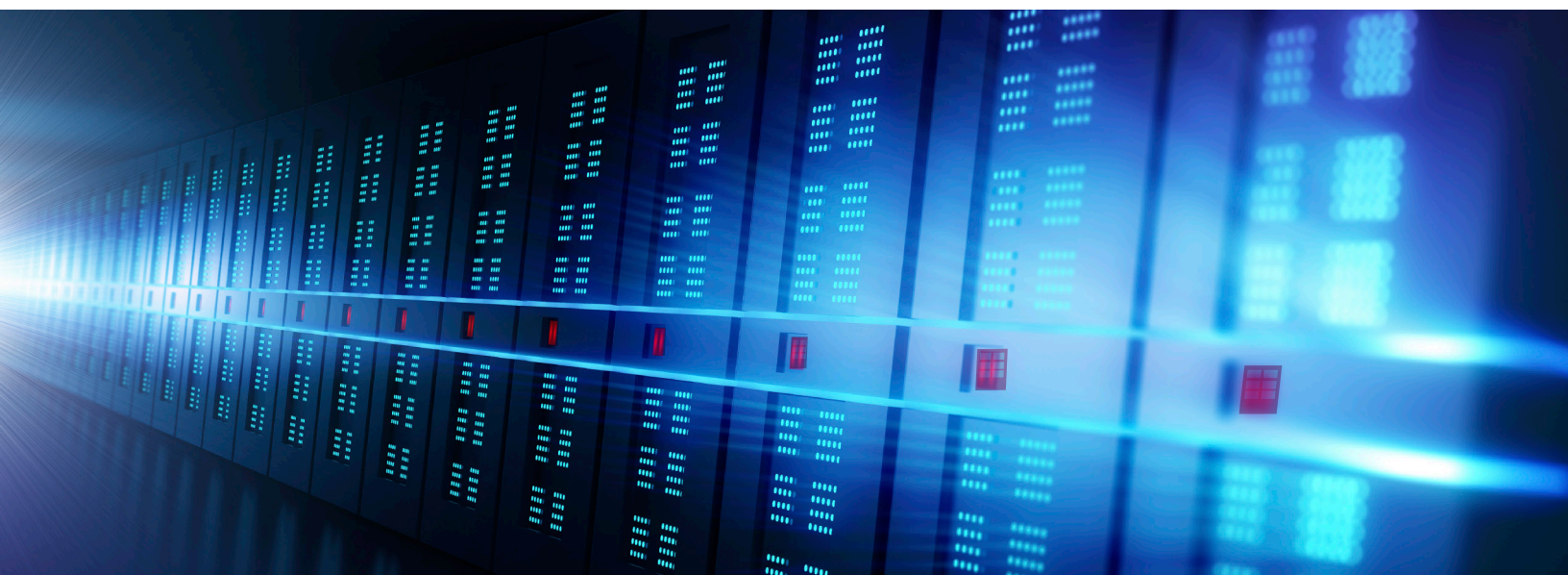


Flash Storage Hits Its Stride in the Data Center

Enterprises are using hybrid-flash and all-flash storage arrays to speed application performance and — surprisingly — to lower their total cost of storage ownership.



For years solid-state flash storage has led something of a double life. Flash drives and memory cards have become familiar and ubiquitous components in the consumer market, replacing spinning-hard-disk drives (HDDs) in some laptop PCs, supporting the proliferation of powerful tablets and smartphones and capturing thousands of photos and videos taken by digital cameras.

At the same time, flash solid-state drives (SSDs) have been the Ferraris of data center storage. Although SSDs deliver incredibly fast performance, reliability and other benefits compared to their mechanical HDD cousins, premium pricing and other characteristics have restricted use of flash SSDs to high-speed caching and other narrow storage roles.

No more.

Today advances in flash storage technology, rapid reductions in SSD costs and clever techniques for configuring and optimizing hybrid and all-flash storage arrays have collectively transformed the calculus of data center storage. More and more companies have already replaced HDD-only arrays with flash-enabled storage systems, and this trend will only accelerate as the performance and TCO benefits of flash arrays become more widely understood.

In 2014 the worldwide flash array market already totaled \$11.3 billion, according to market research firm IDC. Hybrid flash arrays, which contain HDD as well as SSD flash components, constituted

\$10.0 billion of that total. All-flash arrays accounted for the remaining \$1.3 billion. “The impact that flash-based arrays will have on the datacenter is undeniable as more flash-based platforms are delivering enterprise-class data services,” IDC wrote when reporting these market numbers.¹

The emergence of flash-based arrays as general-purpose, high-performance data center storage platforms comes at an opportune time. Many traditional enterprise applications—especially those with intensive and unpredictable I/O demands—have become hobbled by HDD latency limitations as data volumes and user numbers skyrocket. At the same time, new computing models and applications have further strained conventional HDD capabilities. Everything from cloud computing and desktop virtualization to big data and social networking has escalated the need for large-volume, high-performance storage solutions.

Storage-array vendor Dell produces a range of flash-enabled enterprise storage solutions that contain SSDs from industry leaders such as SanDisk, a cutting-edge flash memory supplier. These powerful and economical solutions illustrate how far hybrid and all-flash arrays have already come. They also provide a glimpse of a future in which flash-based arrays will capture an ever-increasing percentage of the data center storage market, supercharging application performance in the process.

“As the economies of scale grow and the flash value proposition becomes more compelling, it’s reasonable to assume that flash will overtake HDDs within the data center in the same way it has in computers, cell phones and MP3 players,” says Manuel Martull, director of marketing at SanDisk. “We’re talking about the flash-transformed data center.”

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— Manuel Martull
director of marketing
SanDisk

DATA
CENTER

The path from niche to mainstream storage

Introduced 30 years ago, solid-state flash memory for years was relegated to niche implementations, due to cost, resilience and other early limitations. Even so, flash’s core characteristics suggested bigger roles in the future. The compact and high-density storage medium contains no moving parts, which eliminates mechanical malfunctions and also greatly reduces power and cooling demands. And, unlike HDDs, with their spinning disks and their read/write heads that must mechanically move to different data locations, SSD flash drives can instantly access any needed data.

Still, it wasn’t until well into its third decade that flash memory started to make significant headway in the data center. Evolving flash technologies and designs, combined with volume manufacturing advances, began to make flash a viable contender in enterprise storage. Even then, the most common data center use for flash early on was as cache memory for just the small portion of data requiring near-instant, submillisecond accessibility. And flash’s relatively high price wasn’t the only factor holding it back from broader storage adoption.

Unlike the magnetic media used by hard disks, flash uses silicon or electronic NAND-gate media, which requires that stored data must be erased before new data can be written. The performance of flash storage can start to drop after thousands of these “program-erase cycles,” and the “write endurance” of any flash SSD is typically expressed in how many full drive writes (or fills) per day the drive can accommodate.

For years flash memory vendors produced mostly single-layer cell (SLC) write-intensive drives, which, although relatively expensive, could handle 10 to 30 drive fills per day. More recently SanDisk and other flash memory manufacturers have developed multilayer cell (MLC) read-intensive flash drives that are much more economical but have lower write endurance and write performance than SLC drives. As such, a workload that involves a high amount of write I/O each day might perform best with an SLC flash SSD, whereas one with less demanding I/O levels could perform sufficiently with a less expensive MLC option.

Flash taking a bite out of the high-performance HDD market

Dell Storage has developed hybrid and all-flash array solutions that intermix the different types of flash in a manner that delivers optimal endurance and performance while keeping costs in line. For some arrays, Dell uses high-endurance write-intensive flash for I/O-intensive “hot” data and then transfers “warm” data as it accumulates to a less expensive MLC flash storage tier. By

By shifting some or all of this workload to a small number of SSDs, we can significantly reduce hardware costs, rack space, support fees and potentially software fees."

— John Shirley
director of product management
Dell



intelligently matching different types of flash to different data needs, the flash SSDs in Dell's arrays have an expected endurance of more than five years. In fact, Dell offers a Limited Hardware Warranty² for its customers with active support agreements, including SSDs.

If the drive wears out, it will be replaced. These same Dell arrays also include a "gas gauge" meter that tracks SSD life expectancy and notifies users when a drive may need replacement. "From a system reliability perspective, SSDs have proven to be more reliable than hard disk drives," says John Shirley, director of product management for Dell Storage.

Beyond their solid reliability, flash-enabled arrays compare quite favorably to HDD arrays in their total cost of ownership (TCO) when an evaluation looks beyond a simple cost-per-gigabyte capacity comparison to consider other factors such as the cost-per-I/O ratio. Other flash characteristics, ranging from the smaller footprint to lower energy demands, also play in their favor in TCO evaluations.

Looking at a typical customer environment quickly reveals that flash can lower overall TCO costs, according to Shirley. "A typical workload in the midenterprise storage market could consist of 20K to 40K IOPS [input/output operations per second]," he says. "It would take hundreds of 15K-rpm drives to support this level of I/O activity."

Furthermore, these high-end 15K-rpm HDDs would typically involve data delivery latencies of 5 to 10 milliseconds (ms), Shirley notes. "By shifting some or all of this workload to a small number of SSDs," he says, "we can significantly reduce hardware costs, rack space, support fees and potentially software fees. We have seen many environments similar to this where using flash-optimized arrays from Dell has dramatically reduced the cost of the solution for the customer while simultaneously improving application performance and system reliability."

Indeed, the economics of flash-based arrays has become particularly compelling vis-à-vis arrays containing high-performance 15K- and 10K-rpm HDDs. For example, one Dell product—the Dell Storage SC4020 all-flash array—not only provides up to a 4x reduction in query time and a 50 percent reduction in rack space compared to similarly provisioned 15K-rpm HDD solutions for data warehousing applications but it does so at a 31 percent lower cost, according to the company.³

"The 10K to 15K drives make up a huge part of the IT storage industry," says Shirley, "and we're seeing our flash-optimized arrays take a huge bite out of that market."

Escalating demand for high-speed, reliable, scalable storage

With the cost-per-I/O and TCO economics of hybrid and all-flash arrays becoming competitive with—and often superior to—the economics of HDD arrays, more enterprises are discovering how solid-state storage can accelerate many of their most critical and demanding applications. Virtually any workload will run faster in writing and reading data to and from flash drives, but data-intensive and high-transaction workloads have historically benefited the most from flash-based turbocharging.



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Combining performance *and* price advantages

Dell has been among the most innovative and aggressive vendors when it comes to delivering hybrid and all-flash arrays to the data center. The company sells two array families that can each deliver enterprise-class hybrid and all-flash solutions. The Dell Storage SC Series provides an intelligent, self-optimizing platform with enterprise-grade features and capacity for SAN and NAS environments. The Dell EqualLogic PS Series offers a peer-to-peer scale-out architecture, which can support multiple arrays in a storage pool, each with its own controller, cache and networks. With each new PS Series array, users gain performance, capacity and bandwidth.

Dell Storage SC Series

The SC Series portfolio currently features two controller options: the Dell Compellent SC8000 and the Dell Storage SC4020. Integrating SSDs from market leaders such as SanDisk, both models of the SC Series enable companies to deploy single- or multi-tier all-flash solutions as well as hybrid arrays incorporating HDDs for cold data storage. Dell's Data Progression technology provides intelligent automation based on real-world data usage, enabling data centers to tier storage automatically. Hot, warm or cold data is dynamically placed on the most appropriate—and most economical—set of drives.

When multiple types of SSDs are deployed in Dell's "flash-optimized" configuration, all incoming writes are sent to WI (write-intensive) SSDs to ensure the highest write speeds. Data is then migrated to RI (read-intensive) SSDs, offering equivalent read performance at a lower cost.

"With multi-tier flash, we provide a solution that performs as if it were composed entirely of the more expensive write-optimized flash drives—but at a much more affordable price point," says Dell outbound marketing manager Holmes. "In addition, because our WI 'write layer' frees your RI drives from primary writes, they'll last longer than drives in competing all-RI arrays."

The Dell Compellent SC8000 scales to 960 drives and over 3PB of raw capacity per array, using optional expansion enclosures to house a wide range of supported 2.5- and 3.5-inch drives. Multiple arrays can be grouped into larger "federated" configurations under unified management. Nondisruptive volume movement between arrays and proactive data placement recommendations are provided by the SC Series' Live Volume and Volume Advisor features. Thin provisioning, space-efficient snapshots and other enterprise features are provided for both hybrid and all-flash solutions.

The Dell Storage SC4020 model provides capabilities similar to the SC8000's in a compact, economical format designed for SMB and other midsize deployments. The SC4020's all-in-one form factor includes dual controllers plus 24 drive bays in a single two rack-unit (2U) chassis—but it can also scale to over 400TB of raw capacity, using the same expansion enclosures as the SC8000.



The SC4020 is designed to be used either for standalone SANs or as a remote office/branch office solution in distributed environments with the SC8000.

In a September 2014 study that evaluated the total cost of ownership of the SC4020, the Enterprise Strategy Group consultancy found that the Dell product offered significantly better TCO than solutions from two competitive vendors. ESG's model and assumptions involved tracking the costs of small- and large-array configurations over an eight-year projected time span. In both instances, the modeled company added flash SSDs to its storage arrays after several years to deal with growth and the increasing need for higher storage performance and capacity.

ESG's model compared the expected costs of all three vendors' arrays across several categories: hardware, software/licenses, support, power and cooling, management and service. The results: In the small storage solution, the Dell SC4020 cost 43 percent and 47 percent less, respectively, than the two competitive solutions evaluated. For the large storage solution, the Dell platform cost 54 percent and 51 percent less, respectively, than the two alternatives.⁴

The fast-storage demands of online transaction processing and other applications are no longer the only catalyst driving flash array adoption. Today's IT world is far different from what it was even a few years ago. Data centers within enterprises as well as at cloud service provider facilities routinely store and serve up many terabytes of data on a daily basis. Companies mine these massive volumes with big data analytics programs to discern meaningful trends, opportunities and threats.

Meanwhile, data centers—as well as the servers, storage and networking components they contain—have become virtualized and “software-defined.” New business cases incorporating everything from social networking to video on demand have materialized. And the pace of business and decision-making has accelerated, with more and more people needing to access more information in near real time than ever.

HDD arrays that could adequately address past business demands are often no match for this brave new world of computing, communications and storage. Consider how flash arrays can better address many of today's workload demands:

- **BIG DATA ANALYTICS** Many organizations are drowning in the data being generated by hundreds of millions of PCs and billions of smartphones and tablets. Adding rapidly to this data deluge is the “Internet of Things,” which will soon encompass hundreds of billions of smart devices, ranging from embedded sensors to connected cars. To convert this data from a burden to a benefit—and to do so in near real time—organizations need sophisticated big data analytics capabilities. They can use these capabilities to comb through massive data sets to gain business-critical insights and knowledge. Flash storage delivers the performance required to make big data analytics as speedy as possible.
- **E-COMMERCE** With the popularity of online shopping on an upward spiral, e-commerce vendors must do all they can to make the shopping experience as enjoyable and efficient as possible. Even simple annoyances such as delays in calling up product specifications or filling in and checking out a shopping cart order can drive consumers from an e-commerce site. Flash-enabled arrays can store the massive amounts of product data common to many e-commerce sites and can serve it up instantaneously.
- **VIRTUAL DESKTOP INFRASTRUCTURE (VDI)** VDI moves the operating system, applications and settings of PCs and other client devices to data center servers for centralized management and deployment. Users can then access their applications and data from virtually any location and with any device. With VDI servers and storage arrays sometimes supporting thousands of virtual desktops, they must deal with fluctuating and unpredictable I/O demands. Those demands include the “boot storms”

Dell Storage PS Series



For its part, the scale-out iSCSI Dell Storage PS Series also offers flash-optimized arrays in both hybrid and all-flash configurations that use SSDs from cutting-edge suppliers such as SanDisk. By delivering industry-leading TCO and ease of use, the EqualLogic PS Series product family has helped Dell capture the top iSCSI vendor title for 26 out of the most recent 28 quarters.⁵

The enterprise-focused EqualLogic PS6210 can deliver up to 1.2M IOPS when configured with eight flash-enabled arrays⁶. The PS4210 Series is priced and sized to fit the needs of smaller data centers and remote offices, offering high IOPS for demanding applications in a hybrid configuration. PS Series hybrid arrays can auto-tier data and store frequently accessed data on flash SSDs for rapid response and less I/O-intensive “cool” data on lower-cost HDDs. The EqualLogic PS Series arrays can also automatically load-balance data across a network of peer-to-peer arrays, helping to ensure optimal performance and data accessibility.

that can occur when countless users log on at the start of a workday. Flash storage can minimize the impact of these fluctuations and spikes, helping ensure that the user experience is comparable to running their applications on a local machine.

- **MEDIA AND ENTERTAINMENT** Flash-enabled arrays can facilitate the delivery of video and other streaming media as well as its production. Streaming media workloads involve large data sets and must ensure that images and audio flow smoothly and in high fidelity to end users. Producers who edit video, audio and multimedia content also require storage that doesn't act as a bottleneck in the production process.

Other applications that can benefit from flash-enabled storage arrays include everything from groupware to high-performance technical computing. Still, despite all of the performance, reliability and operational benefits that solid-state media delivers, flash drives can't tackle these and other application demands on their own. It's only when the drives are intelligently configured, managed and optimized in hybrid or all-flash storage arrays that the full promise of this solid-state media can be achieved.

Configuring flash arrays for any application demand

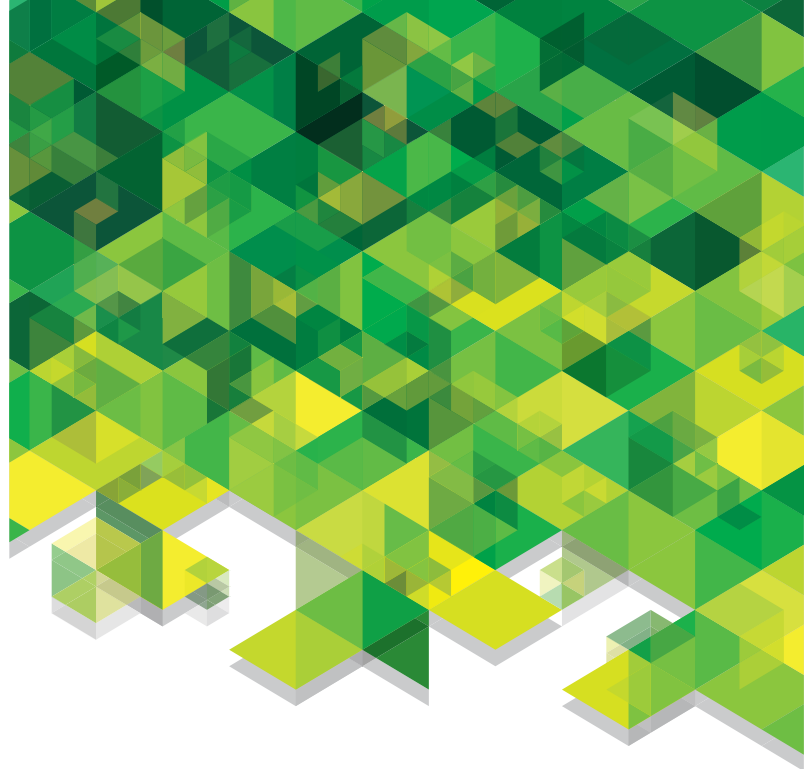
At a high level, flash-enabled storage arrays fall into two broad categories: hybrid arrays and all-flash arrays. As illustrated by IDC's market figures, hybrid arrays are the dominant form today, accounting for nearly 90 percent of the flash arrays that shipped in 2014.⁷ Hybrid arrays are attractive to some enterprises because they represent a less daunting jump than transitioning directly from HDD arrays to all-flash solutions. More important for most, however, is that hybrid configurations enable companies to deploy array platforms that utilize low-cost hard disks for the less demanding activities of the storage function.

\$11.3 billion

2014 worldwide flash array market total.

90%

are hybrid arrays.



In hybrid arrays, the spinning hard disks typically serve to store little-needed or archived "cold" data that users access only rarely. At the other end of the spectrum is the hot data that must be written and read nearly instantaneously. "For hybrid arrays, flash storage plays a mission-critical role for hot data, because flash serves as the read cache and write buffer," says SanDisk's Martull.

For many companies, hybrid arrays will serve as a stepping stone or gateway to all-flash arrays somewhere down the line. It may be years, however, before the economics of flash SDDs can match those of HDDs for cold data storage and other low-demand storage applications. For this reason, other companies will actually follow the reverse path, evolving from an initial all-flash to a hybrid array—provided that their chosen solution has that capability, says Marty Holmes, outbound marketing manager for Dell Storage.

"We expect that many customers will start with an all-flash array," he explains. "Then, as time goes by and they accumulate more data, much of it cold, they may add a tier of spinning disks to keep costs low while continuing to accelerate their applications with full-flash performance."

In addition to determining the right split between flash and HDD storage for their needs, storage array customers also need to ensure that the best *type* of flash SSD is deployed for different data requirements. Some applications may function well and economically on homogeneous flash arrays that incorporate midtier flash drives throughout. However, some hybrid and all-flash arrays can intermix different categories of SSDs to achieve the optimal balance between cost, IOPs and endurance.

The data center future will be here in a flash

As flash SSD capacities and endurance increase and prices continue to fall, flash-enabled arrays will constitute ever-growing percentages of the enterprise and cloud data storage market. Thousands of data centers have already added hybrid and/or all-flash arrays to their storage infrastructure. Most organizations are first attracted by the stunning performance specifications that flash storage delivers, but many are also realizing that intelligently deployed flash elements can actually lower their total operational and ownership costs over time.

Although this paper has focused on the capabilities and benefits of flash-enabled storage arrays, it's important to understand that data centers should approach flash storage with a comprehensive strategy. For example, flash SSDs are already well established as high-performance caches within servers and flash's server-side footprint continues to grow. More broadly, organizations need to ensure that their networks, storage tiers and applications are configured in ways that best exploit the performance capabilities that flash SSDs can deliver. That will sometimes require the engagement of flash specialists and storage consultants to build optimal flash-powered data centers.

Dell offers a comprehensive portfolio of flash-based products, software and services. The company works closely with SanDisk to maximize the enterprise capabilities of arrays incorporating SanDisk's evolving SSDs. Dell also offers flash solutions using its PowerEdge servers, including the Dell Fluid Cache for SAN solution,

which delivers extraordinary application acceleration performance by leveraging a cache pool of servers connected to a Dell Networking private cache network and a Dell Compellent SAN. Dell's team of flash experts and experienced data center consultants can help organizations map out and deploy the flash-enabled solutions that best meet their current as well as future needs.

Flash SSDs are well on their way to eroding HDD's long-dominant position in data center storage. For many high-demand and high-performance workloads, the tipping point from HDD to flash SSD has already occurred. CIOs and other IT managers who still think of flash-enabled storage arrays as expensive and impractical need to understand that flash economics are becoming as compelling as flash performance. Like the SSD media's performance itself, the incursion of flash into the data center will only increase its already impressive acceleration.

For more information about flash SSD technology and products, see sandisk.com/enterprise

For more information about Dell's hybrid and all-flash storage arrays, software and services, see dell.com/storage



¹ IDC press release: "Flash-Based Array Market Proving to Be More Than Just a Flash in the Pan as Market Soars Past \$11 Billion in 2014, IDC Says," January 6, 2015, idc.com/getdoc.jsp?containerId=prUS25359715

² For a copy of the Limited Hardware Warranty, write Dell USA LP, Attn: Warranties, One Dell Way, Round Rock, TX 78682 or see www.dell.com/warranty.

³ Source: Internal tests performed by Dell in December 2014 with Storage Center v6.5.20. Actual performance will vary, depending on configuration, usage and manufacturing variability.

⁴ "Dell Storage SC4020 TCO Analysis," ESG Lab, September 2014. This white paper contrasts SC4020 costs over eight years with comparable solutions from two leading vendors.

⁵ Dell is the #1 iSCSI storage vendor worldwide by revenue and marketshare per information from the IDC "Worldwide Quarterly Disk Storage Systems Tracker Q4 2014" (2008Q1-2014Q4).

⁶ Performance may vary, depending on the workload and drive type. Based on September 2013 Dell performance testing using eight PS6210XS arrays with Dell PowerEdge R620 and R610 servers and Dell Networking switches, using 100 percent read workloads.

⁷ IDC press release, www.idc.com/getdoc.jsp?containerId=prUS25359715

