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WHITE PAPER

5 Requirements for Enterprise Flash: Maximize Your Storage Investment

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April 2015

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Executive Summary and Introduction

Enterprises today have an ever-increasing need for performance to support business-critical applications. However, while CPU performance has grown dramatically over the last 10 years, storage performance has seen much more modest growth. The mechanical disk drive has been the primary technology for storage for over 50 years. The cost of storage capacity has come down dramatically over the years. However, the latencies associated with rotational speed and movement (seek) of the disk access arm have improved very little. This disparity is creating a widening performance gap between the two.

This performance gap stresses the ability of storage to serve critical data at the rate required by the applications that drive the business. Database applications, business and financial analytics, data mining, data warehousing, production archive, virtual machine deployment and virtual desktop infrastructure (VDI) all need a higher performance infrastructure. Addressing storage performance is vital to future growth.

Some organizations have chosen to compensate for the storage performance gap by overprovisioning servers with disk drives that limit the amount of data recorded to a fraction of the disk's capacity. This approach is taken to reduce seek time and stripe the workload across as many disks as possible to parallelize the rotational delays. It sacrifices the low-cost benefits of disk capacity to compensate for lack of performance.

In order to improve the performance of business-critical applications and data center efficiency, enterprises are deploying flash-based storage systems to address the performance limitations of disk drives. While the price per capacity of flash drives can be several times that of disk drives, the price per I/O performance of flash storage is much lower. As little as 4 flash drives can provide higher I/O performance than 768 high-performance 15K RPM disk drives.

The adoption of flash storage devices has been phenomenal. However, as the flash market has matured, there is a growing realization that not all flash-based storage systems are alike. While all flash-based storage systems use the same flash NAND technology, there is a tremendous difference in durability, performance, price and capacity. Storage features also differ in the way this technology is packaged in the flash device, the flash storage system, and the data management system.

This paper identifies the key flash technology considerations to examine to maximize your flash investment in an enterprise storage environment.

What Is Flash and Why Should I Care?

Enterprises have many different options for adopting flash-based storage, but not all flash systems are created equal. Before we look at the different options, we need to understand the basic technology of flash. Flash is a semiconductor technology and has no moving parts. Hence, it is orders of magnitude faster than disk. A flash cell is written when voltage is applied to a substrate and electrons are forced through a thin oxide insulation layer to a floating gate. The insulation layer retains the electrons in the floating gate for some time. This phenomenon gives flash its nonvolatile characteristic.

However, electrons are leaking all the time and every read applies a voltage, which drives out more electrons. So, the data in the cell degrades over time and must be refreshed. A multilevel cell records 2 bits, and data is recorded across a number of cells in a unit called a page. Before data can be recorded in a page, it must be formatted by setting all the bits to 1. This formatting is done for a block of multiple pages. When a cell degrades, an error correction code (ECC) is applied to the page until the number of bad cells exceeds the capability of the correction code. At this point, the page must be rewritten. The page must be rewritten to a newly formatted page and the old page is marked invalid. The rewriting of pages is called "write amplification."

Eventually, the block of pages gets fragmented with more invalid pages than good pages and the block must be reformatted. This reformatting (housekeeping or garbage collection) requires moving the good pages to another block before the formatting is done. During this process, the writes can be blocked, and this condition is known as the "write cliff." Every write or format degrades the insulation layer in the cell until it can no longer retain the electrons. For multilevel cell flash, the number of write or format cycles is about 2,000 to 3,000, which is quite low compared to the durability of disk drive, which is about 10^{18}.

While flash has no mechanical latencies, it has many programming latencies in order to extend its durability and maintain performance. How these latencies are solved will differentiate the value of enterprise flash storage from commodity flash storage.

5 Factors That Make the Difference

Here are 5 factors to be aware of when exploring enterprise flash storage: device architecture, system architecture, data center architecture, performance and economics. Examine flash storage platforms with these factors in mind. This assessment will help you choose a storage platform that will deliver the performance and reliability your business-critical applications demand, with the manageability and economy you need.

1. Device Architecture Matters

While flash offers outstanding performance, the architecture of the flash devices deployed is crucial to addressing issues that can affect flash storage. These issues include:

Reliability and durability. Consider the expected reliability and lifespan of flash memory when selecting a flash storage platform. While single-level cell flash is more durable than multilevel cell flash, it is much more expensive. A multilevel cell flash with an enhanced device architecture can greatly improve reliability and reduce the wear from write amplification. Spare blocks within the device along with a wear-leveling algorithm can extend its durability. Management of the spares, indexing to valid pages, wear leveling, and processing an extended ECC are power-hungry tasks. They require more processing power in an enterprise flash device than is found in commodity flash devices that are used in PCs.

Write cliff. The degradation of I/O processing when managing housekeeping tasks and/or when under heavy write workloads is a common phenomenon associated with many flash controllers. When the write cliff is hit, flash storage housekeeping tasks can severely impact storage performance. This impact can be avoided if the device

controller supports multiple processing paths within the device to remove the conflict between housekeeping and write processing. This degradation in performance will not be noticed until the threshold for spare cells has been exceeded. When evaluating a flash storage device, make sure that you have used all the spares before doing your performance test.

To address these issues, you need a flash device architecture uniquely designed to address the challenges of enterprise data center deployments. As discussed earlier, a flash device needs a powerful multicore processor with multipathing capability to address the device architecture challenges of flash devices. The amount of processing power that is required limits the capacity of a flash device. Flash devices that are designed for the high-volume PC market are made with low-cost processors that limit the capacity that can be supported to gigabytes. Flash devices that are designed for enterprise storage systems must have the processing power to support terabytes of capacity. Here are features to look for in flash device architecture:

- Purpose-built processors with multipathing that support the higher densities and consistent performance required for enterprise storage systems over standard commodity solid-state disk (SSD) devices, which were designed for the PC and appliance markets.
- Designed to improve reliability through advanced error checking.
- Improved durability and lifespan through innovative approaches to wear leveling and minimizing write amplification.
- Garbage collection and housekeeping taken out of the I/O path to eliminate the write cliff.
- Block write avoidance eliminates unnecessary write/erase cycles to extend the effective life of the flash memory.

2. Storage System Architecture Matters

Flash technology, unlike disk technology, has no mechanical latencies, and the I/O performance of flash is a thousand times that of disk for reads. So, changes must be made in the storage system to obtain the best performance. Attaching flash to a storage system designed for traditional hard disks would degrade storage performance for applications. Solving the I/O bottleneck in the device only pushes the bottleneck up into the storage controller. The caching algorithms in Hitachi storage systems have been optimized for flash devices through nondisruptive upgrades to microcode.

How will a flash storage solution integrate with your existing storage solution and application environment? Many flash storage systems are sold as standalone appliances that must be managed individually, and do not integrate with your existing environment, resulting in more administrative overhead. When looking at the system architecture of a flash platform, look for:

- A flash platform that maximizes your investment in storage by integrating with your existing storage system; a platform that gives you the right combination of flash and traditional storage to fit your business needs without creating another storage management silo.
- Scale-up and scale-out capabilities that allow you to grow your storage as your business needs, while keeping applications operating at peak performance.
- A single software platform for managing all your systems and storage types, aiding automation and reducing administrator overhead.
- A flash storage system that supports data encryption. Unlike disk drives that are self-encrypting, flash drives must be encrypted by the storage system. Flash drives also cannot be shredded by overwriting as the writes always go to a new page. Encryption solves this problem of shredding flash drives by shredding the encryption key. This action is known as crypto shredding. A secure flash storage system will also support logging of encryption and key

management events for compliance and auditing purposes. Don't trust your critical data to a flash storage system that does not support these features.

3. Data Center Architecture Matters

Important factors in choosing a flash storage platform include not only the architecture of flash devices and storage systems, but also how the storage fits into your enterprise data center. Look for:

- Storage virtualization and the ability to optimize for flash performance and disk capacity in a hybrid architecture with automated tiering that can provide the best of both worlds. Virtualization enables the benefits of flash performance on legacy disk systems that it virtualizes.
- Dynamic tiering allows you to put your most critical data on high-performance flash arrays, while moving less critical data to less expensive hard disk arrays. An effective dynamic tiering system offers automated, nondisruptive migration of data between storage tiers.
- Data protection is a critical part of a data center's architecture. This includes the ability to make snapshots and clones for point-in-time recovery and nondisruptive backups. Synchronous and asynchronous data replication are also important to meet recovery point and recovery time objectives in the event of a disaster.
- Mainframe is still used for core applications in critical areas like financial, telecommunications and utilities business: These are the applications that can benefit the most from high-performance flash.

4. Performance Matters

Navigating and comparing benchmarks and performance reports for flash storage systems can be confusing. You want the best performance for your business-critical applications, and need to be able to critically evaluate benchmarks and performance claims. When looking at flash performance, there are several factors to consider:

- Does the vendor clearly describe their benchmarking methodology and reference platform?
- Does the vendor test against real-world conditions, application environments and workloads?
- In reporting performance statistics, what does the vendor report? For flash storage, input/output operations per second (IOPS) is a commonly reported benchmark, but latency is a key performance benchmark, as well.

5. Economics Matters

While delivering high-performance storage for business-critical applications is crucial to remaining competitive, you need a storage platform that delivers that performance in a way that is economical. There are several things to look for in the right flash storage system:

- Price-performance that makes flash a cost-effective option for data and applications that require sub-millisecond latency.
- Storage density that packs flash storage into less rack space than SSD or traditional hard drives, saving valuable rack space in the data center. Enterprise flash devices require the processing power to support terabytes of storage.
- Effective I/O rates of your flash storage system, measured in IOPS per gigabyte (IOPS/GB). While a common measure for the cost-effectiveness of a flash system is dollars per I/O, it is important to consider effective I/O when evaluating cost-effectiveness. If the effective I/O rate of a flash solution is only 20% of its theoretical maximum, the dollars per I/O cost is 5x greater than it appears to be.

- Dynamic tiering that allows you to purchase flash capacity for your critical data, while leveraging less expensive disk storage to make your data center more efficient. With dynamic tiering, you gain the benefits of flash deduplication without the problems associated with replication of deduplicated data.

Hitachi Accelerated Flash Delivers What Matters

When it comes to enterprise flash storage systems, Hitachi Data Systems helps close the performance gap with Hitachi Accelerated Flash. Hitachi Accelerated Flash delivers blazing performance for organizations that seek to accelerate the performance of their business-critical applications. Available for the Hitachi storage portfolio, Hitachi Accelerated Flash features:

- A purpose-built flash controller for outstanding performance without sacrificing reliability, outperforming standard SSD storage.
- Integration with Hitachi storage management tools. Add flash to your storage system while keeping a single platform to manage all your storage types.
- Support for dynamic tiering to keep your most performance-sensitive data on high-performance flash storage.
- 3x lower dollars per I/O cost than SSD and 7x lower dollars per I/O cost than hard disk in the storage system.
- Less than half the power consumption per terabyte of hard disk in the storage system.
- Up to 2x the performance of SSD and 4x the performance of hard disk configurations.

DEVICE ARCHITECTURE

Hitachi Accelerated Flash is a unique flash technology. Developed by Hitachi, it builds on the many flexibility, performance, reliability and common management attributes already well-known and appreciated in traditional Hitachi storage. The Hitachi flash controller is purpose-built to provide consistently high performance. By removing housekeeping tasks from the I/O path, the infamous “write cliff” is eliminated, an extended ECC reduces the refresh rate, buffering and compression eliminates excessive writes. In addition, the global wear-leveling management balances NAND (Not And) cell use patterns. All of these capabilities drive increases in the endurance of the flash array.

Additionally, the controller can support higher storage densities than traditional SSD configurations. The smallest capacity flash module drive (FMD), the physical equivalent of an SSD, supports 1.6TB, and Hitachi FMDs support capacities of up to 3.2TB. This increase in supportable capacity translates into significant cost savings when transitioning from hard-disk-drive-based systems.

DYNAMIC TIERING

Deduplication is a commonly used approach to lowering storage costs and improving flash longevity by reducing the amount of data written to storage. However, it is better suited to use with a long-term data store. An active data store requires rehydration of the data when it is accessed. This action will affect durability by creating wear, impacting performance and requiring space for the rehydration.

Hitachi Dynamic Tiering software addresses the business challenges of lowering storage costs and improving flash longevity in a different way. It eliminates the complexities of managing data placement and optimizes the cost-to-performance effectiveness of the storage solution. No complex decision criteria are required. Data is moved based on simple logic around user policies, media type and speed, and sustained I/O requirements.

One to 3 tiers of storage can be defined using any storage media types available to the Hitachi platform, such as flash or hard disk. Data moved between Dynamic Tiering migrates to the most appropriate media, based on the workload. For example, highly active database data will migrate to flash storage. At the same time, aging data that has not been touched for some time will be moved to lower-cost, slower hard disks.

Real-World Success Stories

Hitachi Data Systems has helped organizations worldwide deliver exceptional application performance with Hitachi storage with Hitachi Accelerated Flash and Hitachi Dynamic Tiering.

Owens Corning

Owens Corning, an innovator in producing building materials and services, selected Hitachi as the foundation of its growing and evolving SAP environments and other enterprise applications. With Hitachi Accelerated Flash storage and Hitachi Dynamic Tiering, Owens Corning has seen up to 100% increase in performance for business-critical applications, with 100% uptime. Hitachi Dynamic Tiering automates moving the most active data to the highest performing tier. Therefore, flash tier utilization approaches 100%, maximizing performance at the lowest possible cost and optimizing return on investment for flash expenditures.

Turkcell

Turkcell, a leading mobile phone operator headquartered in Turkey, used Hitachi to migrate an I/O-intensive fraud application to a smaller number of physical disks with Hitachi Dynamic Tiering. At the same time, average response time was lowered from 20ms to 40ms and service quality improved by optimizing processing time in daily jobs. With help of SSD and Hitachi Dynamic Tiering, the total disk count was reduced from 10,215 to 5,744 while keeping the disk capacity the same. This approach reduced the rack count from 63 to 22, and Turkcell was able to reallocate the space gained.

Hitachi Storage Makes the Most of Your Storage Investment

The gap between processor performance and storage performance has continued to grow. Enterprises need a storage solution that helps close the performance gap and enables high performance for business-critical applications to satisfy business demands. While flash storage holds the promise of superior performance, you need a storage

solution that provides the performance of flash, with the reliability, scalability and manageability of traditional enterprise storage. Hitachi Data Systems leads the way with flash solutions for the Hitachi storage portfolio.

Storage systems from Hitachi Data Systems allow you to gain the performance benefits of an all-flash array with all the right factors for an enterprise storage system. Hitachi offerings allow you to:

- Centralize storage for critical applications and provide shared services for all your storage systems through a central management interface.
- Employ a unique hardware-accelerated, object-based file system to support intelligent file tiering and migration, as well as virtual NAS functionality, without compromising performance or scalability.
- Grow a complex storage environment with scalable management while using fewer resources.
- Use storage virtualization to manage more data more efficiently at higher performance and service levels, with a lower acquisition and operating cost.
- Lower operational risk and data loss exposure with data resilience solutions.

Meet Your Enterprise Flash Requirements With Hitachi Storage

Hitachi gives you enterprise-class storage that achieves key business benefits in cost-effective ways. With best-in-class scalability, performance and availability, the Hitachi storage family optimizes support for critical applications, cloud-ready infrastructure and data center consolidations. With support for Hitachi Accelerated Flash, you can meet all your enterprise flash requirements with the Hitachi storage family.

Hitachi Virtual Storage Platform (VSP)

Hitachi Virtual Storage Platform was the first 3-D scaling storage platform designed for all data types. It is the only enterprise storage architecture that flexibly adapts for performance, capacity and multivendor storage. Combined with unique Hitachi Command Suite management software, it transforms the data center.

VSP G1000

Hitachi Virtual Storage Platform G1000 provides the always available, agile and automated foundation needed for a trusted continuous-cloud infrastructure. Powered with Hitachi global storage virtualization, its new software capabilities unlock IT agility and enable the lowest storage total cost of ownership (TCO).

VSP Family Midrange

VSP family midrange systems offer best-in-class flash performance to run workloads at their peak. Automated active flash-tiering responds rapidly to changes in the most active data. Industry-leading storage virtualization consolidates assets to reclaim space, extend life and reduce migration effort. Built with legendary Hitachi reliability, VSP provides nonstop access to data.

Hitachi Unified Storage VM (HUS VM)

Hitachi Unified Storage VM can manage all of your existing storage and consolidate all of your data in a single, virtualized platform to ease information management. HUS VM is built with trusted Hitachi reliability for application availability, lightning performance and lower cost of ownership. Delivering enterprise storage virtualization in a unified platform, HUS VM lets you manage information more efficiently.

Hitachi Unified Storage 150 (HUS 150)

Hitachi Unified Storage 150 is a midrange storage platform that enables businesses to meet stringent service level agreements for availability, performance and data protection. By delivering performance that is reliable, scalable and available for both block and file data, Hitachi Unified Storage simplifies operations and management and improves efficiency.

Summary: Turn the 5 Key Factors in Your Favor

Organizations face increasing performance demands for their business-critical applications. The I/O gap between server and storage performance has left enterprises turning to flash storage to provide the performance that applications demand. Not all flash storage is created equal, though, and determining what to look for in a flash storage solution can be a daunting task.

Examine flash storage from the perspective of the 5 key factors: device architecture, system architecture, data center architecture, performance and economy. This assessment will help you choose a storage platform that will deliver the performance and reliability your business-critical applications demand. It will also help you with the manageability and economy you need.

With Hitachi Accelerated Flash and Hitachi storage, you get not only superior performance, but also the scalability and reliability that make HDS an industry leader. Find out how the Hitachi storage family and Hitachi Accelerated Flash deliver what matters most to your storage infrastructure.

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WP-483-B DG April 2015