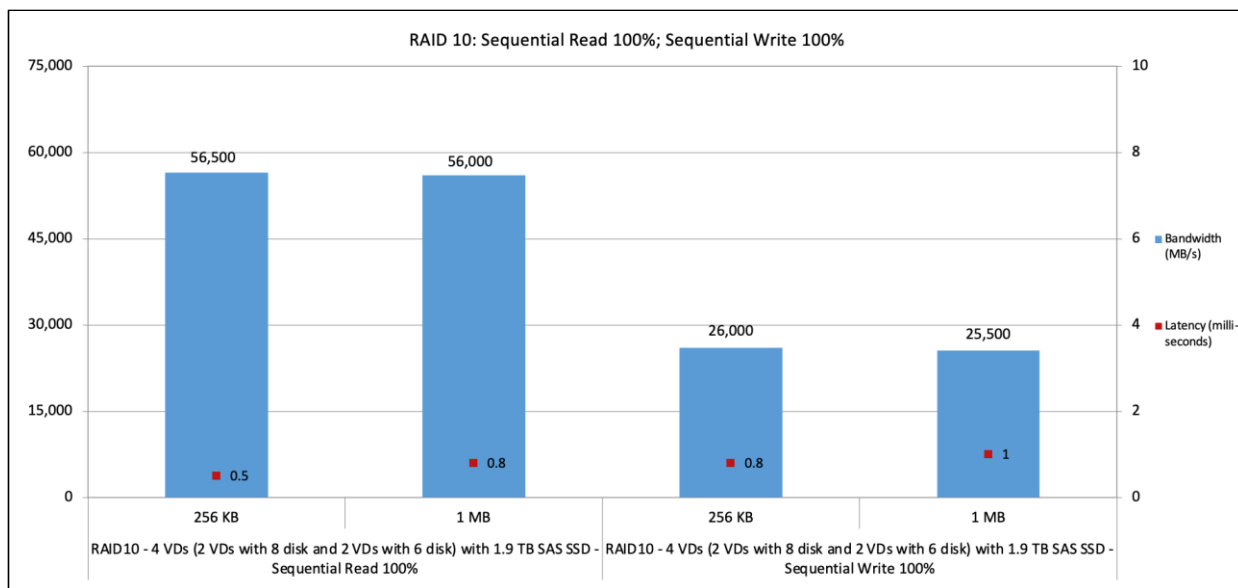


**Figure 4.**  
Cisco UCS C245 M8 RAID 5 70:30-percent random read:write; 50:50-percent random read:write

#### SAS SSD RAID 10 performance

The C245 M8 server has two RAID controllers and each controller manages 14 drives. For the purpose of this RAID 10 testing, for each RAID controller, 2 RAID VD's (VD - virtual drive) were carved out, with one VD configured using 8 drives and second VD with 6 drives. RAID 10 volume requires even number of drives to be configured on each VD and to manage this requirement; we have taken this approach (from 14 drives on a single controller). The performance data shown in the graphs, is gathered from all 4 VD's across both the RAID controllers.

Figure 5 shows the performance of the SSDs under test for the RAID 10 configuration with a 100-percent sequential read and write access pattern. The graph shows the comparative performance values achieved for enterprise value SAS SSD drives to help customers understand the performance for the RAID 10 configuration. The graph shows that the 1.9 TB SAS drive provides performance of more than 56,000 MBps for sequential read and 26,000 MBps for sequential write with 256 KB and a 1 MB block size within latency of 1 milliseconds.



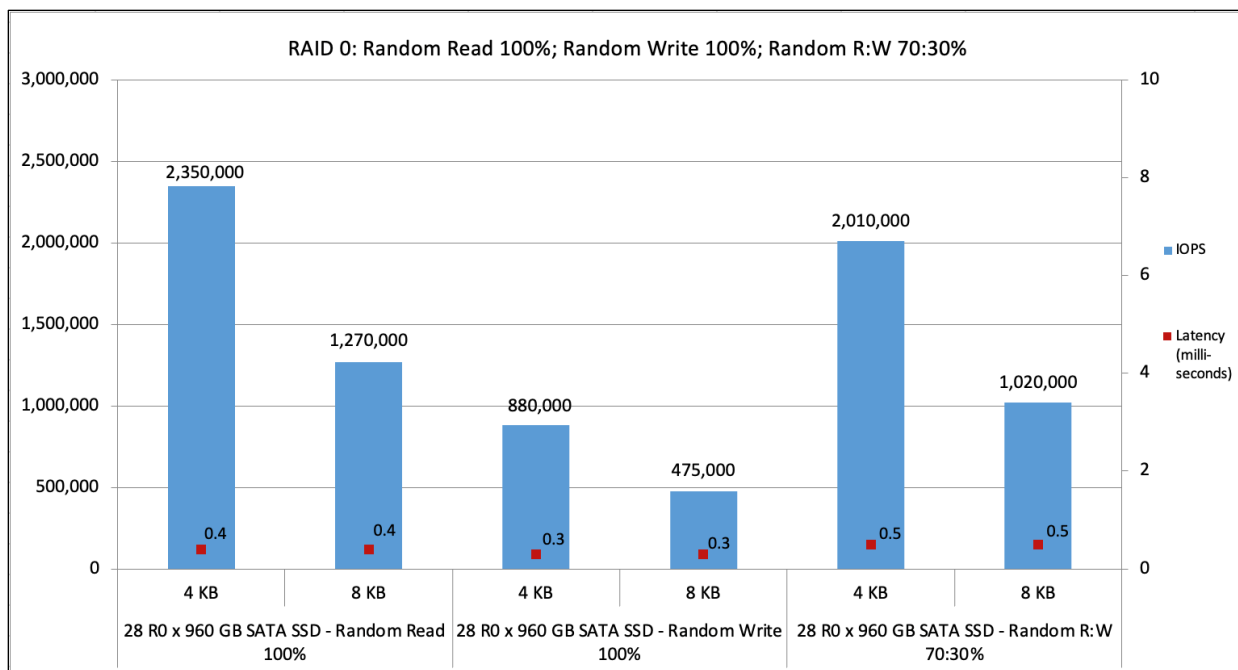
**Figure 5.**  
Cisco UCS C245 M8 RAID 10 100-percent sequential read; 100-percent sequential write

## SATA SSD (960 GB enterprise value 6G SATA SSD) performance for 28-disk configuration

### SATA SSD RAID 0 performance

Figure 6 shows the performance of the SSDs under test for the RAID 0 configuration with a 100-percent random read, 100-percent random write, and 70:30-percent random read:write access pattern. The graph shows the comparative performance values achieved for enterprise value SATA SSD drives to help customers understand the performance for the RAID 0 configuration. The graph shows that the 960 GB enterprise value SATA drive provides performance of more than 2.3M IOPS with latency of 0.4 milliseconds for random read, performance of 880K IOPS with latency of 0.3 milliseconds for random write, and more than 2M IOPS for random read:write 70:30 percent with a 4 KB block size. Latency is the time taken to complete a single I/O request from the viewpoint of the application.

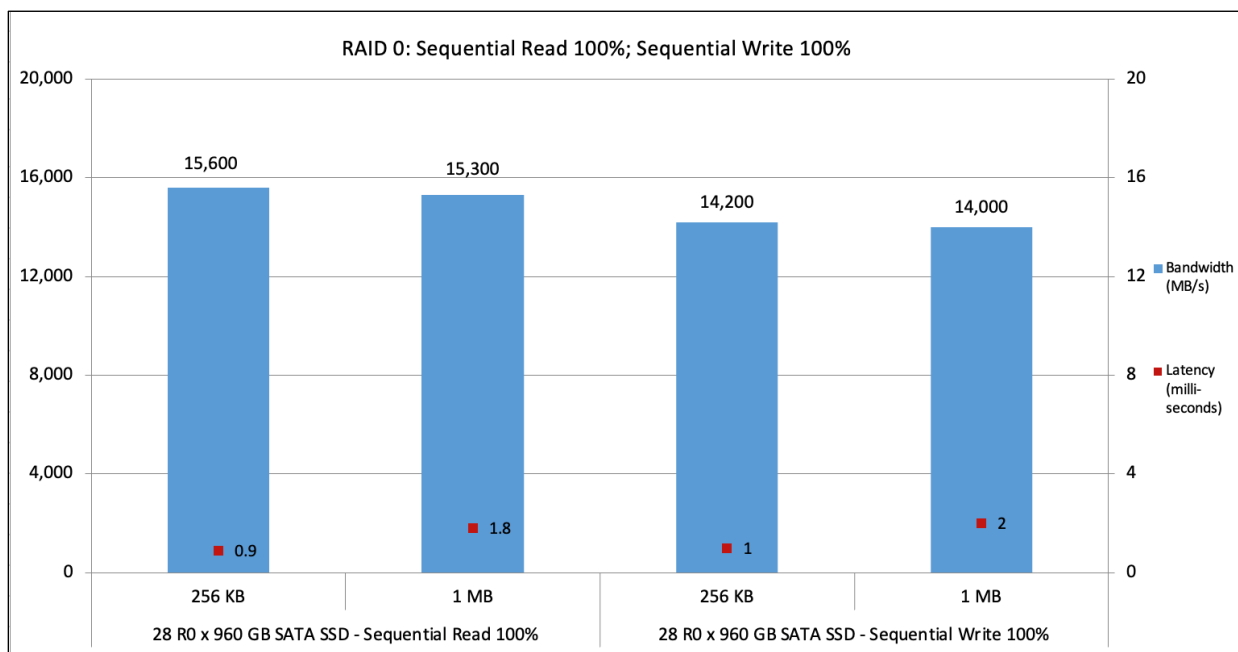




**Figure 6.**

Cisco UCS C245 M8 RAID 0 100-percent random read; 100-percent random write; 70:30-percent random read:write

Figure 7 shows the performance of the SSDs under test for the RAID 0 configuration with a 100-percent sequential read and 100-percent sequential write access pattern. The graph shows that the 960 GB enterprise value SATA SSD drive provides performance of more than 15,000 MBps for sequential read and more than 14,000 MBps for sequential write within latency of 2 milliseconds for 256 KB and 1 MB block sizes.



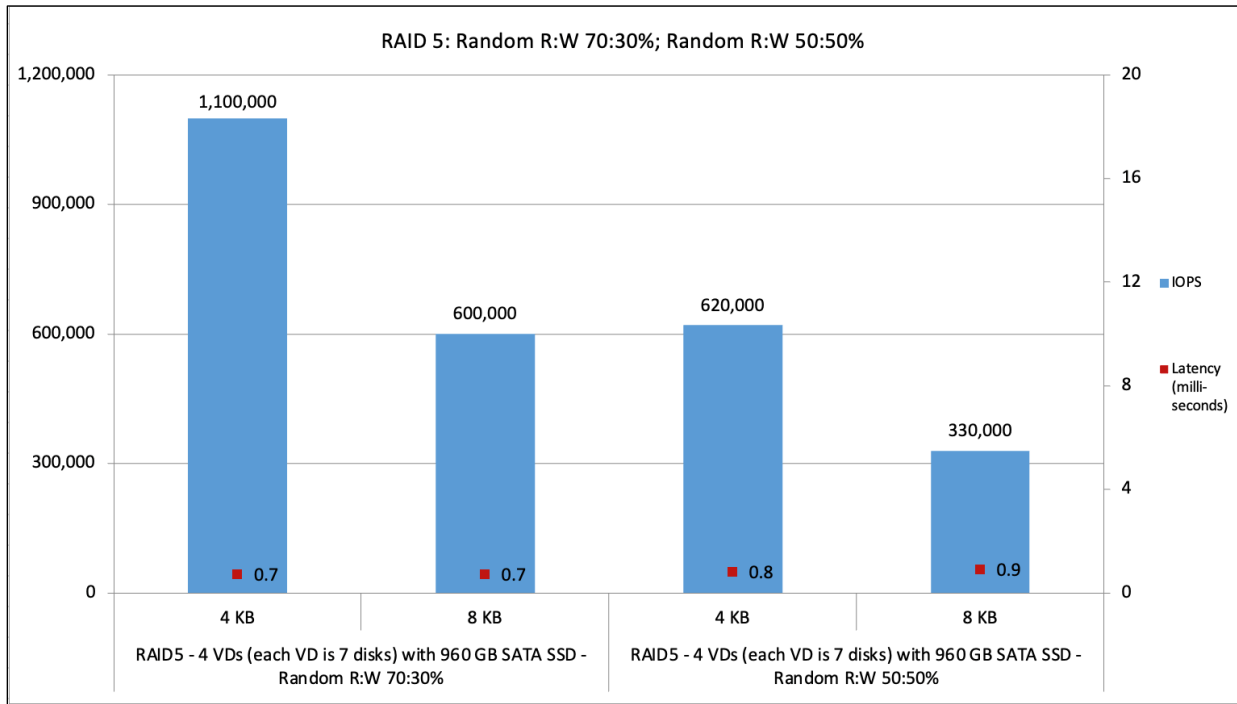
**Figure 7.**

Cisco UCS C245 M8 RAID 0 100-percent sequential read; 100-percent sequential write

## SATA SSD RAID 5 performance

Figure 8 shows the performance of the SSDs under test for the RAID 5 configuration with 70:30- and 50:50-percent random read:write access patterns. The graph shows the comparative performance values achieved for enterprise value SATA SSD drives to help customers understand the performance for the RAID 5 configuration. The graph shows that the 960 GB SATA drive provides performance of 1.1M IOPS with latency of 0.7 milliseconds for random read:write 70:30 percent and 570K IOPS with latency of 0.8 milliseconds for random read:write 50:50 percent with a 4 KB block size.

Each RAID 5 virtual drive was carved out using 7 disks, and a total of 4 virtual drives were created using 28 disks on dual RAID controllers (14 disks are configured on each controller). The performance data shown in the graph is cumulative data by running tests on all 4 virtual drives in parallel.



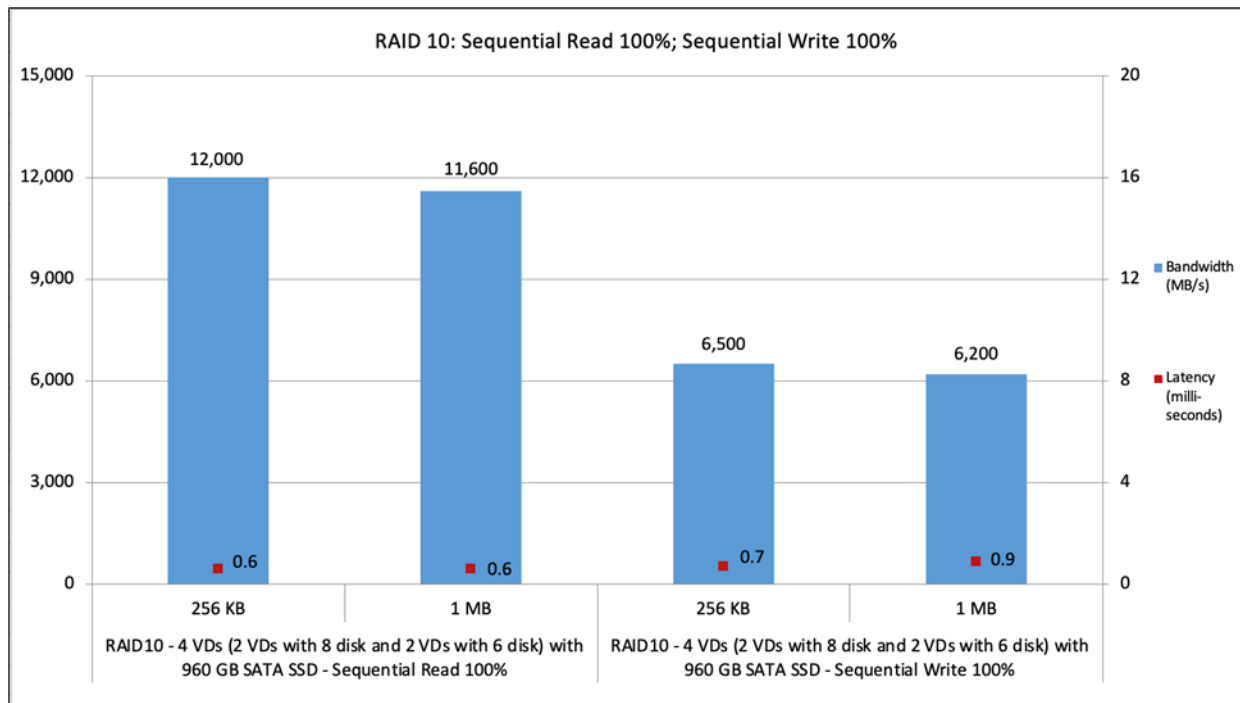
**Figure 8.**

Cisco UCS C245 M8 RAID 5 70:30-percent random write; 50:50-percent random read:write

## SATA SSD RAID 10 performance

The C245 M8 server has two RAID controllers, and each manages 14 drives. For the purposes of this RAID 10 testing, for each RAID controller, 2 RAID VDs (VD - virtual drive) were carved out, with one VD configured using 8 drives and second VD with 6 drives. RAID 10 volume requires even number of drives to be configured on each VD and to manage this requirement, we have taken this approach (from 14 drives on a single controller). The performance data shown in the graphs, is gathered from all 4 VDs across both the RAID controllers.

Figure 9 shows the performance of the SSDs under test for the RAID 10 configuration with a 100-percent sequential read and write access pattern. The graph shows the comparative performance values achieved for enterprise-value SATA SSD drives to help customers understand the performance for the RAID 10 configuration. The graph shows that the 960 GB SATA drive provides performance of close to 12,000 MBps for sequential read and more than 6,200 MBps for sequential write within latency of 0.9 milliseconds for 256 KB and 1 MB block size.



**Figure 9.**  
Cisco UCS C245 M8 RAID 10 100-percent sequential read; 100-percent sequential write

## NVMe performance data with a tri-mode storage controller

The Cisco Tri-Mode 24G SAS RAID Controller supports up to 14 SAS HDDs and SAS/SATA/NVMe SSDs operating at 3Gbps, 6Gbps, 12Gbps, and 24Gbps. It includes a SuperCap and a 4GB Flash-Back Write Cache (FBWC). Performance data was obtained using the FIO measurement tool on Red Hat Enterprise Linux (RHEL) with analysis based on the IOPS rate for random I/O workloads and MBps throughput for sequential I/O workloads. From this analysis, specific recommendations can be made for storage configuration parameters.

The I/O performance test results capture the maximum IOPS and bandwidth achieved with the NVMe SSDs within the acceptable response time (latency) of 2 milliseconds (ms).

The RAID controller (UCSC-RAID-HP) used in this testing is Broadcom 9670W-16i controller. Refer to the Broadcom 9670W-16i product brief (<https://www.broadcom.com/products/storage/raid-controllers/megaraid-9670w-16i>) for more information.

During our testing, results showed that for random I/O (reads) performance with NVMe drives, 5.5+ million IOPS were achieved with 14 NVMe drives populated on a single controller of the server. This was achieved per the maximum performance of x1 PCIe lane for each NVMe SSD configured, and as per the controller design. However, given that the C245 M8 server allows 28 disks to be populated on two controllers in the server, performance will be cumulative of two storage controllers, and random read was measured at 11+ million IOPS.

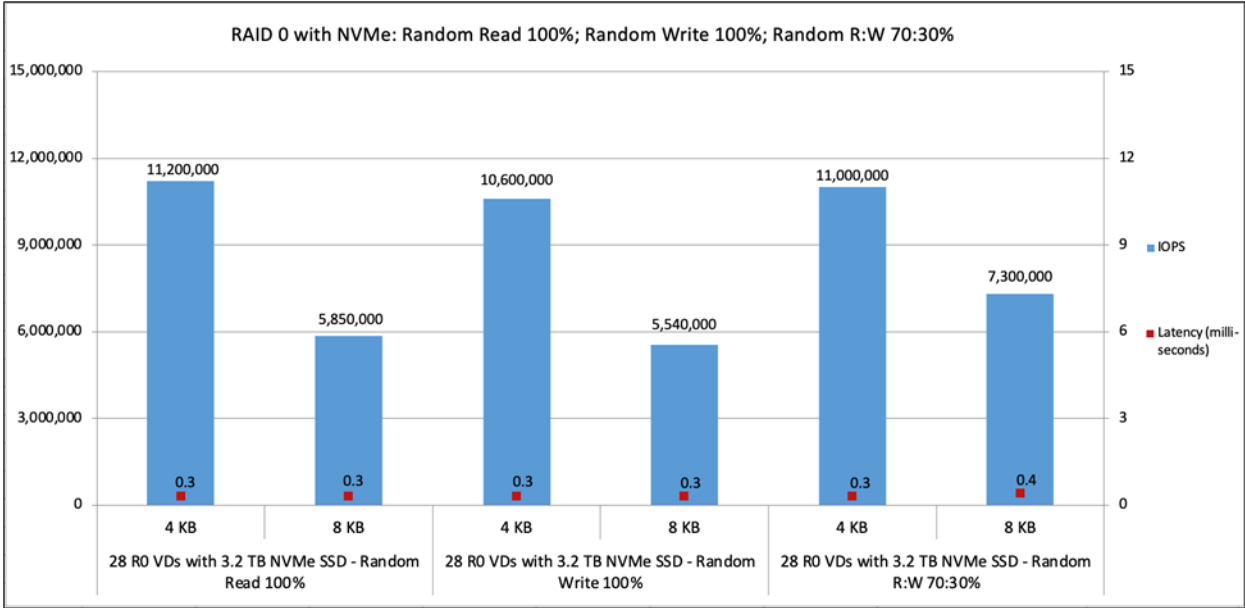
Cisco UCS C245 M8 is the first rack server to support Cisco tri-mode storage controllers where NVMe drives can be configured for RAID. The dual adapter configuration is for performance, not for any fault tolerance between adapters.

**Note:** Performance data for HBA adapter configuration (JBOD) is not included in this document as the supported HBA adapter on C245 M8 server is from a different vendor. This testing is planned in a separate configuration for SAS/SATA drives.

**NVMe performance (3.2 TB U.3 NVMe SSD) for 28-disk configuration with tri-mode controller**

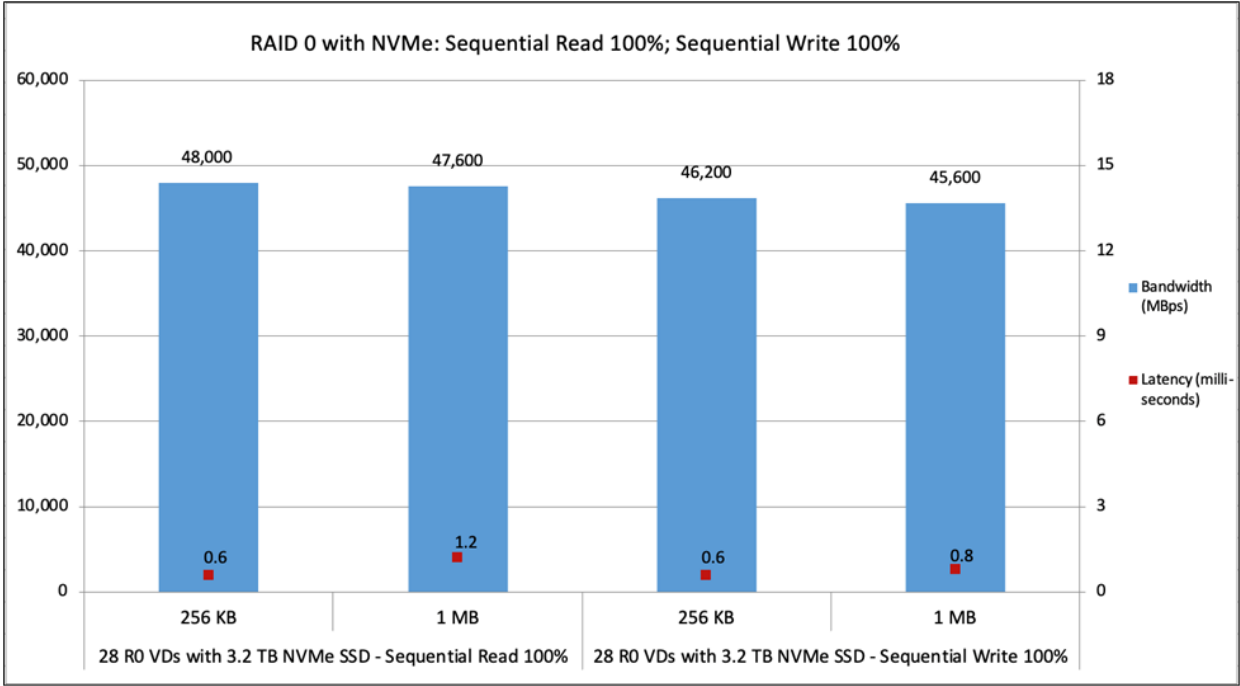
**NVMe SSD RAID 0 performance**

Figure 10 shows the performance of the NVMe SSDs under test for a RAID 0 configuration with a 100-percent random read, 100-percent random write, and 70:30-percent random read:write access pattern. The graph shows the comparative performance values achieved for U.3 NVMe SSD drives to help customers understand the performance. The graph shows that the 3.2 TB NVMe drive provides performance of more than 11M IOPS with latency of 0.3 milliseconds for random read, performance of more than 10M IOPS with latency of 0.3 milliseconds for random write, and performance of 11M IOPS with latency of 0.3 milliseconds for random read:write 70:30 percent with a 4 KB block size. The result shows the maximum performance achievable from the C245 M8 tri-mode RAID controller. Latency is the time taken to complete a single I/O request from the viewpoint of the application.



**Figure 10.** Cisco UCS C245 M8 RAID 0 with NVMe 100-percent random read; 100-percent random write; 70:30-percent random read:write

Figure 11 shows the performance of the NVMe SSDs under test for a RAID 0 configuration with a 100-percent sequential read and write access pattern. The graph shows that the 3.2 TB NVMe SSD drive provides performance of 48,000 MBps for sequential read and more than 45,000 MBps for sequential write, with 256 KB and 1 MB block sizes.

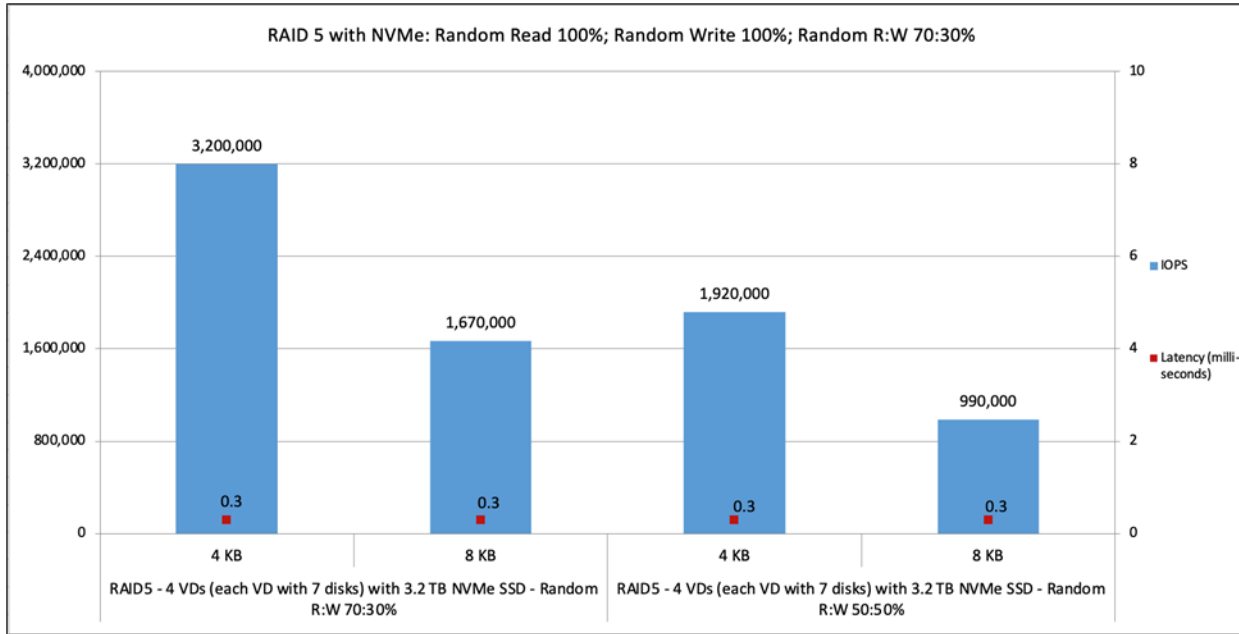


**Figure 11.**  
Cisco UCS C245 M8 NVMe RAID 0 with NVMe 100-percent sequential read; 100-percent sequential write

**NVMe SSD RAID 5 performance**

Figure 12 shows the performance of the NVMe drives under test for a RAID 5 configuration with a 70:30- and 50:50-percent random read:write access pattern. The graph shows the comparative performance values achieved for NVMe SSD drives to help customers understand the performance for the RAID 5 configuration. The graph shows that the 3.2 TB U.3 NVMe drive provides performance of 3.2M IOPS with latency of 0.3 milliseconds for random read:write 70:30 percent and 1.9M IOPS with latency of 0.3 milliseconds for random read:write 50:50 percent with a 4 KB block size.

Each RAID 5 virtual drive was carved out using 7 disks, and a total of 4 virtual drives were created using 28 disks on dual RAID controllers (14 disks are configured on each controller). The performance data shown in the graph is cumulative data from running tests on all four virtual drives in parallel.



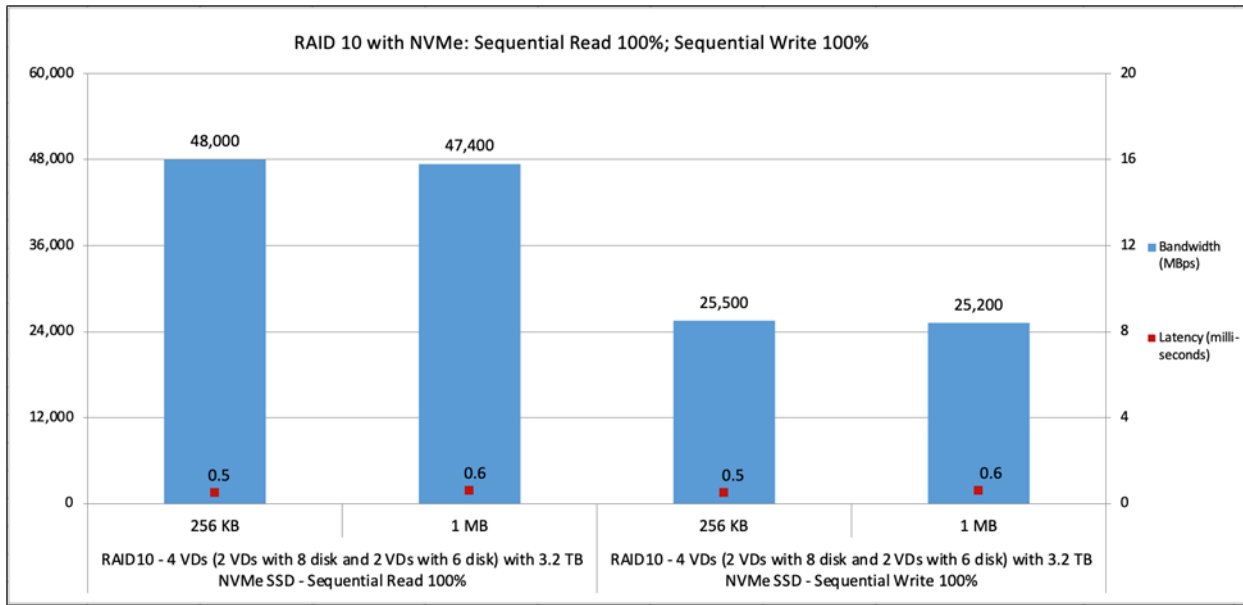
**Figure 12.**

Cisco UCS C245 M8 RAID 5 with NVMe 70:30-percent random read:write; 50:50-percent random read:write

#### NVMe SSD RAID 10 performance

The C245 M8 server has two RAID controllers, and each controller manages 14 drives. For this RAID 10 testing, for each RAID controller 2 RAID Virtual Drives (VDs) were carved out, with one VD configured using 8 drives and the second VD using 6 drives. The RAID 10 volume requires an even number of drives to be configured on each VD; to manage this requirement, we have taken this approach (from 14 drives on a single controller). The performance data shown in the graphs is gathered from all 4 VDs across both the RAID controllers.

Figure 13 shows the performance of the SSDs under test for a RAID 10 configuration with a 100-percent sequential read and write access pattern. The graph shows the comparative performance values achieved for enterprise value NVMe SSD drives to help customers understand the performance for the RAID 10 configuration. The graph shows that the 3.2 TB NVMe drive provides performance of 48,000 MBps within latency of 0.5 milliseconds for sequential read and more than 25,000 MBps within latency of 0.5 milliseconds for sequential write with 256 KB block size.



**Figure 13.**  
Cisco UCS C245 M8 RAID 10 with NVMe 100-percent sequential read; 100-percent sequential write

## Performance summary

The Cisco UCS C245 M8 Rack Server is ideal for applications that demand large capacity with tiered storage benefits, where front and rear NVMe drives can be configured as a low-latency tier and storage-adaptor-managed SSD drives for a capacity tier. With the introduction of a 24-Gbps modular tri-mode storage controller, NVMe hardware RAID can be configured on this storage controller, which was not possible before. Since the server can be configured with dual storage controllers, overall server performance will be cumulative of both controllers, depending on type of drive configured (SAS/SATA/NVMe).

There is a gain in storage I/O performance on the Cisco UCS C245 M8 Rack Server compared to earlier generations of servers, and this is observed for both random I/O and sequential I/O workloads; this is mainly due to improved server architecture, storage controller design, support for NVMe SSDs with storage controller, new SAS4 drives.

## Appendix: Test environment

Table 9 lists the details of the server under test environment conditions.

**Table 9.** Server properties

Name	Value
Product names	Cisco UCS C245 M8
CPUs	CPU: Two 2250-MHz AMD EPYC 9754 Processor
Number of cores	256
Number of threads	512
Total memory	786 GB
Memory DIMMs (16)	32 GB x 24 DIMMs
Memory speed	4800 MHz
VIC adapter	CISCO UCS VIC 15427 MLOM 4x 10/25/50-Gbps Ethernet
RAID controllers	<ul style="list-style-type: none"><li>• Cisco Tri-Mode 24G SAS RAID Controller w/4GB Cache (UCSC-RAID-HP)</li></ul>
SFF SSDs	<ul style="list-style-type: none"><li>• 1.9 TB 2.5-inch enterprise value 12G SAS SSD (UCS-SD19TKA1X-EV)</li><li>• 960 GB 2.5-inch enterprise value 6G SATA SSD (UCS-SD960G6S1X-EV)</li><li>• 3.2 TB 2.5-inch high performance high endurance NVMe SSD (UCS-NVMEG4-M3200)</li></ul>

Table 10 lists the server BIOS settings applied for disk I/O testing.

**Table 10.** Server BIOS settings

Name	Value
BIOS version	Release 4.3.5c
Cisco Integrated Management Controller (Cisco IMC) version	4.3(5.250001)
SMT Mode	Auto
NUMA Nodes per Socket	NPS4
IOMMU	Enabled
Core Performance Boost	Auto
Determinism slider	Power
Global C-state Control	Disabled
CPPC	Auto



Name	Value
Memory refresh rate	1x Refresh
Power Profile Selection F19h	High Performance Mode
Enhanced CPU Performance	Disabled
DF C-States	Auto
AVX512	Auto

**Note:** The rest of the BIOS settings are platform default values.

## For more information

For additional information on the server, refer to:

<https://www.cisco.com/c/en/us/products/collateral/servers-unified-computing/ucs-c-series-rack-servers/ucs-c245-m8-rack-server-ds.html>.

For information on BIOS tunings for different workloads, refer to the BIOS tuning guide:

<https://www.cisco.com/c/en/us/products/collateral/servers-unified-computing/ucs-c-series-rack-servers/ucs-c245-m8-rack-ser-4th-gen-amd-epyc-pro-wp.html>.

For information on the FIO tool, refer to: [https://fio.readthedocs.io/en/latest/fio\\_doc.html](https://fio.readthedocs.io/en/latest/fio_doc.html)

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