Flash Storage Solutions in Healthcare and Life Sciences: What You Need to Know

More and more IT professionals in the healthcare and life sciences industries are finding hybrid-flash and all-flash storage arrays can supercharge application performance while lowering their total cost of storage ownership. Here’s what you need to know to deploy flash storage in your healthcare or life sciences operations.

Staying Ahead of Data’s Explosion in Healthcare and Life Sciences

Data storage demands on the healthcare and life sciences industries are soaring. KMPG estimates that the volume of healthcare data is growing at a rate of at least 1.2 exabytes per year and likely twice that. Such explosive growth doesn’t surprise anyone involved in healthcare and life sciences IT, least of all the CIOs in these industries who are charged with managing the data deluge.

The questions they now face include how to most cost-effectively store and protect these ever-growing mountains of data, while making it securely accessible to qualified clinicians and researchers. Of course, in healthcare they have to do all that in compliance with strict privacy regulations like the Health Insurance Portability and Accountability Act of 1996, better known as HIPAA.

Life sciences can also face privacy requirements, such as in the fast-growing market for personal genome mapping. In other areas — especially the highly competitive biotech and pharmaceutical industries — security is critical to preventing the disclosure of confidential proprietary information, both to competitors and public equity markets.

In particular, as healthcare IT moves to Meaningful Use Stage 3, the challenge is now making data available quickly, accurately, securely, for anyone that needs it — physicians, administrators, and associates. Seeking more performance, less cost. Over the years, falling prices in traditional hard disk drive (HDD) solutions and advances in intelligent storage technologies like automated tiering have helped healthcare and life sciences IT professionals keep pace with growing storage demands.

These approaches range from using limited amounts of relatively expensive cache memory to various RAID schemes and intelligent firmware. But despite these improvements, HDD storage systems have struggled to keep up with the I/O performance requirements of today’s increasingly powerful — and virtualized — applications. They also are starting to reach their limits in such areas as virtualization, scalability and even physical space.

In short, CIOs are seeking storage solutions that can provide speed, scalability and access. Efficiency, reliability and productivity are in demand to help drive down IT’s operational costs.

The good news is that flash storage, solid-state drive (SSD) solutions — either in hybrid (HDD and SSD) or in all-flash storage platforms — are becoming cost-effective alternatives. They are proving themselves in more and more data centers around the world, including those of the healthcare and life sciences industries, in terms of price-performance and often at a lower total cost of ownership.

Although flash storage may initially be more expensive than HDD storage options to implement, it requires less physical space and less hardware, leading to fewer environmental costs, better scalability and fewer licensing costs — all helping to keep operational costs down. Flash storage provides faster processing speeds, which provides distinct advantages when large numbers of users are simultaneously accessing and using large amounts of data, such as in informatics and personalized medicine scenarios.

Behind the numbers. Industry figures are telling. According to market research firm IDC, the worldwide flash array market in 2014 totaled $11.3 billion. Hybrid flash arrays, which contain HDD as well as SSD flash components, were $10.0 billion of that total. All-flash arrays made up the remaining $1.3 billion. Looking ahead, IDC expects the hybrid flash array market to grow at a 21.1 percent compounded annual growth rate (CAGR) through 2016, while all-flash arrays will more than double that with a 58.5 percent CAGR. Further, IDC expects that by 2017 almost half of the world’s storage capacity will be flash-based.

According to Eric Burgener, IDC’s research director of storage, the market for all-flash and hybrid flash arrays is growing for four key reasons:

• "Virtual infrastructure (and the new application workloads associated with it) require storage performance that HDDs cannot cost-effectively meet."
• "New application workloads are driven by mobile
Data is expected to continue to grow at a 44 percent CAGR over the next five years, so the "managing growth" problem will not let up anytime soon.4

Dell and SanDisk are at the forefront of providing flash-enabled enterprise storage solutions that are cost-competitive with HDD-based solutions. In some deployments, when the higher performance of flash storage is combined with savings in space, energy, and labor, the overall total cost of ownership can be lower than HDD-based storage solutions.

In this paper, we will elaborate on Burgener’s points and share what we know about this fast-evolving technology. Ultimately, we want business and IT decision makers in the healthcare and life sciences industries to become better informed about how to incorporate flash storage in their strategic IT roadmaps.

**Addressing the Storage Challenges Facing Healthcare and Life Sciences**

Data growth in the healthcare and life sciences industries have several sources. One is the adoption of electronic health records (EHR). Use of EHR has skyrocketed, especially in the U.S., where federal government incentive payments have helped drive private sector deployments.

According to the latest data available from the U.S. Department of Health & Human Services, nearly 80 percent of U.S. healthcare providers in 2013 are using EHR to manage patient information, while almost 60 percent of hospitals are using it.3 If anything, EHR adoption among physician offices and hospitals has only increased since.

Another fast-growing driver of healthcare storage capacity is medical imaging. In the developing world, it’s become a primary diagnostic tool but with huge storage demands. For example, MRI image file sizes range up to 6MB in size, with from 100 to more than a 1,000 images contained in a series for a single patient.6 One 3D CT scan uses 1GB of storage. These and other imaging systems, including X-rays and PET scans, require what are called picture archiving and communications systems (PACS) to store and retrieve their images.

**Data torrents.** The amount of data going into PACS is astronomical. According to the U.K. government, the country’s National Health Service adds a million images to its database each day. In the U.S., with five times the U.K.’s population, it’s safe to assume a similar multiplier in the number of medical images captured each day — if not even more, given the fee-for-service model in the U.S. that drives extensive use of diagnostic imaging.

Life sciences are not immune to large, high-performance data storage requirements. Genomic sequencing places huge demands on storage, often rivaling the needs of high-performance computing. That’s especially the case in the fast-growing market for genomic analysis, where each whole genome can range from 200GB to 300GB.

At the same time, pharmaceutical development and clinical trials continue to grow in complexity, requiring bigger and faster data storage to help lower the costs of clinical trials and also improve time-to-market. What’s more, as pharmacological and genomic technologies merge to provide predictive and personalized approaches to therapeutic drug deliveries, the growth curve in data storage requirements will only accelerate.

The "blender effect." Then there’s virtualization. Both healthcare and life sciences are no different than other industries in their adoption of this technology. It applies both at the enterprise application level and at the client level, the latter reflecting the growing use of virtual desktop infrastructure (VDI) to save costs on fully featured client devices. A hospital nursing station, for example, may need just a thin desktop client device to access the hospital EHR system instead of a full desktop PC.

In these situations, HDD storage systems can have a hard time keeping up with the performance requirements of virtual machines and virtualized applications. That’s because their I/O access patterns are much more random due to the "blender effect" of virtualization. To explain, this phenomenon starts as a server’s operating system sequences each virtual machine’s I/O stream, which the hypervisor then multiplexes, combining the streams.

The result is an extremely random I/O pattern, which spinning magnetic HDD disks don’t handle well, because their rotational latencies and seek times create I/O bottlenecks. These bottlenecks can reduce the effective I/O per second (IOPS) rating of HDD systems by as much as 90 percent.7 In turn, application performance suffers. Even without the falling prices of flash storage, that much performance degradation in a HDD storage model supporting virtualization can make flash look much more attractive by comparison.

**Hot data access.** Finally, while much data in the healthcare and life sciences industries is archival, and so needs only infrequent access, more and more data must be at the ready and accessible to large numbers of users, such as in a large enterprise VDI environment. Flash-enabled storage is ideal for such “hot” Tier-1 data requirements.
In the course of a day, for example, a particular patient’s EHR and imaging data may need to be available to several physician specialists, a number of shift nurses, several allied health professionals, the hospital pharmacy, and even the patient’s insurance carrier. These various access requests may come via several different enterprise applications, all virtualized and delivered to a range of devices — bedside, at the nurse’s station, at the pharmacy counter, and even on clinicians’ smartphones or tablets outside the clinical setting.

The Advantages of Enterprise Flash Storage for Healthcare and Life Sciences
Fortunately, flash storage performance and capacities continue to increase while prices keep falling. Note in Figure 1 that the average cost per gigabyte of an all-flash array has decreased by more than half from 2012 to 2014, and it is forecast to drop by almost half again through 2016. On a $/GB basis, flash storage is nearing 15K RPM HDD prices.

These trends are making all-flash and hybrid-flash solutions more economically compelling than ever compared with traditional all-HDD solutions. At this point in the technology’s evolution, the healthcare and life sciences industries must consider flash storage as a core part of any long-term storage strategy. The advantages are just too many to ignore.

Flash first-aid. Consider the case of one of Dell’s healthcare customers, a midsize U.S. hospital with 600-plus employees who access its EHR system each day. Overnight backups on the hospital’s HDD-based storage area network (SAN) were taking 10 hours, running right into the morning rush. The result was storage I/O bottlenecks that were reducing EHR performance to a crawl, seriously affecting clinical productivity throughout the hospital.

The hospital deployed two Dell Storage SC-Series 8000 flash-optimized arrays, each with 60TB of storage. The primary SAN contains three tiers, with two tiers of flash storage and a bottom tier of spinning-disk storage. A secondary SAN features two tiers of spinning-disk storage. With this new flash-optimized storage system, which cost a third of competing systems, the hospital cut its backup times in half, while improving its EHR database performance by 40 percent. And automated tiering has virtually eliminated a manual tiering process that took up the better part of each week for members of the IT staff.

How Flash Storage Works: A Short History and Overview
With flash storage destined to play an ever-larger role in the storage strategies of the healthcare and life sciences industries, it’s important for these industries’ business and IT decision makers to know more about how the technology works.

A short history of flash. Solid-state flash memory debuted more than 30 years ago, a derivative of a technology called EEPROM (electrically erasable programmable read-only memory).

In fact, SanDisk co-founder Dr. Eli Harari developed the Floating Gate EEPROM, which demonstrated the practicality, reliability and endurance of semiconductor-based data storage. His pioneering work laid the foundation for the flash memory market that has significantly affected the consumer electronics industry to this day. Electronic cameras and music players are among the early consumer products so enabled, with their functions now mostly subsumed into today’s smartphone and tablet devices.

Cache memory. Even as evolving technologies and designs — coupled with volume manufacturing — lowered the cost of flash memory, its main use in data centers until recent years was as cache memory for data needing near-instant, sub-millisecond accessibility. Its limited use was due to two reasons: one was the then-higher cost compared with HDD storage, and the other was related to how data gets written to flash memory.

To explain the latter, it’s important to know that flash technology in SSD storage is fundamentally different than HDD storage. The former is silicon-based, with electronic NAND gates made much like semiconductors; the latter is magnetic media, similar to what media like floppy disks, VHS videotapes, and music cassettes used.

Trade-offs. Because flash has different performance, cost and data-retention traits that may affect the economics and operations of the application workloads in a data center, the following information will help readers understand what those impacts can be. Let’s start with the related phenomena of write cliff and write endurance.
Write cliff. The need to erase a block of NAND gates in a flash drive before they can be written means that some blocks must be held in reserve, pre-erased, in order to improve performance. This eliminates the latency that would occur if the erase process was performed every time blocks were needed.

A write cliff happens if a flash drive runs out of pre-erased blocks, especially when the drive fills up or during a sustained write-intensive operation. It’s then possible to have a long delay (50+ milliseconds), while the flash drive works to create a free block of NAND gates. This write performance degradation in a flash drive is called a "write cliff."

Write cliff is usually addressed by over-provisioning capacity in a process called “wear leveling.” This spreads out re-writes to the same block across new locations on the flash storage thus ensuring that the drive wears out evenly, increasing drive life span.

Write endurance. Unlike magnetic media on HDD storage, data stored in flash storage must be erased before anything new can be written or “programmed.” This is called the program-erase (P/E) cycle.

The maximum number of P/E cycles of NAND gates on flash storage is a few thousand. After that, the performance and reliability of the flash drive drops dramatically: up to a 10 times performance degradation may occur. This characteristic — called "write endurance" — limits the number of write operations that can be performed on a flash drive and is expressed in full drive writes per day (or drive fills per day).

Today, write endurance is handled with three common types of enterprise flash drives, which can affect particular application workloads as well as data center economics and operations.

- **Read-Optimized (RO) or Multi-Layer-Cell (MLC) flash drives**: This type of drive is optimized and the most cost-effective for read operations, such as accessing a database table.
- **Write-Intensive (WI) or Single-Layer-Cell (SLC) flash drives**: This type of drive has a higher write endurance and is typically more over-provisioned than the RO drives. The increased write endurance comes at a cost, making this the most expensive and most reliable enterprise flash drive.
- **Mixed-Use (MU) or Enterprise MLC (eMLC) flash drives**: This type of drive attempts to strike a balance between SLC and MLC drives both in terms of write endurance and cost.

**Flash Deployment Strategies for Healthcare and Life Sciences Storage**

As shown in Figure 2, flash storage can be used in different layers of a healthcare or life sciences enterprise storage array to improve application I/O performance.

**Flash as cache in storage arrays.** As mentioned previously, one of the earliest uses of flash has been as a second layer cache within the storage array. It’s still a valuable approach today. The concept is to insert a faster medium between the DRAM-based system cache and slower HDD array. The array’s management software is enhanced with the intelligence to use the flash drives as a second level of cache. By moving hot data into the flash storage cache, the need to read data from slower HDD storage is reduced. This in turn reduces latency, which can mean a boost in application performance.

**Flash as multiple tiers in a hybrid storage array.** Given the cost reduction of flash storage, it is now economically feasible to deploy multiple flash drive types as multiple storage tiers in an array. By taking advantage of this strategy, healthcare and life sciences IT staff can deploy larger capacities of flash storage. Combined with the intelligent tiering capabilities, like what’s available in the Dell Storage portfolio, it extends the high-performance flash storage benefits to much more of the overall array, leaving lower tiers, especially cold storage, to the HDD’s lower performance — and lower cost.

**Server-attached flash for application acceleration.** This approach positions flash storage physically closer to the application, using a PCI bus that’s capable of faster access speeds than industry-standard disk drive interfaces, such as SAS or SATA. Flash drives are connected directly to the high-speed PCI bus. Intelligent software then enables the server to leverage the flash storage as an extension of the server memory cache.

Note that this approach can deliver extreme performance acceleration for targeted workloads, but it can also create islands of flash storage that can be stranded in servers. As a result, such benefits accrue to the applications running on a particular physical server.

**HDD vs. SSD: What’s the Difference?**

Unlike HDD storage devices, which use a spinning magnetic platter to store data, SSD storage devices use solid-state memory NAND chips. HDDs have several different mechanical moving parts, which make them susceptible to handling damage and wearing out. Solid-state drives have no moving parts and are therefore much less susceptible to handling damage even during use. SSDs deliver ultra-high performance input/output operations per second (IOPS), with very low latency for transaction-intensive server and storage applications. Properly used in storage systems with HDDs, they can reduce total cost of ownership through lower power consumption, lower operating temperatures (reducing air-conditioning demands), and space savings.
All-flash storage arrays. This approach eliminates HDD storage devices altogether and delivers an all-flash SSD-based storage system. While the array hardware can be off-the-shelf or custom-made, its firmware and software must be designed to deal with the previously mentioned write cliff and write endurance issues. This approach provides dramatic and sustained performance improvements for all workloads running on the array.

Flash Storage Use Cases in Healthcare and Life Sciences

Specific use-case scenarios, such as the ones below, may help readers to understand how flash storage technology may be able to help improve their operational storage performance, while lowering costs.

Virtualization. Healthcare IT is rapidly adopting virtualization. Information-driven healthcare needs infrastructure, including server, storage, networking and client virtualization. In the past, healthcare IT infrastructure was too often set up in departmental "silos" with different individuals or teams overseeing storage, servers, networking, and desktop — sometimes with each reporting to different areas within the healthcare IT organization.

Now, with the advent of virtualization technologies, healthcare IT can converge these various roles and responsibilities. Life sciences can benefit, too. What were formerly silos of specific areas of expertise are being replaced by domain and application experts, who can take advantage of the same platforms created to support VDI, cloud and big data informatics.

For example, healthcare providers are increasingly deploying VDI to enable secure and regulatory-compliant patient data access from endpoints throughout the hospital, all with less cost. They are also deploying VDI with specific requirements for electronic medical records management, patient data security and operational continuity.

Healthcare providers are using VDI as a more efficient model for their many users needing real-time continuous access to the patient data in the data center. By homogenizing the endpoints and keeping patient data centralized in the data center — not the desktop or other client devices — security is enhanced by keeping data off vulnerable and accessible endpoints. In addition, client management becomes much more standardized and, as a result, more consistent and ultimately easier and less time-consuming.

In these ways, virtualization is improving security and client manageability with VDI solutions. This helps to lower operating costs, which can help pay for the investment in flash storage.

Imaging and EHR workflows. Due to information-driven healthcare initiatives, diagnostic digital imaging such as CT angiography, PET and CT scans for cancer, digital mammography and open MRIs have become ubiquitous in healthcare providers, large and small. While these kinds of medical imaging have helped transform healthcare, they have also created an exponential demand for storage requirements for healthcare providers’ data centers.

Medical imaging in combination with EHR management enable early detection and more accurate diagnoses of treatable diseases. However, to make that a reality, images and patient data need to be accessible and “at the ready” when physicians need to review them and make decisions.

The challenge for healthcare IT is how to store this massive amount of data and make it available to the multiple care givers who need to access it at the touch of a button. The multi-tiered storage architectures of the past are in need of an upgrade and the transition to flash technology provides the answer to many of the challenges and advancements healthcare IT professionals are faced with today.

Big data informatics. Healthcare and life sciences research are merging in the areas of utilizing genomics and informatics for personalized medical treatments with much greater precision and efficacy than in the past. As healthcare further evolves to become more and more data-driven, it is adopting big data technologies, which are leading to an explosion in the amounts of data that must be stored and accessed. Data-intensive research, such as genomics, population health management, and molecular modeling, are producing massive data sets that have to be easily stored, shared and accessed — all securely and, in many cases, in compliance with relevant regulatory statutes.
Flash storage, with its low latency and ease of use — especially in support of virtual machines — enables hospitals to scale up storage quickly and easily. It also provides high-performance storage technology that is both fast and reliable. Speed and reliability are two necessities for getting the right data to the point of care in a matter of seconds, which is more often required in a clinical healthcare setting than in medical research.

**Dell and SanDisk: Delivering Tomorrow’s Flash Storage Solutions Today**

The Dell Storage portfolio — including the SC-Series (formerly Compellent) and the PS-Series (formerly EqualLogic) — offers a wide range of flash-based products, software and services. Dell also offers flash solutions in its PowerEdge servers, including the SanDisk Fusion ioMemory PCIe cards and Dell’s own Fluid Cache for SAN solution.

Dell works closely with SanDisk to maximize the enterprise capabilities of its arrays by incorporating SanDisk's ever-evolving SSD flash storage. In fact, SanDisk has the industry’s broadest portfolio of flash solutions and expertise, from USB keys to high-performance, enterprise PCIe products, plus flash storage management software and flash appliances.

**Conclusion: Flash Storage, a Solid Solution for the Storage Needs of Healthcare and Life Sciences**

All-flash storage arrays might well become the ultimate tool for IT professionals in the healthcare and life sciences industries to manage the ever-growing data demands of their enterprises. But to meet their needs today with scalability for the future, hybrid flash storage solutions can provide a viable way forward.

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

For more information about SanDisk’s complete portfolio of flash storage solutions, visit www.sandisk.com/enterprise.