The digital economy continues to grow, and as it does, it places an increased value on information held within datacenters. Today, enormous amounts of data are being created from a variety of sources, such as applications, new mobile devices, big data analytics, and the cloud. This is changing the speed with which business is conducted and the scale in which it occurs. Moreover, the digital explosion shows no sign of slowing, and IDC expects the amount of data being stored to grow in excess of 50% per year over the next few years.

For IT managers, dealing with these vast quantities of data presents a significant challenge at a time when storage budgets are limited and IT staffs are shrinking. Over the past five years, spending on IT hardware and software has increased by almost 25%. Yet, these challenges do not fully convey the pain points that continue to exist for enterprises that are dealing with the data growth in a cost-effective manner. Compounding the task is the need to provide higher performance and improved responsiveness required in the most demanding environments.

Enterprises are faced with a myriad of challenges such as the vast quantities of data being generated in our digital universe, the ever-growing number of applications, the cloud, virtualization, and big data analytics. Taken together, these issues place pressure on enterprise infrastructures to deliver higher performance and improved responsiveness at greater levels of efficiency. While a number of IT trends factor into the transformation of today’s datacenters, the use of solid state storage (SSS) in conjunction with solid state drives (SSDs) has begun to play an important role in the enterprise market, and the enterprise all-SSS array market will grow to $1.2 billion in revenue by 2015.

IDC has examined the growing use of flash across the enterprise and how the technology is being deployed to improve performance and efficiency. This Technology Spotlight discusses various aspects associated with deploying flash technology and explores the role that Hitachi Data Systems and its full portfolio of flash solutions play in this increasingly important market.

Introduction

The use of SSS technology is not new to the enterprise. In fact, both battery-backed DRAM systems and nonvolatile NAND flash memory have been used for a number of years. However, advancements in semiconductor technology and the growing use of NAND flash in the consumer market have pushed NAND flash–based SSDs into the enterprise as a cost-effective solution to deliver higher performance and improved responsiveness while mitigating some inefficiencies within existing hard disk drive (HDD)–based infrastructures. In the all-flash array (AFA) market, there are fundamentally two architectures regarding the underlying flash media. The first architecture utilizes off-the-shelf commodity SSD for flash storage, and the second architecture — which is used by a number of AFA companies — consists of custom flash modules designed to vendor specification and manufactured by a third party. When utilizing custom flash modules, AFA companies must either design the flash controller themselves or contract out the development of the controller (usually to the flash module supplier).
The AFA market is nascent, and it isn't clear which architecture will prevail; however, it's important that customers discuss this topic with their AFA vendor to understand its reasoning for choosing one architecture over another. IDC recommends that when choosing an AFA vendor, customers consider not only the architecture as a single component but also how the entire AFA performs as a storage system that serves data to applications.

SSDs are having a profound impact on storage system architectures. When SSDs were first introduced, they were simply used to replace existing HDDs and speed up the existing infrastructure. However, there are a multitude of different performance and capacity requirements depending on the enterprise workload. Thus, as the technology has evolved, multiple approaches have emerged, depending on the operating environment, to capitalize on the benefits associated with solid state storage.

This means that flash will help business and technology leaders transform their infrastructure by making it more physically and operationally efficient. It also means that SSD and flash technology will be utilized in multiple architectures within the datacenter to deliver on both short-term and long-term business requirements. Thus, to provide the best match for the performance and capacity necessary for the various types of workloads, the following architectures have emerged:

- **Server based.** A server-based architecture provides the lowest latency because the flash or SSD is closest to the compute and application infrastructure from an I/O path perspective. This approach can be targeted specifically to a single application for acceleration with minimal investment.

- **In the network.** Flash is typically deployed as a caching layer between the host and storage layers. Network caching is used for applications when there is inadequate flash capacity on the server to achieve the required high cache hit rates.

Within the storage array, there are two options:

- **Hybrid array.** Hybrid arrays combine HDDs with SSDs in conjunction with intelligent data placement software or policies. In these solutions, SSDs can be leveraged either as persistent storage (written to the drive and can survive a power cycle) via automated tiering technology or as a cache layer within the array. In either case, a relatively small amount of NAND flash is used to accelerate and optimize the system’s performance beyond traditional HDD-only solutions.

- **All-flash array.** All-flash arrays are purpose-built enterprise-grade storage devices utilizing only flash-based SSD as the media. These solutions contain no traditional HDDs, but they leverage persistent flash storage in dedicated environments. In the short term, the AFA-only solutions have a performance advantage; however, as enterprise features are introduced into the I/O path, all-flash optimized hybrid storage systems could compete with AFA systems as I/O latency disparity converges.

**Benefits**

Solid state storage in conjunction with SSDs is not a new technology. However, advancements in semiconductor technology and the growing use of NAND flash in the consumer market have pushed NAND flash-based SSDs into the enterprise as a cost-effective solution to mitigate the performance gap by complementing existing storage infrastructures. When coupled with new software technologies, such as intelligent caching and automated storage tiering, these advances have made SSD deployments easier and solid state storage more usable across the enterprise.
SSDs are built leveraging a semiconductor nonvolatile memory (typically NAND flash), an advanced device controller, and an interface to connect to the host. Today, these devices are transforming the entire computing industry as a result of inherent benefits, such as:

- **Higher performance.** SSDs can achieve multiple gigabytes per second of random data throughput. SSDs offer high input/output operations per second (IOPS) performance. For example, a single SSD can provide in excess of 10,000 IOPS — an order of magnitude improvement over the fastest HDDs. Additionally, SSDs provide a more consistent I/O response time because of their fast, predictable access time and high bandwidth.

- **Greater efficiency.** By leveraging SSDs in an intelligent manner, storage vendors aim to make their storage solutions more physically and operationally efficient. For example, by placing the most frequently accessed data, or hot data, on high-performing SSDs and less frequently accessed data, or cooler data, on the most cost-effective HDDs, storage vendors can increase efficiency. Additionally, many of today's techniques to improve storage performance (such as short stroking or overprovisioning a large quantity of HDDs to achieve IOPS) can lead to inefficiencies. IDC research found that in these situations, on average, organizations that were leveraging the right balance of SSDs were able to reduce the average physical footprint while delivering more transactions (IOPS) over a similarly configured environment with traditional storage media.

- **Cost savings.** Solid state is a more expensive storage media compared with HDDs on a dollar-per-gigabyte basis ($/GB). Yet, when solid state storage is intelligently integrated into a system with storage optimization technologies, storage vendors lower the acquisition cost and total cost of ownership (TCO). Moreover, $/IO/GB is optimized with the use of solid state storage. And the use of storage efficiency technologies, such as deduplication and compression, applied to the use of flash can dramatically reduce the effective SSD $/GB requirements.

**Trends**

The all-flash storage system market is quickly maturing from a single controller, high-performance storage appliance market to an enterprise storage array market, with most vendors delivering redundant controllers in the past 12 months. Total spending on all-flash storage arrays was $0.3 billion in 2012, or 0.7% of the total enterprise storage arrays, and represents 11% of the total I/O-intensive segment. From a capacity shipped perspective, all-flash storage arrays were 31PB. The "arms race" now is to deliver asynchronous replication to customers. IDC believes the availability of remote asynchronous replication will be the greatest technology accelerator to all-flash storage system sales in 2013 and 2014.

For enterprise customers, flash storage changes everything. It is transforming the speed of business, and it makes "real time" an expectation, not an aspiration. However, at the same time, enterprise customer imperatives remain the same:

- Performance
- Cost and storage efficiency
- Service including enterprise-grade availability, reliability, and flexibility features and quality of service (QoS)

Today, business and technology leaders need a scalable approach that delivers on their short-term and long-term business requirements. With regard to deploying flash, "one size" does not fit all; a full portfolio of flash solutions designed specifically for the enterprise to match customer needs is imperative.
Today’s storage technology options are more complex than ever. To address this data explosion and extract value from it, IT managers must:

- **Deliver higher performance and improved responsiveness.** Processor and memory performance have grown with Moore’s law, especially when coupled with the increased usage of multicore processors, virtualization, and accelerated network speeds. However, storage performance has lagged behind. Improving the I/O data path and addressing performance bottlenecks are critical to providing the necessary performance throughput. Improving responsiveness is another critical factor. In some implementations, flash-based systems that support external storage virtualization and tiering can be deployed to add flash performance to systems not designed to take advantage of flash. After installed storage is virtualized, tiering allows the data on existing systems that has the most demanding performance requirements to automatically migrate to the flash in the new flash-based system. As tiering management software advances, some solutions can pin a percentage of the volume from a virtualized array in the cache of the newly added all-flash system to ensure a performance boost to a critical subset of data. Whether accessing email, an enterprise resource planning (ERP) system, or an OLTP database or performing real-time analytics, users face I/O delays and system latencies that cost time and money. Delivering the right data, at the right time, and in the shortest amount of time ensures that applications and expensive CPUs are not waiting for data.

- **Lower costs and increase efficiency.** Hardware price per capacity costs continue to decrease, and the implementation of new storage technologies such as data compression and deduplication has increased storage efficiency. However, performance improvements are not keeping up with the rate of data growth and the need to extract value from that data. This performance gap creates inefficiencies and forces enterprises to purchase ever-increasing amounts of hardware. Successful organizations focus on return on investment (ROI) and TCO when selecting a storage solution.

- **Provide enterprise-grade service.** The 24 x 7 nature and speed of business require enterprise-grade availability, reliability, and flexibility features (e.g., snapshot, cloning, replication, multiprotocol access). In addition, the quality of service and data integrity that are expected in the enterprise further challenge IT management.

For IT managers considering flash, gone are the days when flash was used in only high-performing environments that could justify the cost premium. Yet, integrating SSD haphazardly is not the answer either. A framework is necessary to help customers determine the optimal flash solution for their specific needs. Organizations need to consider the following:

- Achieving performance objectives versus overprovisioning storage capacity
- Making everything faster versus specific data sets or volumes
- Identifying the types of workloads to target for performance improvement with flash
- Increasing application speed in terms of higher IOPS versus achieving consistent latency
Product Profile

Hitachi Data Systems (HDS) is focused on developing and delivering storage solutions and services for all segments of the storage systems market. Among the company's storage products are high-end arrays such as the flagship Hitachi Virtual Storage Platform (VSP), the midrange Hitachi Unified Storage (HUS) family, and the more recently launched Hitachi Unified Storage VM (HUS VM), which combines the software capabilities of VSP with the hardware form factor of HUS. HDS also developed a unique flash capacity solution it calls Hitachi Accelerated Flash (HAF) storage, which leverages a Hitachi flash memory controller that offloads advanced flash management functions with dense MLC memory packaging.

Over the past several years, HDS has committed its resources to the development of flash technology for enterprise deployment. In 2010, HDS introduced the Hitachi VSP, which is designed for all data types. According to HDS, the VSP architecture flexibly scales for performance, capacity, and advanced virtualization, including external multivendor storage. In July 2013, the company will launch the HUS VM all-flash array, which will include the HAF storage option along with significant controller software updates that optimize performance for flash. The company continues to develop its "pervasive flash portfolio" — flash anywhere and everywhere it's needed within the enterprise. Among HDS initiatives in the near term are the following:

- Introduction of HAF across all of its external storage families
- Extended capacity options for HAF, including a 3.2TB flash module capacity later this year
- Expansion of server-based flash offerings from key partners

In addition, HDS continues to build its Hitachi Unified Compute Platform (UCP) solutions and reference architectures with server and storage flash where it is most appropriate. The company is also pursuing an expansive flash-enhanced data placement strategy that leverages flash capabilities but drives datacenterwide application-defined data movement via advanced software.

The combination of Hitachi Dynamic Tiering and Tiered Storage Manager software enables HDS to have a strong position in policy-based tiering. According to HDS, the company is beginning to leverage business intelligence in conjunction with array performance in tiering offerings, allowing for batch jobs or weekends to be excluded from automated tiering calculations, for example. In addition, HDS is working toward enhanced flash management capabilities in the next year. The company is pursuing an engineering strategy of active data management that is driven by an application-led design but that will touch on all critical levels: volumes, virtual infrastructure, and then applications. The company's software will analyze performance capabilities across environments and move toward predictive intelligence to proactively move data to the right performance tier.

New products from HDS are aligning to solve business problems; they are designed to address data processing challenges organizations face with flash without forcing users to deal with additional infrastructure silos or disruptions. As a result, HDS aims to enable organizations to maximize their investments and derive all the performance from flash storage.

Challenges

Cost remains a key hurdle for many IT managers evaluating flash technology. Flash is a more expensive storage media than HDDs on a dollar-per-gigabyte basis. Significant cost justification is required to overcome the price disparity, especially when purchasing must be cleared through procurement departments that aren't technology savvy. Yet with proper integration, enterprise-grade flash can deliver on both short-term and long-term business requirements by improving storage efficiency, reducing overall storage environment costs, and accelerating business-critical application performance.
One of the major inhibitors of flash adoption is the current metric for comparing storage pricing, which is dollar per gigabyte. IDC believes $/GB is a good way to quantify and compare capacity pricing; however, it is not a good metric for comparing performance. Recently, dollar per IOP has been used to compare flash and HDD in an attempt to rationalize flash’s value with respect to performance. Ultimately, $/GB and $/IOP can be gamed in a TCO or ROI scenario to show favorable results, usually at the expense of overall solution cost or undersized configuration. IDC proposes different metrics to demonstrate value:

- **Dollar per gigabyte used.** There are many ways to deploy a storage solution with differing media, protection type, software, hardware, and so forth. The "storage waterfall" shows how storage capacity is consumed from raw to actual bits written by the application. $/GB used is the key performance indicator (KPI) for storage bits written divided by total cost of the solution. IDC believes $/GB used accounts for the cost of capacity and performance because the amount of application bits written is the same in any configuration; however, the underlying infrastructure can vary vastly to support the performance requirements of those bits. Therefore, IT organizations should seek solutions that drive down their $/GB used because the metric accounts for performance and capacity, while organizations that strive to only lower $/GB may be increasing their overall storage costs when performance is required.

- **Dollar per workload.** Similar to $/GB used, $/workload focuses on the total or "all in" cost for delivering a workload. Where $/workload becomes interesting is leveraging sunk assets to deliver additional services, so the additional service $/workload is essentially free. For example, let’s say a 15TB flash array was purchased to run a 10TB database, so $/workload is the cost of the array. Because of the performance characteristics of flash, the database workload may not use all of the available performance. Therefore, snapshots may be used instead of traditional clones to present copies of the database without impacting source database performance. Since the cost of the flash array was already sunk (and was the smallest unit of purchase), the workloads using the snapshot copies are essentially free, or $/workload is $0, whereas in a traditional HDD-centric environment, full clones may have been necessary instead of snapshots, which would increase $/workload to more than $0.

**Conclusion**

Flash will have a profound impact on the future of enterprise storage. Memory-based storage systems and SSDs have been deployed in enterprises for many years in environments that demanded the best performance regardless of the cost. However, IDC believes that because of the declining cost of NAND flash media and system-level advancements, solid state technology will become pervasive across the enterprise and complement existing storage systems.

Today’s business and technology leaders should look to solution providers that offer a comprehensive portfolio to meet diverse enterprise workloads and those that have a strategic framework to help customers determine the optimal flash solution for their specific needs. IDC believes the market for flash solutions will continue to be important, and to the extent that HDS can address the challenges described in this paper, the company has a significant opportunity for success.