SOLUTION BRIEF

Data Center
Storage

Introducing Intel® QLC 3D NAND Technology

Invest in efficient, cost-effective flash storage that increases storage density and capacity while reducing operational costs

As Storage Demands Increase, So Does the Need for Density and Cost Efficiency

Data is constantly changing and expanding, presenting an ever-evolving challenge for businesses. Data centers are rethinking storage architectures as they address the demands of the massive amounts of data generated by the digital economy, artificial intelligence (AI), the Internet of Things (IoT), and emerging 5G networks. IDC predicts that worldwide data creation will grow to an enormous 175 zettabytes (ZB) by 2025.[1]

It is not just in the data center that storage capacity is an issue. Consumer PCs, also, need larger and larger drives as file sizes increase. For example, 4K raw video consumes about 742 GB per hour[2], while 300 raw photos can take up almost 2.5 GB.[3]

Businesses must be prepared to manage their data growth. Without a modern data strategy in the data center and on the desktop, enterprises risk operational inefficiencies, poor customer experiences, and lost revenue. Efficient data storage is an important part of any data strategy, and historically this has been the role of hard disk drives (HDDs). But there are a number of problems with continually increasing the number of HDDs that comprise an enterprise's mid-tier storage layer:

- HDD performance is lackluster at best.[4] The modern data center requires high-performance storage for data-rich workloads such as machine learning, deep learning and big data analytics. For mainstream consumer PCs, HDD performance, or even Serial AT Attachment (SATA)-based solid state drive (SSD) performance, may not be sufficient and often does not offer an attractive price per gigabyte (GB).
- More HDDs create a larger storage footprint, which drives up costs.
- HDDs have moving parts and fail at a much higher rate than SSDs, which have no moving parts and their health can be tracked with telemetry—resulting in a high quality of service and a low level of catastrophic failures.[5]

Today's data centers and end users need a storage technology that offers large-capacity, efficient, cost-effective storage—and that's exactly what Intel has been developing over the last several years, culminating in Intel® Solid State Drives (Intel® SSDs) with quad-level cell (QLC) 3D NAND Technology.

Business Drivers and Outcomes

Intel® QLC 3D NAND SSDs are designed to handle today's capacity data and bulk storage demands.

Take Advantage of a Proven Process

Intel brings longstanding expertise and technical leadership in data management. Intel's innovations address the capacity and cost issues of today's storage demands for both the data center and the consumer PC, while providing a reliable foundation for future growth. QLC NAND is based on cell technology with more than three decades of proven reliability and quality.

Innovative vertical floating gate technology helps Intel's QLC SSDs have a very small cell size (meaning more cells fit on a single die) and 64 layers—all of which translates to efficient, cost-effective storage with large capacity. These SSDs feature high reliability with strong protection from charge loss. Rigorous qualification and compatibility testing produce a highly reliable SSD. (For additional details on Intel's QLC technology, see the sidebar, "QLC 3D NAND Technology Explained".)

Get Reliability and Capacity at an Amazing Price

With Intel QLC 3D NAND SSDs, Intel has helped solve the complex challenges of creating low-cost, high-density media that performs reliably and well, and has good endurance.

Intel QLC 3D NAND Technology offers an affordable, scalable solution that can help shrink HDD and tri-level cell (TLC) SSD system footprints.[6] Compared to tri-level cell (TLC) SSDs, QLC SSDs provide 33 percent more bits per cell.[7] Fewer systems to maintain leads to power and cooling savings[8], while also reducing operation and capital costs associated with drive replacements.[9]

Speed Up Data-Intensive Workloads

Intel QLC SSDs use the PCI Express (PCIe) interface, not the SATA interface. PCIe supports the Non-Volatile Memory Express (NVMe) protocol, which provides low latency and high throughput. This results in a significant performance benefit compared to SATA-based SSDs. PCIe acceleration blasts through SATA bottlenecks[10,11], unleashing the full power of QLC Technology (see Figure 1).

Transitioning from SATA to NVMe on PCIe offers excellent user benefits in the data center, such as fast job completion, excellent cluster utilization for high-performance computing (HPC) or other I/O-intensive applications, and data-driven decisions in real-time through elimination of storage bottlenecks for big data and advanced analytics.

QLC SSDs are best suited for large-capacity storage characterized by read-intensive workloads, delivering better value than HDDs for massive bulk storage.

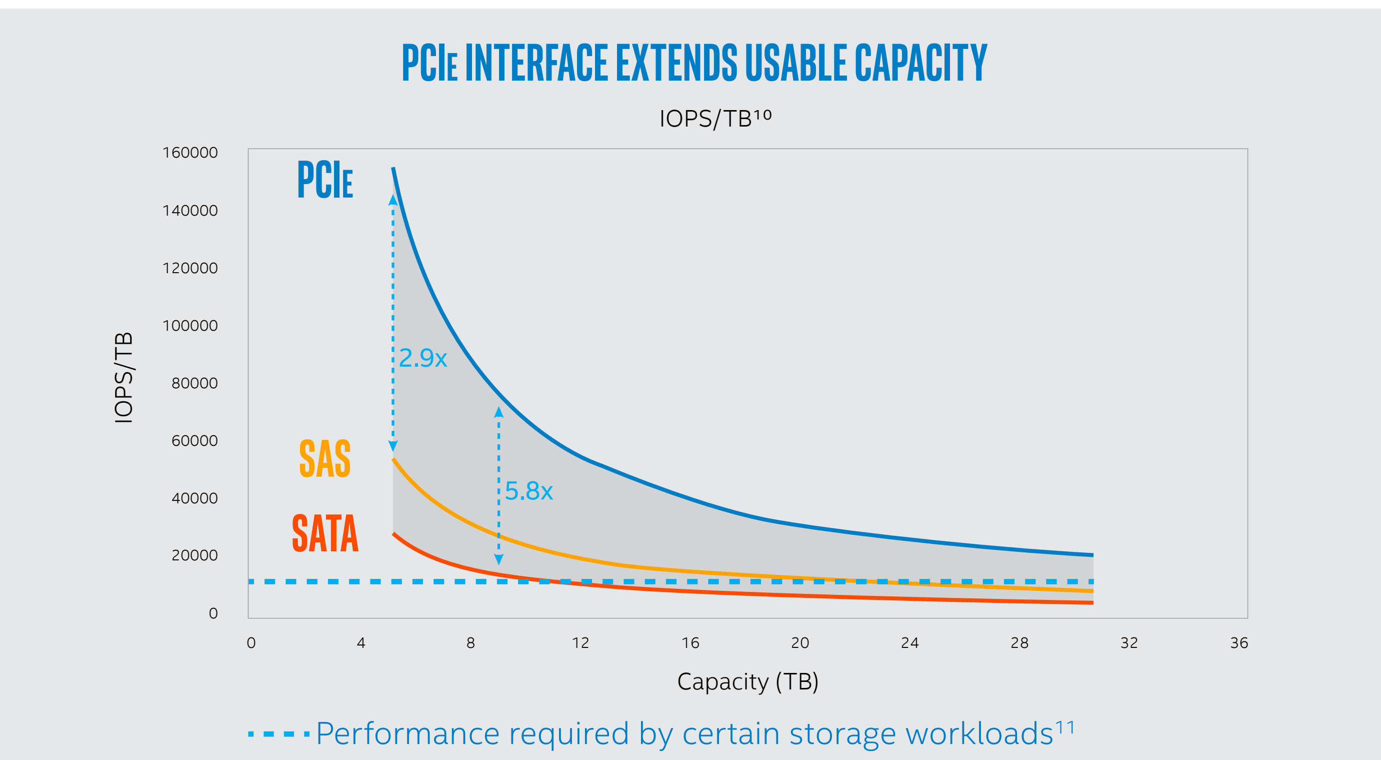

Figure 1. Quad-level cell (QLC) technology on the PCIe interface accelerates workloads at larger capacities. At higher QLC capacities, SAS and SATA interfaces limit performance capabilities.

Want Even More Performance?

Data center workloads that require extremely high I/O operations per second (IOPS) and very low latency with a heavy write mix or caching (such as in-memory databases) can benefit from pairing QLC SSDs with Intel® Optane™ technology.

Intel Optane technology can boost client PC performance as well. A computer with a 7th gen or newer Intel® Core™ processor, an Intel QLC SSD and an Intel Optane memory M10 module delivers exceptional speed and responsiveness so you can wake your computer instantly, search and find files quickly and save large files in a flash.

Summary

Storage matters. Prepare for the future by investing in storage technology that is ready to handle the oncoming flood of data. Intel QLC 3D NAND Technology is transforming the economics of storage, which offers cost-efficient, highly dense storage with good endurance and PCIe acceleration. If you're looking for a reliable mix of performance, capacity and value that can tackle today's storage needs—in the data center or on the desktop—consider replacing aging HDDs and limited-capacity TLC SSDs with Intel QLC 3D NAND SSDs.

Find the solution that is right for your organization. Contact your Intel representative or visit **https://www.intel.com/content/www/us/en/architecture-and-technology/3d-nand-technology.html**

QLC 3D NAND Technology Explained

Readers who want to know not only what quad-level cell (QLC) technology can do, but also what it is, here's a not-too-technical explanation. First, a bit of history. NAND technology debuted in 2006 with the 4 Gb/die 2D planar gate cell, often referred to as a single-level cell (SLC). Driven by a focus on density and cost reduction, Intel engineers introduced the multi-level cell (MLC), which yielded 2 bits per cell. Over time, Intel shrank the size of the cell from the original 50 nm down to 20 nm—reaching a density of 128 Gb/die. Shrinking the cell improved the economics and benefitted both Intel and its customers. But further scaling proved impractical since the fixed number of electrons per gate created challenges in moving to even more bits per cell.

Responding to this challenge, in 2016 Intel engineers changed the orientation of the already-proven floating gate to vertical and wrapped it into a gate all-around structure. This resulted in almost six times as many electrons per cell, enabling the scaling of bits per cell while maintaining the utmost cell reliability. Intel also designed a unique architecture for the support circuitry, placing it almost entirely under the array. The resulting 3D, tri-cell level (TLC) technology could store 384 Gb/die.

In 2018, 3D QLC flash became a reality: 64 layers with four bits per cell, capable of storing a whopping 1,024 Gb/die. Cell stacking has accelerated the pace of Moore's Law and has resulted in a 256x increase in areal density compared to the original 2D SLC technology.

Solution Provided By:

[1] Seagate, November 2018, "Enormous Growth in Data is Coming — How to Prepare for It, and Prosper From It." https://blog.seagate.com/business/enormous-growth-in-data-is-coming-how-to-prepare-for-it-and-prosper-from-it/

[2] 4K Shooters, "How Much Hard Disk Space Do You Need If You Shoot in 4K?" http://www.4kshooters.net/2014/06/25/how-much-hard-disk-space-do-you-need-shooting-4k/

[3] O'Reilly.com, "Image Resolution and Memory Capacity." https://www.oreilly.com/library/view/digital-photography-the/0596008414/ch01s02.html

[4] Compares 4K random read IOPs and Queue Depth 32 between Intel D5-P4320 SSD and Toshiba N300 HDD. 175,000 IOPS: Measured data from Intel D5-P4320 7.68TB SSD. 4K random read IOPs; Queue Depth 32. 532 IOPS: Based on Tom's Hardware benchmarks for Toshiba N300 8TB 7.2K RPM HDD. 4K random read IOPs; Queue Depth 32: https://www.tomshardware.com/reviews/wd-red-10tb-8tb-nas-hdd,5277-2.html. Hence 4K random read IOPS are 329X better.

[5] HDDs fail 4.2x more. Based on datasheet AFR target of .44% for Intel® SSD D5-P4320 vs industry AFR Average (1.84%): Source for Intel® SSD D5-P4320 – Intel, source for industry AFR average - Backblaze.com https://www.backblaze.com/blog/hard-drive-stats-for-q1-2018/. For this claim, "better reliability" means a lower annual failure rate (AFR) for the product.

[6.] Comparing 3.5' 4TB WD Gold TB Enterprise class 7200 RPM HDD enabling up 24 HDDs per 2U and a total of 20U and 960TB total to 30.72TB E1.L Intel® SSD D5 P4326 (available at a future date) enabling up to 32 per 1U and a total of 1U and 983TB total. So 20 rack units to 1 rack unit.

[7] 33% more bits per cell. TLC (tri-level cell) contains 3 bits per cell and QLC (quad level cell) contains 4 bits per cell. Calculated as (4-3)/3 = 33% more bits per cell.

[8] Power, Cooling, Consolidation cost savings. Based on HDD: 7.2K RPM 4TB HDD, AFR of 2.00% and 7.7W active power, 24 drives in 2U (1971W total power) https://www.seagate.com/files/www-content/datasheets/pdfs/exos-7-e8-data-sheet-DS1957-1-1709US-en_US.pdf

SSD: 22W active power 44% AFR, 32 drives in 1U (704W total power); Cooling cost based on deployment term of 5 years with KwH cost of $.158 and number of watts to cool 1 watt 1.20 Based on 3.5" HDD 2U 24 drives and E1.L 1U 32 drives.

[9] Drive Replacement cost savings. Calculation: HDD 2% annual fail rate (AFR) x 256 drives x 5 years = 25.6 replacements in 5 years; SSD: 0.44% AFR x 32 drives x 5 years = 0.7 replacements in 5 years.

[10] Source – Intel. Intel® SSD D5-P4326 performance from product specification. SATA & SAS data based on theoretical max IOPS for SSDs utilizing each interface at 4K block size. PCIe* IOPS based on simulated 4K random read, queue depth (QD) 256 performance estimates conducted by Intel for the Intel® SSD D5-P4326 PCIe*-based QLC SSD at different capacities: 3.84 TB, 7.68 TB, 15.36 TB, and 30.72 TB. SATA IOPS set to 100K IOPS for all capacity points based on 100K IOPS being the max random read performance for current competitive SATA SSDs. The Micron 5210 Series* SSDs product brief (https://www.micron.com/-/media/documents/products/product-flyer/5210_ion_ssd_product_brief.pdf) shows a max 4K random read IOPS of 83 K and 90 K IOPS for 3.84 TB and 7.68 TB SKUs, respectively. SAS IOPS set to 200K for all capacity points based on SAS interface theoretical max performance being 2x that of SATA III – 12 Gb/s versus 6 Gb/s. Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance. Consult other sources of information to evaluate performance as you consider your purchase. For more complete information about performance and benchmark results, visit www.intel.com/benchmarks. Performance results are based on testing as of July 2018 and may not reflect all publicly available security updates. See configuration disclosure for details. No product can be absolutely secure.

[11] Source: NetApp. Usable capacity is defined as any drive capacity that can provide up to 10K random 4K read IOPS/TB no matter how much total capacity the drive has. This was based on this NetApp blog (https://blog.netapp.com/blogs/the-importance-of-io-density-in-delivering-storage-as-a-service-part-1/), which identifies ~8 K IOPS/TB as the "extreme" workload threshold. We have rounded that up to 10K IOPS.