Solution Brief

SOLIDIGM

QLC NVMe SSDs Are Optimal for Modern Workloads

What are QLC SSDs?

At four bits per cell, quad-level cell (QLC) technology expands data capacity beyond single-level cell (SLC), multi-level cell (MLC), and triple-level cell (TLC) solid state drives (SSDs). The greater density provided by QLC drives enables more capacity in the same space, for a lower cost per gigabyte.

Why are QLC SSDs Needed Now?

More data is being created, stored, and analyzed than ever before. High-growth segments in computing today—such as artificial intelligence (AI) and machine learning (ML), big data/analytics, hyperconverged infrastructure (HCI), high-performance computing (HPC), content-delivery networks (CDNs) cloud digital video recorder (cDVR), and cloud storage—all require access to ever-expanding data volumes. And because these workloads need rapid, high bandwidth access to data, they require read-optimized performance with low latency.

While hard disk drives (HDDs) have historically been the standard for warm storage, they are struggling to keep up with the demands for these read-intensive workloads. Additionally, HDDs require a significant footprint in the data center, which adds to space, power, and cooling costs.

TLC SSDs, on the other hand, are a good fit for mixed and write-heavy workloads, but they are typically not as cost-effective and capacity-optimized for large-scale, read-centric data needs. With 33 percent more bits per cell than TLC SSDs, and efficient form factors providing up to 61.44TB of storage, Solidigm QLC SSDs enable both accelerated data access and high capacities (see Table 1).

> Compared to legacy HDD arrays Solidigm QLC SSDs can consolidate warm storage footprints up to 18x[1], reduce the total cost of ownership (TCO) of a typical hybrid array up to 61%[2], and accelerate access to stored data by up to 25x[3].

	HDD	QLC SSD	TLC SSD
Read Speed:	Very Slow	Very Fast	Very Fast
Write Speed:	Very Slow	Very Fast	Very Fast
Capacity:	High	Very High	High
Space Efficiency:	Poor	Excellent	Very Good
Operating Expenses:	High	Lower	Low

[Table 1. QLC SSDs: The sweet spot for read-intensive workloads]

Solidigm QLC 3D SSDs: Unlocking the Value of Stored Data

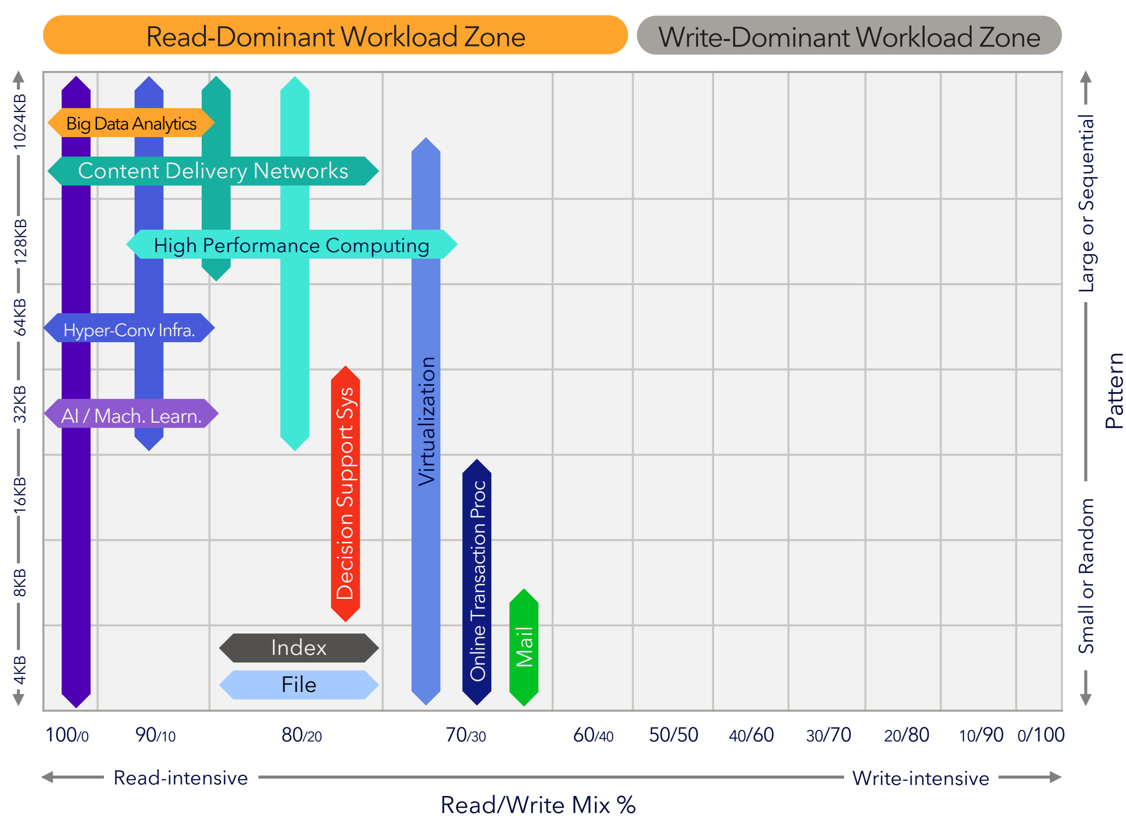
Like TLC SSDs, QLC SSDs can saturate the PCIe 4.0 bus on the read side and deliver near-TLC-like latency and quality of service (QoS). This makes the drive orders of magnitude more responsive than HDDs (see Table 2).

	HDD Seagate Exos X20[4]	QLC SSD Solidigm SSD D5-P5336[5]	TLC SSD Intel SSD D7-P5520[6]
Sustained transfer rate (HDD)/sequential read (SSD)	285 MB/s	7,000 MB/s	7,000 MB/s
Random read performance	168 IOPS (4K QD 16)	1.005M IOPS (4K QD 256)	700K
Latency (random read/ write)	4.16ms	110 µs/31 µs	75 µs/15 µs

[Table 2. How QLC SSDs compare to HDDs and TLC SSDs]

Modern Workloads: Characteristics and Storage Needs (H3)

QLC SSDs are optimized for read-intensive workloads needing rapid access to vast datasets. Figure 1 shows examples of a range of workloads[7] that QLC is well suited for based on I/O patterns.



[Figure 1. QLC SSDs are optimized for read-intensive workloads]

The unique characteristics of these workloads are detailed in Table 3.

Segment	Workload Description	Storage Input/Output (I/O) Characteristics[7]
AI/ML data pipelines	Data pipelines store and move data efficiently through all AI/ML stages while also delivering performance and scalability to support other workloads.	▪ **Bandwidth:** High-bandwidth reads (training and inference phases) and writes (ingest phase) ▪ **Latency:** Very low, with high QoS ▪ **Endurance:** Low to moderate total bytes written (TBW) required because performance storage absorbs most writes ▪ **Pattern:** Sequential reads (training and inference phases) and writes (ingest and preparation phases) ▪ **Block size:** Highly variable
Big data/analytics	Collect and manage massive datasets to enable data mining and analysis for new insights.	▪ **Bandwidth:** Very high-bandwidth reads from capacity storage ▪ **Latency:** Low, with high QoS ▪ **Endurance:** Low TBW required because writes are to performance storage ▪ **Pattern:** Sequential reads from capacity storage, multiple read requests present as random, and sequential writes to performance storage ▪ **Block size:** Very large block reads and writes
CDN/video on demand (VoD)	Stream video content to end users. Mid-tier and edge servers are used to move content close to users to optimize the customer experience and reduce network traffic.	▪ **Bandwidth:** High read bandwidth ▪ **Latency:** Low, with high QoS ▪ **Endurance:** Low TBW required because writes are typically less than 5 percent[8] ▪ **Pattern:** Highly read-intensive (up to 95 percent[8]) with sequential writes scheduled at low-use periods; reads most often present as random due to multi-user and caching distribution methods ▪ **Block size:** Very large (most reads and writes are 128KB or more[10])

Segment	Workload Description	Storage Input/Output (I/O) Characteristics[7]
cDVR	Enable content to be saved in edge appliances in place of traditional DVRs. This creates a high-capacity, high-bandwidth storage workload with locality constraints on space, power, and cooling.	▪ **Bandwidth:** Sufficient bandwidth per capacity to saturate the interface ▪ **Latency:** Low, with high QoS ▪ **Endurance:** Low to moderate TBW because content is overwritten infrequently and performance storage is used to manage wear ▪ **Pattern:** ~10/90, because less than 10 percent of recorded content is viewed;[9] reads are from the performance tier and mostly sequential, but they can present as random due to multi-user and caching distribution methods ▪ **Block size:** Very large reads and writes
Cloud storage	Cloud service providers (CSPs) offer a range of storage services to enterprises based on capacity, throughput, and access time.	▪ **Bandwidth:** Highly variable (CSP offerings range from 250 MB/s to 4,000 MB/s per drive[10,11]) ▪ **Latency:** Broad range (CSP services can be as low as sub-millisecond to single-digit-millisecond) ▪ **Endurance:** Low TBW required because the capacity tier is paired with a performance tier ▪ **Pattern:** Block storage is random or sequential; object storage is sequential, but multiple simultaneous small objects can present as random ▪ **Block size:** Block storage default is 4KB; object storage is highly variable (ML data is 2–4KB; rich content is 64KB or higher)

[Table 3. Best-fit QLC SSD segments and workloads]

Extract More Value from your Data with Solidigm QLC 3D SSDs

Built on proven technology, Solidigm QLC 3D SSDs provide exceptional high-bandwidth, low-latency read performance to support modern business-critical workloads, including ML, AI, CDNs, analytics, and big data while helping to lower TCO compared to HDDs and TLC SSDs by consolidating the storage footprint and reducing operational costs.

Learn more: solidigm.com/products/data-center/d5.html

[1] "Up to 18x reduction of warm storage footprint" claim is based on comparing 20TB HDDs, which require 18 (2U) of rack space to fill up 2PB or storage, against 61.44TB Solidigm SSD D5-5336 E1.L drives, which require 1U of rack space to fill up 2PB of storage.

[2] Comparing object storage solutions with a 100PB total solution capacity. All-QLC single-layer capacity configuration: Solidigm D5 P5336, 61.44TB, U.2, 7000 MB/s throughput, 16W average active write power, 5W idle power, 95% capacity utilization, RAID 1 mirroring, calculated duty cycle 8.9%. Hybrid configuration: Capacity layer-Seagate EXOS X20 20TB SAS HDD ST18000NM007D (https://www.seagate.com/products/enterprise-drives/exos-x/x20/), 70% short-stroked throughput calculated to 500 MB/s; 9.4W average active power, 5.4W idle power, Hadoop Triplication, 20% duty cycle: Cache layer – Micron 7450 15.36TB, 6800 MB/s throughput, 16.6W average active write power, 5W idle power, 7% cache to capacity ratio recommended to meet customer SLAs; https://www.micron.com/products/ssd/product-lines/7450

[3] Sequential read performance based on Solidigm SSD D5-P5336 (https://www.solidigm.com/products/technology/d5-p5336-product-brief.html compared to Seagate Exos X20 (https://www.seagate.com/products/enterprise-drives/exos-x/x20/).

[4] Seagate. Exos X20 SATA Product Manual." https://www.seagate.com/products/enterprise-drives/exos-x/x20/.

[5] "Solidigm D5-5336 Series: https://www.solidigm.com/products/data-center/d5/p5336.html

[6] Solidigm SSD D7-P5520 Series: https://www.solidigm.com/products/data-center/d7/p5520.html (Distributed Asynchronous Object Storage).

[7] Storage workload characterizations are, unless noted otherwise, Solidigm estimates based on subject-matter expert deep knowledge of storage I/O patterns and behavior for a given segment.

[8] Percentage is an estimate based on Solidigm internal analysis across top tier CDNs.

[9] Percentage is an estimate based on Solidigm internal analysis across top tier cDVRs.

[10] Amazon AWS. "Amazon EBS Volume Types." https://docs.amazonaws.cn/en_us/AWSEC2/latest/UserGuide/ebs-volume-types.html.

[11] Tencent. "An Overview of Cloud Hard Drive Prices." https://cloud.tencent.com/document/product/362/2413.

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