

Micron® 7300 NVMe™ SSDs vSAN™ 6.7U3 Cluster Performance¹

Enterprise IT and cloud managers want the fast, low latency and consistent performance of NVMe™ storage that their virtualized applications demand — without breaking their budgets.

With the Micron® 7300 NVMe SSD family, you don't need to reserve NVMe storage for only your top workloads. Expand the benefits of NVMe across your virtualized data center with Micron's 7300 SSDs that leverage the low power consumption and price-performance efficiencies of 3D NAND technology. The Micron 7300 delivers fast NVMe IOPS and GB/s, ideal for a wide array of broadly deployed, mixed read-write, virtualized workloads across local and cloud data centers.

This white paper discusses how the Micron 7300 performs as both the cache tier (800GB) and capacity tier (3.84TB) with VMware® vSAN™ 6.7U3 in a performance-optimized and a density-optimized configuration.

Why We Chose VMware vSAN 6.7U3

VMware vSAN is an industry-leading hyper-converged infrastructure (HCI) solution — a technology that is part of VMware's vSphere® environment, coupled with the ESXi™ hypervisor.

According to VMware^{2,3}, vSAN 6.7U3 offers substantial benefits:

- **Flash-optimized IOPS:** Optimizations deliver up to 50% more IOPS than previous versions.
- **Deduplication and compression:** Software-based deduplication and compression optimizes all-flash storage capacity.
- **Data protection (erasure coding):** Increases usable storage capacity by up to 100% while keeping data resiliency unchanged.

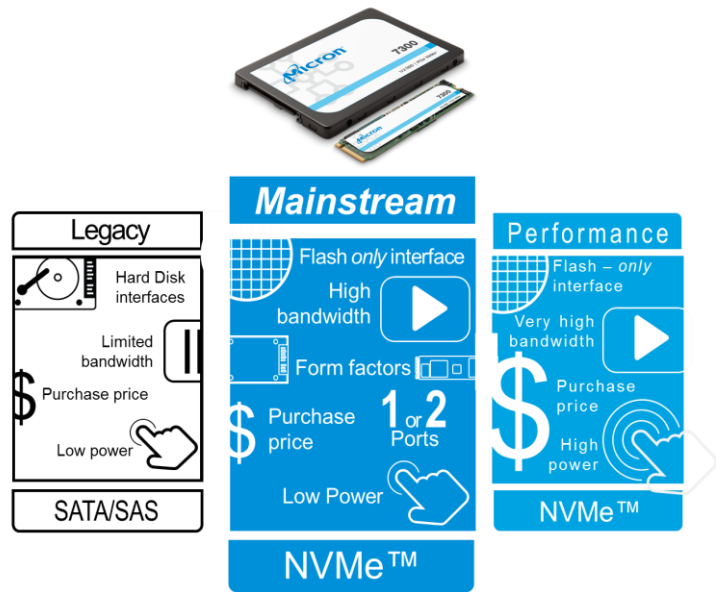


Figure 1: Micron 7300 Mainstream NVMe SSDs

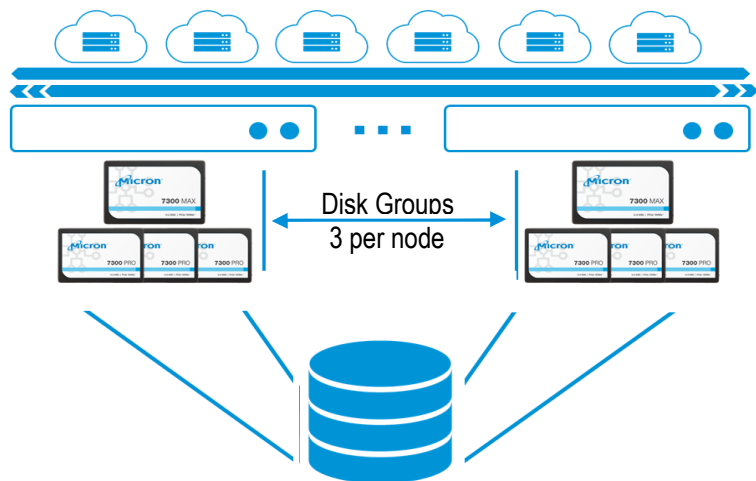


Figure 2: Tested vSAN Configuration

Hardware Components

Micron 7300 NVMe SSDs

This vSAN configuration is built on the Micron 7300 MAX and 7300 PRO enterprise NVMe SSDs (the 7300 MAX used for the cache tier and the 7300 PRO used in the capacity tier). The configuration also utilizes Micron DRAM (the details of which are not discussed in this document).

SSD	Tier	Random Read	Random Write	Read Throughput	Endurance (TBW)
7300 MAX 800GB	Cache	220,000 IOPS	60,000 IOPS	3,000 MB/s	4.5PB+
7300 PRO 3.8TB	Capacity	520,000 IOPS	70,000 IOPS	3,000 MB/s	9.8PB+

Table 1: 7300 NVMe SSD Specifications

There are three nodes in the test cluster, with three disk groups per node. Each disk group consists of four 7300 NVMe SSDs:

- Cache Tier: One 7300 MAX, 800GB
- Capacity Tier: Three 7300 PRO, 3.8TB

Server Platforms

This solution utilizes 2 rack-unit (2U), dual-socket x86 servers based on the Intel® Purley platform. Each server is configured with two Intel Gold 6142 processors, each with 16 cores operating at 2.60 GHz. These processors align with VMware’s AF-8 minimum requirements (VMware’s nomenclature for a large-sized all-flash configuration).

vSAN Storage

vSAN Storage Operations

vSAN uses a two-tier storage architecture, where all write operations are sent to the cache tier and are subsequently de-staged to the capacity tier over time. Each disk group supports up to 600GB of cache tier storage and up to five disk groups per host.

vSAN Configurations: All-Flash and Hybrid

vSAN can operate in two modes:

- **Hybrid:** SSDs are used for the cache tier and rotating media for the capacity tier.
- **All-Flash:** SSDs are used for both the cache and capacity tiers

With a hybrid configuration, the cache tier is used as both a read and write cache, keeping hot data in the cache to improve hybrid design performance. In a hybrid configuration, vSAN dedicates 70% of the total storage space for the capacity tier and the remaining 30% is dedicated for the write buffer.

In an all-flash configuration, vSAN uses 100% of the total storage space for a write buffer, with no read cache.

vSAN offers multiple options to define a storage policy. Testing performance-focused and density-focused configurations using both 100% write and 100% read enables inferring approximate performance based on deployment goals and workload I/O patterns

vSAN Storage Policies

vSAN offers multiple options to define your storage policy. Tables 2 and 3 show the storage policies tested in this document. For each configuration, four different workload profiles were run, generating 4K and 128K random read and write I/O. Since read and write performance typically differ drastically, both 0% read and 100% read were tested.

Configuration	FT Method	FTT	Checksum	Dedupe+Compression
Performance	RAID-1 (Mirroring)	1	Yes	No
Density	RAID-5/6 (Erasure Coding)	1	Yes	Yes

Table 2: Performance and Density Configuration Details

The performance configuration offers better performance but requires twice the capacity of the actual data set. The density configuration improves on capacity (only requiring an additional 33% additional raw capacity than the data set requires), but with a performance penalty.

vSAN also defines the failure tolerance method (FTM) and failure to tolerate (FTT). Table 2 shows the additional raw storage needed for each option and the capacity multiplier for each FTM and FTT.

FTM	FTT	Raid Level	Data Copies	Capacity Multiplier
RAID-1 (Mirroring)	1	RAID-1	2	2
RAID-1 (Mirroring)	2	RAID-1	3	3
RAID-5/6 (Erasure Coding)	1	RAID-5	3 + 1p	1.33
RAID-5/6 (Erasure Coding)	2	RAID-6	4 + 2p	1.5

Table 3: vSAN Fault Tolerations Details

Deduplication and Compression

vSAN deduplicates and compresses data in what VMware refers to as a “near-line” process in which both operations execute as part of the same operation while vSAN is destaging from the cache tier to the capacity tier.

During destaging, vSAN creates a hash of each 4K block. If the resulting hash matches the hash of another block in the capacity tier, vSAN does not write the data with the matching hash, but instead writes a pointer to the previously written block.

If the new block’s hash does not match an existing block’s hash, vSAN will try to compress the block and then write the new block to the capacity tier.

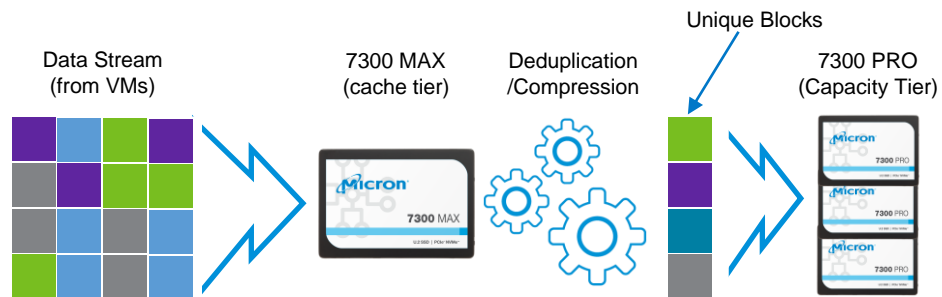


Figure 3: Deduplication and Compression

Enabling deduplication and compression shows little capacity gain when the data is incompressible. Furthermore, enabling these features with this type of data may potentially reduce performance. Figure 3 illustrates vSAN’s deduplication.

Measured Performance

Tests measuring performance use two working set sizes to show the difference in performance when a working set can fit 100% within the cache tier, and a second in which the working set is too large to fit fully into the cache tier. In this document, we describe the tests where the working set fits in the cache tier as a “cache test” and the tests where the working set exceeds the cache tier capacity (and hence must reside partially in each of the cache and capacity tiers) as a “capacity test.”

Cache Test Results

This comparison uses a working set size that fits completely within the cache (cache test). This test eliminates most destaging from the cache tier into the capacity tier.

4K Random Read

In this case, the density configuration (with deduplication and compression enabled) performing a 100% read I/O profile shows a minor impact on performance, with 6% lower IOPS and 2% higher latency than the results measured using the performance configuration (Figure 4).

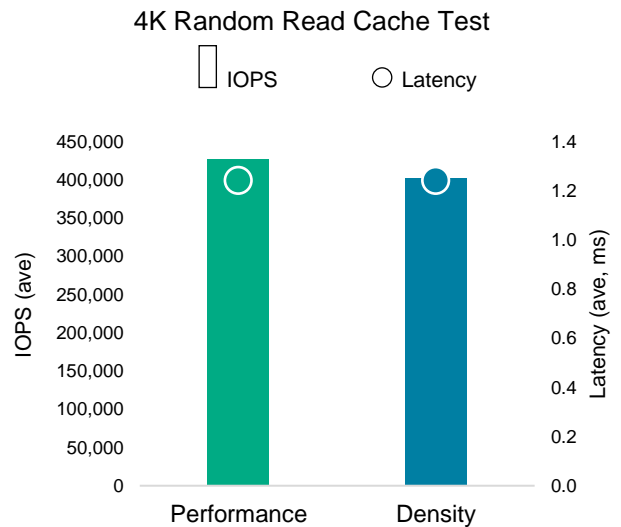


Figure 4

4K Random Write

Figure 5 shows how the performance changes for a 100% 4K random write test.

As expected, deduplication and compression, as well as RAID-5/6, add significant overhead during write operations, since both options require additional compute operations.

Enabling these two options reduces IOPS by 28% and increases latency by 40%.

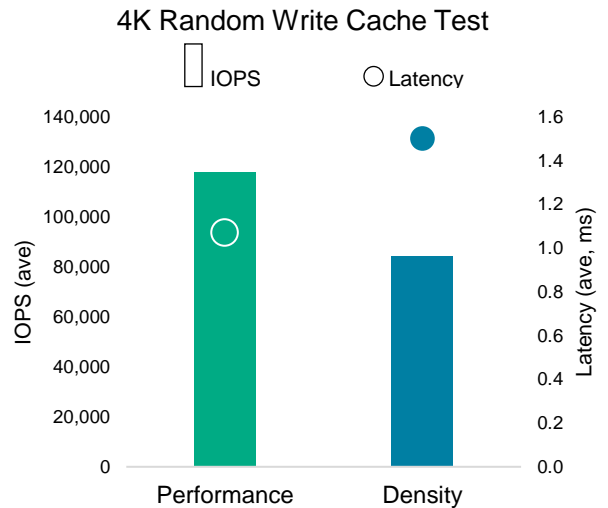


Figure 5

128K Sequential Read

Figure 6 shows the performance of 100% 128K sequential read operations.

This test shows the maximum throughput potential. Therefore, its values are shown in MB/s.

The Performance profile delivers almost 11 GB/s of read performance.

Like with the 4K test, moving to the Density profile has minimal impact on performance, with 10% lower IOPS and 7% higher latency.

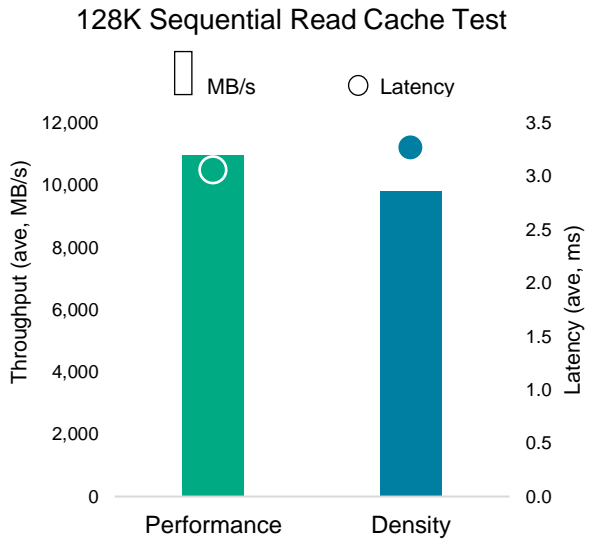


Figure 6

128K Sequential Write

Figure 7 shows the performance of large block, 182K sequential write I/O.

The Performance profile can deliver over 4 GB/s per second while the density profile is significantly lower. The effects of erasure coding and enabling deduplication and compression are readily visible.

When workload I/O is predominantly writing, these features reduce performance substantially.

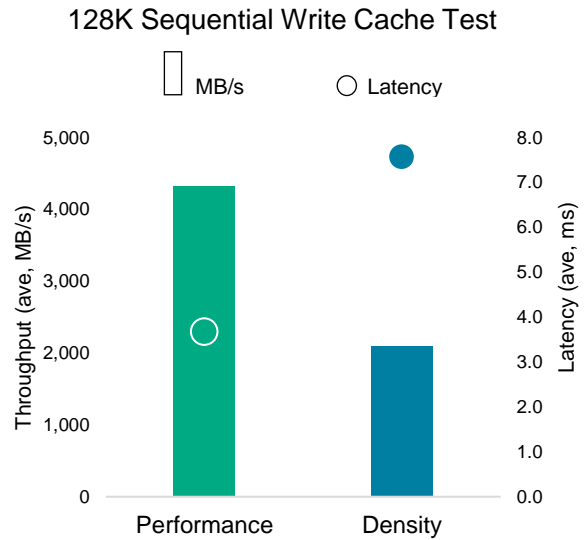


Figure 7

Capacity Test Results

This comparison uses a working set that does not fit entirely into the cache tier, forcing a portion of user data to reside in the capacity tier. There are considerable destaging operations for write-intensive workloads, which reduces performance.

4K Random Read

Figure 8 shows the performance of a 100% 4K random read capacity test.

The Performance profile yields 422K IOPS, which is close to the performance of the cache test (due to reads being served from the capacity tier).

The Density profile loses minimal performance, with 5% lower IOPS and 4% higher latency compared to the Performance profile.

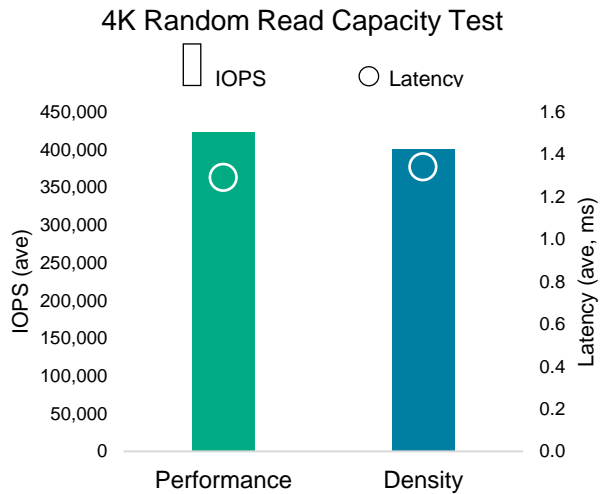


Figure 8

4K Random Write

Figure 9 shows the performance of 4K random write with the large working set size.

As seen in cache tests (Figure 9), we see a large decrease in performance when enabling RAID-5/6 and deduplication and compression.

Switching from the Performance profile to the Density profile reduces IOPS by 39% and increases latency by 67%.

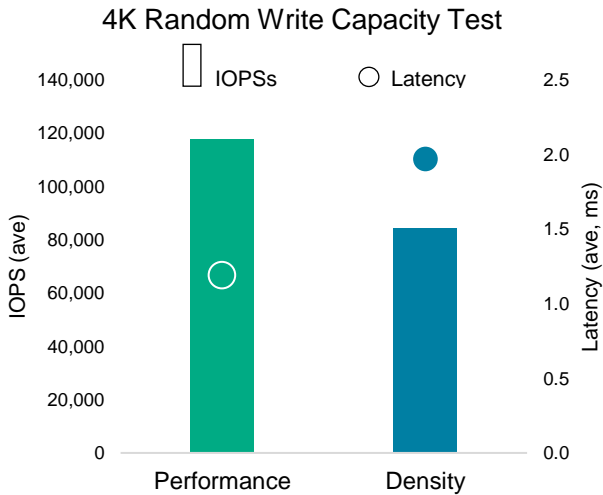


Figure 9

128K Sequential Read

Figure 10 shows a similar trend to the 128K sequential read cache test.

Relative to the Performance profile, the Density profile shows a performance reduction of 9% and a latency increase of 9%.

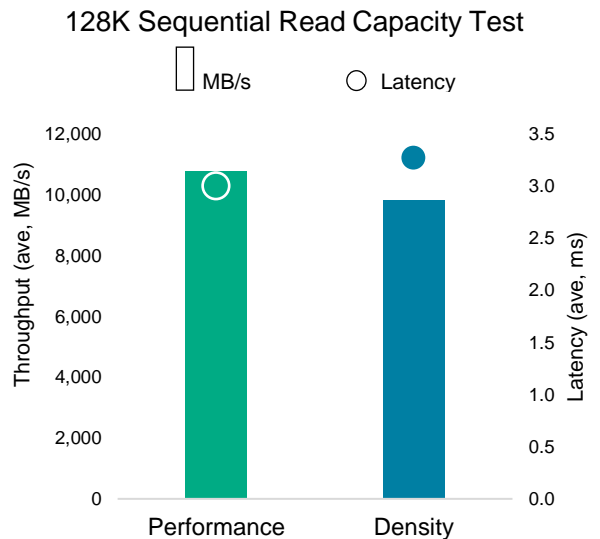


Figure 10

128K Sequential Write

Figure 11 shows that enabling RAID-5/6 and deduplication and compression has a very large performance penalty for write I/O.

Here we see a 58% performance reduction and a 2.36X latency increase.

This workload has the largest performance difference between the Performance and Density Profile. If the target workload consists primarily of large block sequential writes, enabling these features may lead to undesirable results.

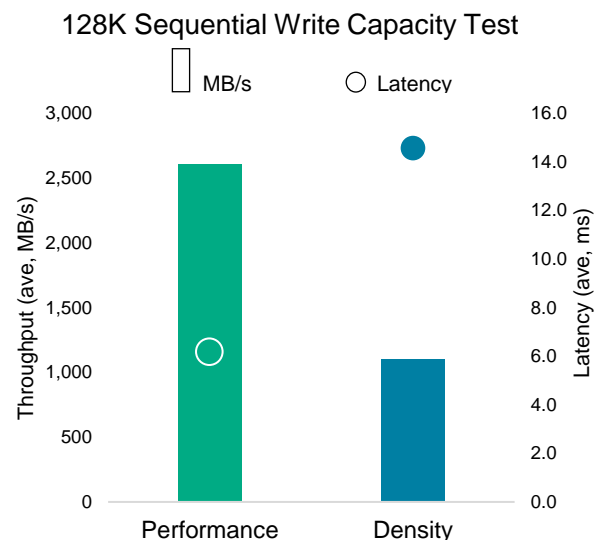


Figure 11

Conclusion

The test cases show that the performance of your vSAN cluster is highly dependent on your working set size, read/write ratio, and storage policy.

When the working set fits in the cache tier, a higher performance is typically observed. Conversely, working set sizes that exceed the cache tier size typically result in lower performance.

As expected, a RAID-5/6 erasure coding configuration with deduplication and compression enabled shows decreased performance relative to RAID-1 mirroring, but only for write operations. Hence, read-heavy workloads that require a large amount of capacity may be beneficial to enable these features.

The Micron 7300 brings the value of a flash-optimized design to this vSAN configuration. With pricing similar to legacy interface SSDs, the 7300 offered immense NVMe bandwidth, is thin enough to drive meaningful platform density and isn't a budget breaker.

The 7300 SSDs can also simplify these powerful designs by enabling one SSD family to deliver on the needs of the entire platform storage — from boot-up to cache tier to capacity tier. Available in M.2 and U.2 (7mm) form factors, the 7300 family is designed to enable performance-starved applications and workloads to thrive. The Micron 7300 brings affordable NVMe to mainstream enterprise and cloud deployments.

Learn more about the entire Micron 7300 family at www.micron.com/7300.

micron.com

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