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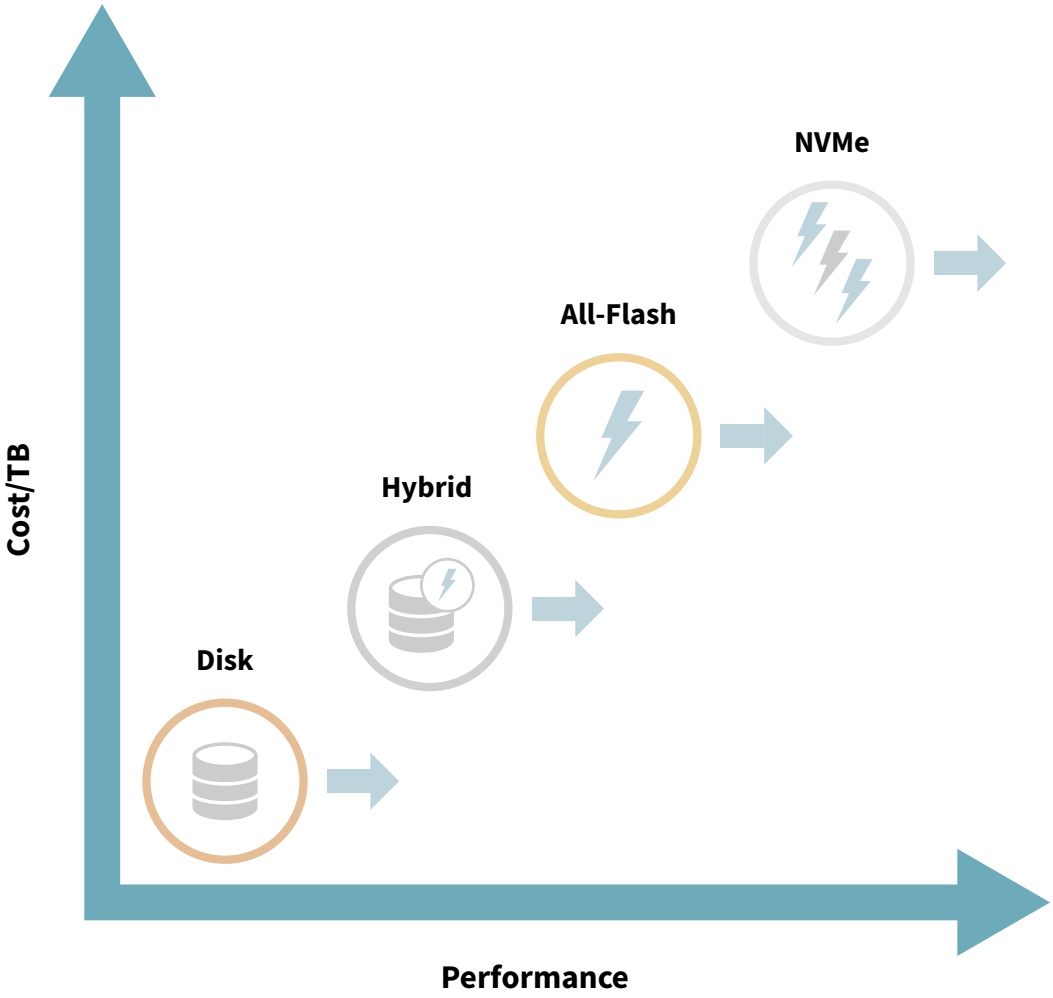

Storage in the Era of NVMe

An Evaluation Guide for IT Teams

FREEFORM DYNAMICS, 2020

It's time to ride the storage express

How and where you use solid-state storage is the new differentiator for enterprise storage

As an IT professional dealing with storage, you will already have a good idea of how the demands of an application and its associated data will shape the type of storage required. For instance, cold data might fit well on cloud storage, an archive platform or tape. Similarly, disk arrays remain a strong option for secondary storage or even for primary applications where capacity and cost matter more than performance.

The game-changer though is solid-state storage such as Flash and NVMe (Non-Volatile Memory express), thanks to its high performance and its non-mechanical nature. That lack of moving parts also brings a range of other benefits including lower power consumption, smaller size and greater density, and of course it produces no noise or vibration. Expensive at first, it was initially added to disk arrays as a performance-enhancing layer to create hybrid arrays, an approach that is still cost-effective today in many scenarios. Technology evolution and cost reductions then brought us the enterprise-grade All-Flash Arrays (AFAs) that have become the "new normal" for high-performance primary storage.

Now the rapid maturation of NVMe and NVMe-oF (NVMe over Fabrics), and their potential as **end-to-end NVMe**, means that everything is changing again. Fortunately, if you're familiar with the concept of tiering from the disk world then it is similar – except that the type of disk involved no longer matters. Instead, the key performance differentiator is what type of solid-state storage is used and how it is implemented:

Hybrid Disk	This combination of disk storage with performance-boosting Flash or NVMe still has its uses, for example where low cost and high capacity are paramount, where physical space and electrical power are not at a premium, and where the slower read speed of disk can be tolerated or worked around.
All-Flash Arrays	The new mainstream option for general-purpose use, All-Flash Arrays are not just fast, but consistently fast, serving multiple applications simultaneously with relative ease. They have all the advanced storage management features enterprises have come to expect, plus capabilities that disk arrays cannot easily support such as in-line data reduction.
NVMe Arrays	Its leaner software and the use of solid-state storage on the fast PCIe bus allows NVMe to deliver super-fast parallel data access direct to the processor (or shared via arrays and a PCIe switch). Although it is more expensive than general-purpose Flash, this makes it ideal for workloads needing the highest performance and simultaneous access to data.
NVMe over Fabric	NVMe-oF can extend the NVMe protocol over a range of low-latency links (a minimum of 25Gbps is preferable) such as InfiniBand, Fibre Channel and Ethernet. It both offloads storage processing from the server CPU for efficiency, and allows NVMe storage to be accessed remotely, giving systems fast access to very large volumes of data.

We will see more combinations and versions appear, especially as new classes of memory are developed and brought to market. As a very rough guide to performance, where a Flash SSD might be at least five times faster than a disk drive, an NVMe SSD could be five times faster than Flash. So where the original hybrid arrays added Flash SSDs to disk for improved performance, the next-generation adds NVMe SSDs to All-Flash or disk arrays. NVMe can also incorporate different media types. Most NVMe modules today use Flash media, but there are already examples based on faster and even more expensive Storage Class Memory (SCM), such as 3D XPoint from Intel and Micron, and Samsung's Z-NAND.

NVMe: 6 key things to look or plan for

Most storage in use today, even SSDs and the general-purpose All-Flash Array, relies on at least some technology that was developed with spinning disks in mind. Under the covers, NVMe is very different and it represents a break with the past.

At a high-level, NVMe simply extends the Flash continuum upwards. After all, it is still based on solid-state storage - that is, Flash and successors like storage-class memory.

Look closer though, and it has the potential to change almost everything, especially once the data path is end-to-end NVMe. Its support for massive parallelism and multiple threads provides better resource utilization, and potentially moves the bottleneck back from storage to the server layer. Similarly, NVMe-oF allows larger data sets and long-distance clustering, while retaining key features such as QoS management and defined data locations for compliance.

Performance

NVMe connects via the processor's fast PCIe bus, not a legacy serial connection designed for disk drives. This removes layers of latency-inducing software left over from the disk days and eliminates the serial bottleneck of interfaces such as SAS/SATA. This allows NVMe to provide very fast parallel data access.

Capacity and scalability

NVMe can be installed as a PCIe card or module in a server or PC, within an All-Flash or hybrid disk array to enhance its performance, or as scalable all-NVMe storage arrays. Servers and arrays may in turn be connected together via NVMe-oF for networked storage. The key factor is that it is all NVMe from end-to-end.

Availability and resilience

Flash may well be non-volatile in normal use, but any storage device can fail so NVMe still needs backup and protection. This may include employing flexible RAID, or asynchronous replication to a second site via NVMe-oF. Look too for systems that provide fast hardware recovery via hot-swappable NVMe modules.

Intelligent data management

Data reduction with minimal performance impact is essential to minimize NVMe capacity cost. So too is a high degree of RAID level flexibility to support rapid data growth and make more efficient use of expensive capacity. Similarly, multi-node NVMe-oF systems must intelligently balance I/O operations across the nodes.

Skills and operation

We need to break with the past at some point, but preferably via a smooth migration, not by adding a new storage silo. Ultimately you will want to optimize the whole storage stack to fully exploit end-to-end NVMe, but in the meantime, add NVMe as part of a wider storage infrastructure with common management skills and software.

Future-proofing

Preparing for your future business needs is essential. It is likely that there will be more digital workstreams, shared with more partners, or greater demand for parallel data access. Planning for NVMe and NVMe-oF is part of getting ready for uncertainty, because you don't want to be constrained by your storage infrastructure.

Understanding the array landscape

Nine key criteria that matter

Turning specifically to storage arrays, making effective investment decisions today means matching the essential business imperatives of growth, risk mitigation and cost reduction to all the available options, even as you plan to add the latest NVMe technologies. The strengths and opportunity matrix below offers some guidance on what matters here (key: more stars is better).

		Disk	Hybrid Disk	All-Flash Arrays	NVMe Arrays
Characteristics	Practical scalability	★★	★★★	★★★	★★★★
	Minimize space/heat/power	★	★★	★★★	★★★
	Low cost of capacity	★★★★	★★★	★★	★
Performance	Parallel access to data	★	★	★★	★★★★
	High IOPs & low latency	★	★★	★★★	★★★★
	Low cost of performance	★	★★	★★★★	★★★
Operational	Workload versatility	★	★★★	★★★	★★
	Current adoption trend	★	★★★	★★★	★★
	Low cost of operation	★	★★	★★★★	★★★★

For guidance purposes only

Locate your application's practical and budgetary requirements on the matrix, then use our rankings to help guide your thoughts and plans. For instance, if high capacity at a low cost is key, then disk may still be the best option – unless the array must also be versatile enough to handle for example workload consolidation. In the latter case, hybrid disk may be a better option. Similarly, if you require massive scalability and very good performance, with cost as no barrier, then NVMe-oF could be appropriate, while All-Flash Arrays are a strong contender for the best overall cost balance, covering capacity, performance and operation.

Note that we have also begun to see intermediate 'next generation' hybrid NVMe arrays, where a relatively small proportion of NVMe is added to older disk or Flash-based array technology.

In conclusion

We hope that the above helps you crystalize your understanding of where All-Flash, NVMe and NVMe-oF fit in the ever-evolving continuum that is enterprise storage.

In particular, it shows the importance of understanding end-to-end NVMe and its potential: NVMe adoption is already growing rapidly, and the breadth of its applicability can only grow as the price differential between it and other technologies continues to fall.

For more information on NVMe and NVMe-oF, please read our introductory guide 'NVMe: a fresh start for storage'.

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