White Paper

How New QLC SSDs Will Change the Storage Landscape

Sponsored by: Micron

Jeff Janukowicz
October 2018

IDC OPINION

The digital economy is rapidly changing businesses and creating new challenges for organizations. One result is that IT professionals worldwide struggle to improve efficiency in the datacenter and deliver higher performance in a cost-effective manner while managing ever-growing data sets.

Extracting business value from these data sets has never been more important in a fast-paced, competitive environment. Organizations now deploy analytics, artificial intelligence (AI), decision support applications, and machine learning and deep learning algorithms to search overcrowded data warehouses and overflowing data lakes for essential nuggets of true business insight.

But current storage media can both hinder that effort and exacerbate datacenter inefficiencies. Corporate data typically lives on hard disk drives (HDDs). Developed roughly 50 years ago, HDDs can provide a low dollar per gigabyte but can be inefficient and slow running in today's modern datacenters. For example, HDDs can cause inefficiencies and impede the performance of many next-generation applications, which must read massive amounts of data in order to process it and extract value quickly. For these workloads, the sheer number of HDDs required to deliver a high level of performance contributes to datacenter sprawl. In taking up more space and consuming more resources than necessary, HDDs increase datacenter footprints and associated costs.

Solid state drives (SSDs) present CIOs, IT managers, datacenter architects, and other IT professionals with a better option for storing massive amounts of data while keeping up with the "instant on" demands of the digital world. These semiconductor-based storage technologies are optimized for the performance, reliability, and endurance of today's datacenter servers and storage systems. Unlike hard drives, SSDs have no moving parts. Instead of storing data on magnetic platters, SSDs store data on NAND flash memory. SSDs need only milliseconds (or microseconds) to wake up from a sleep state, and they don't have to move a drive head to different parts of a disk to reach the desired data. These inherent capabilities provide applications with much quicker access to data. The value of analytics, machine learning apps, and other business intelligence (BI) programs lies in their ability to read and analyze data quickly and efficiently — a hallmark of SSDs.

This speed provides organizations with the type of real-time business insight needed to improve corporate decision making. SSDs can hasten content classification, tagging, and user authentication in NoSQL databases. They improve content delivery — including the delivery of streaming video — allowing companies to provide a more consistent experience to more customers. Since computers can "learn" only as quickly as they can read and analyze data, SSDs improve machine learning and deep learning efforts. Perhaps most important, SSDs can save corporations from the costs associated with lack of insight and customer dissatisfaction caused by the suboptimal performance of these cutting-edge applications.

SSDs don't work best for every program; companies still need HDDs for storing colder data that is infrequently accessed or data created by write-heavy applications. Many applications now rewrite very little data, yet they constantly read and analyze it. For these applications, new enterprise SSDs based on quad-level cell (QLC, or 4 bits per cell) NAND flash are an ideal choice and are poised to alter the storage landscape. QLC SSDs deliver an affordable way to move more applications to flash by packing 33% more bits into every cell, and they are optimized for the performance of high-growth enterprise workloads now and in the future.

As the digital economy grows and IT customers look to deliver new digital experiences and products, IDC expects the market for SSDs will expand because of many of the inherent benefits of QLC technology and its ability to provide more fast capacity for less. QLC SSDs will complement existing storage solutions, and IT customers should start considering the newest of these technologies now to modernize their datacenters and meet the expanding storage requirement over the next few years.

IN THIS WHITE PAPER

This white paper will help CIOs, IT managers, datacenter architects, OEMs, and other IT professionals learn more about the types of SSDs now available and which SSDs will best serve their enterprise clients in which situations. The white paper covers the current and future markets for these drives as well as the benefits and challenges associated with the technology. It also discusses the latest in SSD technology: QLC SSDs that store 4 bits of data per cell.

SITUATION OVERVIEW

A Growing Market

It is vital to consider the impact that data has on a digital economy. Mobile devices, internet-connected products, and cloud computing are all generating enormous amounts of data that need to be stored, analyzed, and used by consumers and businesses alike. IDC expects the amount of digital content created to grow to 163ZB by 2025; the amount of data stored will increase at a CAGR of 34.4% from 2017 to 2022.

Organizations need to find ways to efficiently store and access their data in a cost-effective manner. Historically, much of the enterprise data has been stored on HDDs. While HDDs have provided IT customers with a low dollar per gigabyte to store the vast amounts of data being generated, enterprise customers now require more efficient and faster way to access their data to keep up with the demands of today's IT environment.

Thanks to advances in NAND flash technology such as QLC technology, SSDs have become an effective way to deliver the required performance, reliability, and endurance. But not all SSDs are created equal. Just as datacenter executives must choose between HDD and SSD storage, there are a myriad of options when selecting the right SSD for the right workload.

The Evolution of SSDs

When SSDs were introduced as a new technology to the enterprise many years ago, there were several concerns around the technology that at the time was primarily being used for consumer-grade applications. How could a technology not originally designed for the 24 x 7 demands of the datacenter be used in the enterprise?

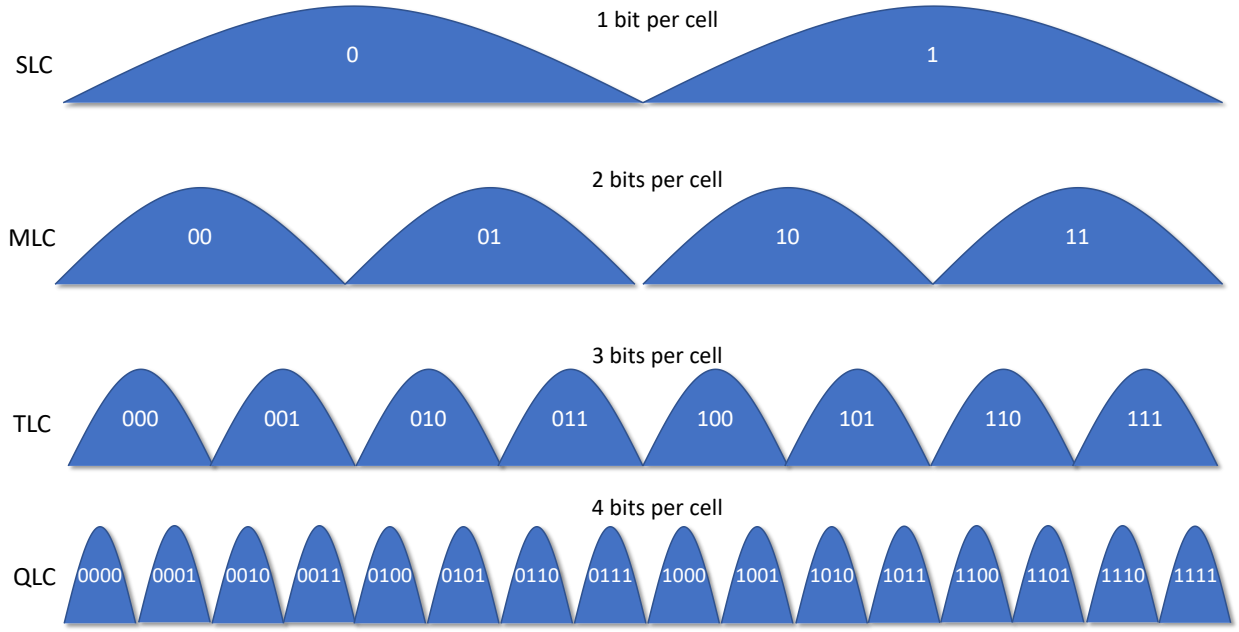
One of the primary concerns for many IT customers was that NAND flash has a finite number of write cycles that create the inherent wear-out characteristics of flash SSDs. Simply stated, as data is written to an SSD, the drive will eventually wear out as more and more data is written to the device over its life span, diminishing the integrity of the data stored on the SSD. This concept is analogous to tires on a car or ink in a printer cartridge; over time, SSDs eventually wear out or get used up and need to be replaced for optimal use. For enterprise IT customers, this brought about a new condition that needed to be factored into the overall storage requirements — endurance. The endurance of SSDs is quantified by two industry metrics: total bytes written (TBW), which was developed by JEDEC, and drive writes per day (DWPD).

Several techniques are used to improve the endurance of SSDs and make them viable for the datacenter environment. Today, SSDs use advanced algorithms and design architectures, such as wear leveling, to even distribution of write accesses across the total capacity of the SSD or overprovisioning the SSD with additional NAND flash to improve performance and endurance. Yet the type of fundamental NAND flash used has a direct impact on the performance and endurance of an enterprise SSD.

Today, four basic types of NAND flash are used in an SSD based on the number of bits stored in each cell (see Figure 1). With each type of NAND, there are cost, density, performance, and endurance characteristic trade-offs. Single-level cell (SLC) stores only 1 bit of information and requires only 2 voltage levels to represent 0 or 1. This is the simplest implementation of NAND and has the highest cost and endurance. Multilevel cell (MLC) requires 4 voltage levels to represent 00, 01, 10, and 11, while triple-level cell (TLC) requires 8 different levels and QLC needs 16 distinct levels. QLC NAND flash has not only the highest density and lowest cost but also lower endurance and write performance compared with other types of NAND flash.

FIGURE 1

NAND Flash SSD Technology



Source: IDC, 2018

The first SSD introduced over a decade ago leveraged SLC technology because, at that time, it was the only technology capable of delivering the performance and endurance required in demanding enterprise applications. However, these drives were extremely expensive and thus limited adoption to only those environments that could afford or justify the cost. To enable broader adoption, vendors introduced MLC drives to lower price points and allow SSDs to reach more mainstream applications. Several years ago, TLC drives were introduced by SSD vendors and have expanded the area where SSDs can be leveraged. The emergence of QLC NAND flash technology enables the industry to find more ways to expand the number of use cases while both increasing capacity and lowering cost.

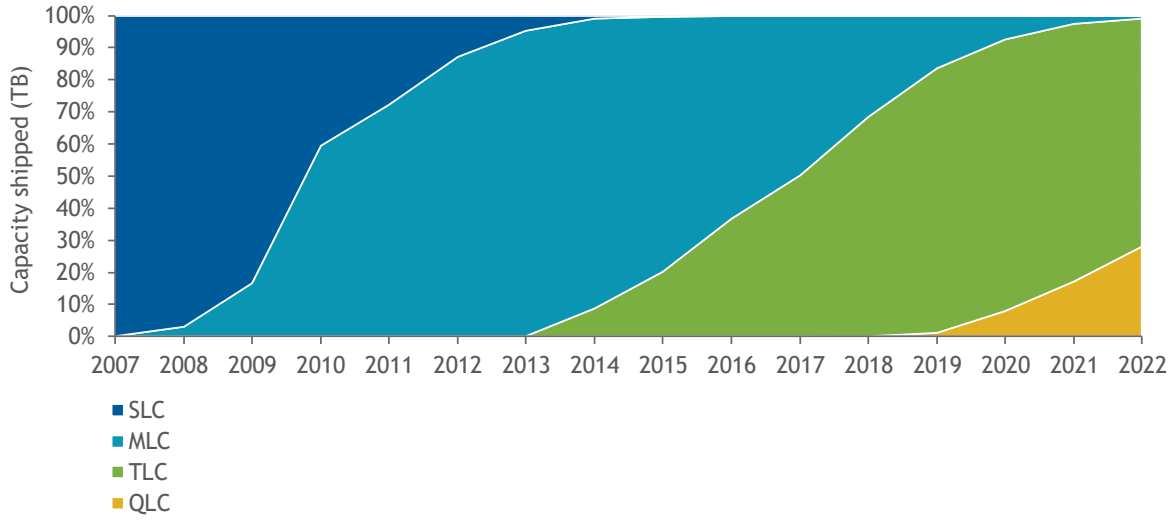
As a result, the market for SSDs has evolved, and IT managers have a number of SSD options that include:

- **Single-level cell SSDs.** These SSDs are designed for high-density mission-critical applications that must meet stringent standards for reliability regardless of cost. SLC SSDs store only 1 bit of data per cell. Because of the high cost per gigabyte stored, and because higher-density SSDs are growing increasingly reliable, single-level cell SSDs are falling out of favor for many applications.
- **Multilevel cell SSDs.** These SSDs store 2 bits of data per cell. MLC SSDs offer enterprise users a balance of write performance and endurance for a wide range of cost-sensitive, write-centric, high-density applications, including "always on" apps.
- **Triple-level cell SSDs.** TLC SSDs store 3 bits of data per cell. This technology provides enterprise datacenters with significant storage density as well as a blend of enterprise write performance and endurance. They offer a sound price-to-endurance ratio for medium-performance, mixed and read-centric workloads.
- **Quad-level cell SSDs.** These next-generation SSDs provide an extremely high density of 4 bits per cell. QLC SSDs are cost effective because they offer a lower dollar per gigabyte compared with other SSDs with the trade-off of lower write performance and endurance. QLC SSDs are best used as low-cost storage for read-centric applications, which represent some of the faster-growing enterprise use cases such as AI, machine learning, deep learning, real-time analytics, big data, object stores, and media streaming.

While SLC and MLC were once the SSD technologies of choice for many enterprise applications, IDC expects the market to continue to evolve and move to an increasing number of TLC and QLC SSDs (see Figure 2). Significant volumes of TLC-based SSDs shipped in 2018, sating the datacenter's appetite for increased capacity at potentially reduced total cost of ownership (TCO). IDC believes QLC SSDs will grow in popularity among organizations that need the densest storage available.

FIGURE 2

Worldwide Enterprise NAND Flash SSDs Total Capacity Shipped by Technology, 2007–2022



Source: IDC, 2018

MODERNIZING THE DATACENTER

Seemingly ubiquitous datacenter modernization and transformation initiatives have fueled SSD adoption throughout the enterprise. IT departments now strive to rearchitect datacenters to better serve both corporations and their individual users. They work to more rapidly deploy new apps, improve the customer experience, and mine corporate data for better business insight.

On the journey to modernize, quickly deploy, and scale infrastructure to meet the expanding storage requirements expected over the next few years, IT professionals are challenged to deliver more for less. They need to deal with an increasing number of users and the enormous amount of data that is created. They also need to find ways to get more out of each rack, overcome datacenter floor space limitations, and lower overall power and cooling consumption with a limited overall IT budget.

With increasing performance and improving efficiency as top priorities for many IT professionals, it may seem surprising that many datacenters still use legacy solutions to store the data used by these applications. What is behind their tolerance of inefficiencies, datacenter sprawl, and high power consumption? The answer is cost. HDDs have long enjoyed a reputation as the lowest cost-per-gigabyte option for data storage. But there are alternatives now, as SSD prices continue to drop, thanks in part to QLC-based SSDs. As new computing needs arise, the two forces of lower prices and QLC make SSDs an ideal choice for many applications.

SSD vendors continue to narrow the price divide between their wares and HDDs, effectively making them more cost effective and leveraged more broadly across the many enterprise datacenters. SSD vendors now manufacture lower-cost, higher-density SSDs to meet the needs of cutting-edge programs and initiatives. SSDs' ability to support those apps at a more reasonable purchase price will make solid state drives a more attractive option for many datacenters as will the reduction in TCO.

USING QLC SSDs IN THE DATACENTER

High-density QLC SSDs will complement existing storage solutions and help datacenters achieve a variety of benefits, such as:

- **Supporting data-hungry workloads.** SSDs can help datacenters meet the performance and storage demands of some of the fastest-growing workloads, such as real-time analytics, artificial intelligence, machine learning and deep learning data lakes, big data, business intelligence, and content delivery programs. By providing active archiving of massive data sets, these drives enable sophisticated applications to read hundreds of megabytes per second. They can also provide speedy access to vast numbers of users and provide for quick VM backup and restore.
- **Increasing storage capacity and reducing TCO.** Each generation of SSDs offers significantly more storage capacity than the generation before it. Today, for example, QLC SSDs offer a 33% higher storage density per bit than TLC SSDs. QLC SSDs are available in multiterabyte capacity points to store the vast amount of data being created.

  Increased storage density enables platform consolidation, which typically reduces TCO. Traditional datacenters rely on massive arrays of HDDs to store data and run applications. Deploying SSDs to store data for read-centric applications can help IT professionals reduce rack space and otherwise consolidate datacenters, reducing datacenter footprints and associated TCO — including HVAC costs. Often, when TCO is taken into account, datacenters find SSDs to be less expensive than HDDs.

  SSDs also help reduce TCO by dramatically improving power efficiency, typically measured in terms of idle power consumed, maximum power consumed, and number of operations performed per watt of energy used. HDDs consume significant amounts of power because they have to spin heavy platters and move read heads and write heads. Unlike HDDs, SSDs do not have parts that move as they read or write data, so they consume less energy and typically draw three times less power when used for read-centric workloads.
- **Reducing latency.** Latency (or access times — the amount of time it takes to return the data) is often significantly better on SSDs than HDDs. High-density QLC SSDs provide a read latency similar to that of lower-density SSDs but at a lower cost per gigabyte stored. Lower latency provides quicker access to data and ultimately provides a better user experience.

POTENTIAL OBSTACLES

No technology meets every computing need. No SSD is right for every workload. What challenges do datacenters need to consider before investing in SSDs?

SSD "wear out" (or endurance) still presents a challenge for datacenter managers depending on the storage workload. SSDs have a finite number of write cycles — the physical cells that power the SSDs wear out over time if applications write significant amounts of data to them. Wear out is gradual, with performance degrading as individual cells fail. While today's enterprise SSDs have many additional features to mitigate these concerns, IDC recommends SSDs, particularly QLC SSDs, for applications that are read centric (which would typically represent a read-to-write ratio of 70% or more) rather than write centric.

Performance is another concern. Enterprise users will find slight write performance differentials as they climb the SSD ladder. In general terms, increased storage density (in terms of bits per cell) comes at the expense of top write performance. Write performance slows slightly as more information is packed (written) into each cell. In general, QLC is slower than TLC, which is slower than MLC, which in turn is slower than SLC from a write performance perspective.

Initial investment will remain a barrier for some organizations. Datacenters can often recoup initial investment through reduced TCO, but for some, purchase price remains paramount. Though prices are dropping, SSDs typically cost more than HDDs and don't eliminate the cost-per-gigabyte advantage of HDDs. However, QLC SSDs are a more cost-effective solution than similarly configured SSDs built using MLC or TLC technology. IDC expects that customers could save about 15–20% when leveraging QLC SSDs compared with TLC drives.

CHOOSING THE RIGHT SSD

Evaluating SSDs for datacenter applications can be challenging given the myriad of options for IT professionals. The best-fit SSD for each data set will depend largely on storage requirements and having a solid understanding of the workload.

Workloads are datastreams generated by applications and can vary widely depending on how each application is accessing storage. As a result, IT professionals need to look deeper into each application than they might have in the past to effectively modernize their datacenter and provide best performance in an efficient, cost-effective manner. To do this successfully, IT professionals have to know the I/O stream, know what the read-to-write ratio is, understand the average block transfer sizes, and understand the very nature of the writes (are they random or sequential?). All of these things illustrate what it means to know the workload.

For example, content delivery, video on demand, and content streaming can have workloads that are very read intensive, with a clear majority of the I/O stream being read by massive, parallel requests for datastreams by users. In contrast, many indexing and database logging workloads have a heavy write workload where there is a 50:50 read-to-write mix because they are constantly writing new data to remain up to date.

IT professionals can take the proper steps to choose the right SSD only by understanding these workloads. Today, there is not only a wide assortment of enterprise SSDs targeting specific workloads but also a broad mix of SSD endurance levels to support those applications. These offerings range from high-endurance solutions to very read-intensive drives. Ultimately, the selection of an SSD's endurance rating will depend on its intended application. Yet there are several other factors to consider when evaluating an enterprise SSD for your datacenter:

- **Form factors:** 2.5in. drive, M.2, or add-in card (AIC)
- **Interface:** SAS, SATA, and NVMe
- **Performance metrics:** IOPS, throughput, latency, and quality of service (QoS)
- **NAND technology:** SLC, MLC, TLC, or QLC

When selecting an SSD, an organization should work with a vendor that provides a full portfolio of SSDs capable of delivering the right drive for the right workload. For example, Micron's SSD portfolio contains multiple models that are optimized to deliver the best performance for the particular workload. This helps avoid inefficiencies and/or overpaying for performance that is not necessary for the application.

For high-performance, read-intensive applications, IT professionals should consider an SSD that is designed and optimized for those target workloads to deliver the most cost-effective solution and avoid paying for extra endurance that a datacenter does not need. For example, the Micron 5210 ION SSD is the world's first QLC SATA solid state drive. Built on Micron 64-layer 3D eQLC, the Micron 5210 ION SSD has been designed to cost effectively manage the workloads of the following application and database types:

- Real-time analytics
- Artificial intelligence data lakes
- Machine learning and deep learning data lakes
- Business intelligence
- Decision support systems
- Active archives
- Large block and object stores
- vSAN performance capacity tiers
- Content delivery networks
- NoSQL databases
- User authentication

The Micron 5210 ION delivers value for traditional and nearline storage while narrowing the affordability gap between HDDs and flash. Storing 4 bits of data onto each cell, the Micron 5210 ION drives a much more approachable price point in terms of per-bit storage cost and provides an affordable way to move more applications to flash.

Performance-focused, read-centric workloads have historically relied on arrays of HDDs to deliver the capabilities that datacenters demand. The Micron 5210 enables that storage capacity with far fewer drives, therefore providing significant consolidation opportunities at the system, rack, and datacenter levels. This consolidation reduces datacenter footprints and improves power efficiency, dramatically reducing TCO.

QLC SSDs, such as the Micron 5210 ION, also help datacenters address some of the SSD challenges discussed previously in this white paper. For example, leveraging sophisticated SSD controllers with advanced error correction codes and wear leveling technologies helps address wear-out issues. Advanced architectures and digital signal processing features mitigate the performance lags that can sometimes arise with high-density drives. In sum, the introduction of QLC SSDs with high storage density will complement existing SSD solutions and help close the gap between legacy HDD-based solutions by addressing the storage needs of large-scale, read-centric applications that require fast and reliable data access in a cost-effective manner.

CONCLUSION

The enterprise storage market is inexorably moving toward SSDs for a wide range of datacenter applications and even all-flash datacenters. SSDs now available range from single-cell drives to QLCs that pack 4 bits of information onto each cell. Not every SSD is right for every workload, but QLC SSDs can be an alternative to HDDs, which have traditionally been used for cost-sensitive, read-intensive workloads where performance matters. CIOs, IT managers, datacenter architects, OEMs, and other IT professionals now have access to high-density QLC SSDs that will improve the performance of high-read applications while reducing datacenter costs, improving user satisfaction, and fueling business insight.

About IDC

International Data Corporation (IDC) is the premier global provider of market intelligence, advisory services, and events for the information technology, telecommunications and consumer technology markets. IDC helps IT professionals, business executives, and the investment community make fact-based decisions on technology purchases and business strategy. More than 1,100 IDC analysts provide global, regional, and local expertise on technology and industry opportunities and trends in over 110 countries worldwide. For 50 years, IDC has provided strategic insights to help our clients achieve their key business objectives. IDC is a subsidiary of IDG, the world's leading technology media, research, and events company.

Global Headquarters

5 Speen Street
Framingham, MA 01701
USA
508.872.8200
Twitter: @IDC
idc-community.com
www.idc.com