Solution Brief

Intel® QLC 3D NAND SSDs Data Center Storage
Cloud DVR

Modernize Cloud DVR Infrastructure with Intel® QLC 3D NAND SSDs

Reduce your cDVR TCO while deploying a storage infrastructure that can efficiently scale with rapidly evolving customer needs.

With the popularity of cDVR, consumers are demanding near-unlimited capacity. Compared to other technologies, Intel® QLC 3D NAND SSDs are well-suited for cDVR growth and scalability needs.

The cloud digital video recorder (cDVR) market is expanding rapidly. This growth is driven by consumer demand for more content and convenience from cable and telecom service providers. Faced with an overwhelming array of content choices across hundreds of channels and streaming services, subscribers are increasingly willing to pay for cDVR to control what they watch, when they want to, on multiple devices both inside and outside their homes.

cDVR is appealing because it allows subscribers to save TV shows, movies, on-air programs, and sports events without the constraints of traditional physical DVRs. Such set-top DVR boxes have limited capacity, often requiring that viewers delete old shows. Maintenance and updates for set-top DVR devices are expensive for service providers, with an average $150 per truck roll in the North America region.[1] These devices are also closed systems, inaccessible to lucrative advertising models.

It's for these reasons that cDVR is attractive to service providers, who are constantly innovating to add new features that retain current users and draw new ones. Recent examples of these innovative features include catch-up TV (view after the program has aired), restart TV (record from the start after a show is in progress), pause-live TV (pause and resume live programming), and follow-me TV (watch a program on one device then continue on another device).

While cDVR brings new revenue opportunities and helps overcome the limitations of set-top DVRs, it presents fresh challenges to service providers. The increased usage of cDVR creates a high-capacity, high-bandwidth storage workload on edge servers with accompanying demands on space, power, and cooling. Large amounts of data at the edge must be efficiently stored and made available to consumers at required service levels.

Support cDVR growth reliably and affordably

The majority of legacy cDVR storage solutions are all-hard-disk-drive (HDD) arrays organized into drives dedicated for active use (record and playback content) and archive use (store content that has not been accessed for a certain time). These storage solutions are limited in their ability to scale for future premium viewing features and storage needs as cDVR demand continues to grow. They also hamper operational cost efficiencies with cDVR growth because HDDs require a significant footprint at their edge locations, increasing space, power, cooling, and replacement costs. These factors can lead to a high total cost of ownership (TCO).

The more practical option for cDVR storage needs is to replace inefficient HDD arrays with efficient, scalable Intel 3D NAND SSDs.

Making the right choice for current and future needs

When addressing their growing storage needs, cDVR providers can stay the course and continue to add HDD arrays to their sites or, like most, make the move to all-NAND arrays. In doing so, they can decide whether to deploy triple-level cell (TLC) solid state drives (SSDs) or quad-level cell (QLC) SSDs. This section will look at two scenarios, specifically comparing:

- All-SATA TLC to all-NVMe QLC storage architectures
- All-NVMe TLC to all-NVMe QLC storage architectures

Partnering with a lead cDVR solution provider, Intel modeled a prototypical cDVR site. The site services 200,000 subscribers with a peak recording concurrency of 100 percent, peak playback concurrency of 30 percent, recording bitrate of 16 Mbps, and playback bitrate of 5.5 Mbps. For this prototypical site, subscribers have access to thousands of channels, 20 percent of their storage need is archival, they need two hours per day of active content storage, and that content is retained for 4 days before processing to archival storage. These requirements drive a total cDVR site need for 43.3TB of capacity and throughput of 3.44 Tbps. Because both capacity and input/output (I/O) needs must be met, storage requirements are determined by the higher number of drives required for capacity or I/O.

Evaluating all-SATA TLC storage vs. all-NVMe QLC NAND SSD storage

For this scenario, Intel compared servers utilizing SATA-based 7.68GB Intel® SSD D3-S4511 SSDs to servers with NVMe-based30.72TB Intel SSD D5-P5316 drives that are built on QLC NAND. The pre-populated server cost of $10,000, server material cost of $50, 1,100-W power requirement, and failure rate of 0.40 percent were assumed equal for the systems.[3]

With lower performance than NVMe SSDs, the determining factor for SATA SSD drive count was throughput. Conversely, with much higher performance than SATA SSDs, the drive count determinant for QLC NAND SSDs was the combined capacity requirements of active and archive drives. Table 1 summarizes the findings. The overwhelming capital expense (CapEx) and operational expense (OpEx) savings of NVMe SSDs lead to a total TCO advantage of 36 percent.

Table 1. SATA TLC NAND SSD versus NVMe QLC NAND SSD TCO comparison[2]

		Intel SSD D3-S4511 SSD (7.68TB)	Intel SSD D5-P5316 (30.72TB)
CapEx (cost of drives, servers, and other materials)			
Total CapEx		**$9,152,391**	**$6,507,971**
OpEx			
	Rack units (RU)/rack	33	33
	Total racks	19	5
	Rack burden	$2,500	$2,500
Five-year rack burden[4]		$237,500	$62,500
	Power cost	$0.12	$0.12
	Cooling cost	$0.12	$0.12
	Drive power (W)	16	25
	Total drive power (kW)	78	30
	System power (W)	1,100	1,100
	Total system power (kW)	223	52
Five-year power and cooling		$1,582,844	$431,571
	Annual failure rate	0.40%	0.40%
	Failures/year	19	5
	Replacement cost/failure	$0	$0
	Replacement labor/failure	$150	$150
Five-year failure cost		$14,597	$3,649
Total five-year OpEx		**$1,834,941**	**$497,720**
TCO		**$10,987,332**	**$7,005,692**

TCO isn't the only story here. The QLC NAND SSD solution also provides for more efficient scaling. The SATA SSD solution consumes 19 total racks, while QLC NAND SSDs consume only five, saving a massive amount of floor space and allowing for efficient capacity scaling as users and content are added. Even with far fewer drives, the total I/O capacity of QLC SSDs (9.73 Tbps) also enables efficient I/O scaling to support more users and more features.[2]

Evaluating all-NVMe TLC storage vs. all-NVMe QLC NAND SSD storage

In this scenario, an all-NVMe TLC NAND SSD approach using 15.36TB Micron 9300 drives was compared to an all-NVMe QLC NAND SSD approach using 30.72TB Intel SSD D5-P5316 drives. The pre-populated server cost of $10,000, server material cost of $50, 1,100-W power requirement, and failure rate of 0.40 percent were assumed equal for the systems.5

Higher capacities enabled by QLC NAND SSDs deliver significant OpEx savings. Requiring only five racks to deliver the targeted total capacity compared to nine racks for the TLC NAND SSDs, QLC NAND SSDs enable reductions in costs for power, cooling, racks, and drive replacement. These reductions lead to a TCO savings of 32 percent, as shown in Table 2.

Table 2. NVMe TLC NAND versus QLC NAND SSD TCO comparison[5]

		Micron 9300 TLC NAND SSDs (15.36TB)	Intel SSD D5-P5316 QLC 3D NAND (30.72TB)
CapEx (cost of drives, servers, and other materials)			
Total CapEx		**$9,422,586**	**$6,507,971**
OpEx			
	RU/rack	33	33
	Total racks	9	5
	Rack burden	$2,500	$2,500
Five-year burden[4]		$112,500	$62,500
	Power cost	$0.12	$0.12
	Cooling cost	$0.12	$0.12
	Drive power (W)	18	25
	Total drive power (kW)	44	30
	System power (W)	1,100	1,100
	Total system power (kW)	103	52
Five-year power and cooling		$773,634	$431,571
	Annual failure rate	0.40%	0.40%
	Failures/year	10	5
	Replacement cost/failure	$0	$0
	Replacement labor/failure	$150	$150
Five-year failure cost		$7,298	$3,649
Total five-year OpEx		**$893,432**	**$497,720**
TCO		**$10,316,018**	**$7,005,692**

QLC NAND is a better choice for reasons beyond TCO savings. TLC NAND will not keep pace with the drive capacities of QLC 3D NAND, and it therefore is not as well suited to scaling with growing storage needs. Intel 3D NAND technology is built to scale beyond four bits per cell, with a roadmap designed to meet the long-term needs of the cDVR market.

In addition, it is worth reiterating that the savings for both comparisons are for only one site. As cDVR service providers look to realize savings at scale through deployment of modern storage, the QLC NAND advantage becomes even more clear.

Table 3. Comparison of TCO for TLC NAND SSDs and QLC NAND SSDs as the number of sites scales

Five-year TCO	SATA TLC SSD-based storage	NVMe TLC NAND–based storage	NVMe QLC NAND–based storage
1 site	$ 10,987,332	$ 10,316,018	$ 7,005,692
50 sites	$ 549,366,600	$ 515,800,900	$ 350,284,600
100 sites	$ 1,098,733,200	$ 1,031,601,800	$ 700,569,200
200 sites	$ 2,197,466,400	$ 2,063,203,600	$ 1,401,138,400

Ample endurance for cDVR workloads

Intel QLC NAND SSDs provide class-leading endurance,[6] and when combined with their large capacities, they can deliver more than sufficient endurance for cDVR workloads.

The endurance viability of a cDVR drive can be determined by comparing the *required* total bytes written (TBW, measured as terabytes written) to the *available* TBW of the storage system. Required writes is a combination of the writes to the active cDVR tier (write demand from peak recording for a private copy model) and writes to the archive tier (mostly off-peak-hour writes for aged content). In one prototypical scenario, this might total 7,272 TB/day, or 2,654,280 TB/year.

Available TBW is determined by multiplying the number of drives in the storage system, the drive writes per day (DWPD) rating for all drives, the drive capacity, and the number of days in five years. In the same prototypical scenario, using Intel SSD D5-P5316 drives, the equation is as follows:

1,216 drives × 0.41 DWPD × 30.72TB/drive capacity × 365 days/year × 5 years = 27,951,268 TBW available over five years

Dividing "TBW available" (27,951,268) by terabytes required per year (2,654,280) yields 10.5 years. This demonstrates that Intel QLC NAND SSDs have the endurance to last more than twice the specified drive life for this prototypical cDVR workload.

Intel QLC 3D NAND is ready for your cDVR services

QLC NAND technology is not as new as one might think. Intel is shipping its third generation of QLC 3D NAND SSDs, and since the first generation, these SSDs have been delivering the same JEDEC standard quality and reliability as TLC NAND technology. Their quality and reliability far exceed that of HDDs, and they offer more than enough endurance for cDVR workloads.

By delivering both TCO and scalability benefits that exceed that of SATA and NVMe-based TLC NAND SSD–based storage servers, mature QLC NAND technology is the clear choice for cDVR service providers.

Learn more

About Intel® 3D NAND SSDs

Intel® SSD D5-P5316 product brief

"QLC NAND Technology Is Ready for Mainstream Use in the Data Center"

"QLC NAND SSDs Are Optimal for Modern Workloads"

[1] MediaKind. "Cloud DVR – what have we learned from the last 6-8 years?" mediakind.com/blog/cloud-dvr-what-have-we-learned-from-the-last-6-8-years/.

[2] Cost per GB of the Intel SSDs is based on Intel Recommended Customer Price (RCP) as of September 27, 2021. Actual price can vary and may not reflect the pricing used in the TCO model.

[3] Intel SSD actual annualized failure rate (AFR). The Intel SSD D3-S4511 is based on internal Intel TLC SSD and QLC SSD data. The Intel SSD D5-P5316 is projected actual AFR based on internal Intel TLC SSD and QLC SSD data.

[4] Based on Intel market research as of May 2021.

[5] The cost per GB of the Micron 9300 SSD was based on Newegg pricing (as of September 27, 2021), while the cost per GB of the Intel SSD is based on Intel Recommended Customer Price (RCP) as of September 27, 2021. Actual price can vary and may not reflect the pricing used in the TCO model.

[6] Class-leading endurance. Comparing a 7.68 TB Intel SSD D5-P4320 (2,803 TBW) to a 7.68 TB Micron 5210 ION SSD (700 TBW) based on micron.com/products/ssd/product-lines/5210.

Your costs and results may vary.

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