MAKING THE RIGHT FLASH MEMORY STORAGE ARRAY BUYING DECISION:

HP 3PAR StoreServ 7450 Delivers the Best of Modern, Next Gen Flash Memory Architectures and Proven Data and Storage Management Software Services

By DCIG Lead Analyst Jerome Wendt
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Executive Summary

Another seismic shift in data center infrastructures is underway. Much like the transition from physical to virtual that has occurred over the past decade, a similar transformation from HDD-based storage arrays to all-flash arrays is about to commence.

The big difference between the transition from physical to virtual machines and the forthcoming shift from HDD-based to all-flash arrays is that organizations will rarely have the luxury of first trial hosting their 2nd and 3rd tier applications on all-flash storage arrays. The performance and cost associated with these all-flash storage arrays immediately positions them for use with high performance, mission critical applications.

This makes upcoming storage array buying decisions even more critical than normal. Do organizations “play it safe” and stick with proven, HDD-based arrays? Or do they look to put in place a new, all-flash storage array that best positions them for the future?

Many organizations would prefer this latter all-flash storage array option assuming they can identify one that delivers the best of what both HDD-based and next-gen, all-flash storage arrays have to offer without their respective downsides. Those organizations who prefer this option will find the HP 3PAR StoreServ 7450 beckoning.

It provides the next-gen, all-flash storage array architecture that harnesses and delivers the performance that flash has to offer. It also facilitates the non-disruptive introduction of real-time, inline deduplication into production environments as well as the needed other storage management technologies that optimize and maximize available flash capacity.

Just as important, the HP 3PAR StoreServ 7450 brings forward the mature data and storage management software services from its pre-existing HDD-based storage arrays. This combination of a next-gen flash architecture and proven data and storage management software services gives organizations the flexibility and confidence to consolidate and host multiple applications and operating systems on a single all-flash storage array.

In so doing, organizations may leverage the HP 3PAR StoreServ 7450 to embrace the high performance future that all-flash storage arrays provide without putting either their data or infrastructure at risk.
An Extra Step in the Storage Array Buying Decision Process

Making a storage array buying decision from among the numerous products available on the market today has to rank as one of the most difficult decisions facing organizations today. Even before the recent flood of hybrid and all-flash storage arrays entered the market, DCIG had identified over 150 different midrange models available from over 30 different storage providers. The influx of hybrid and all-flash storage arrays only exacerbates the situation. Added together, these increase the number of storage array models from which organizations may choose to well over 250.

While numerous storage arrays exist, the reality is that the factors that influenced the purchase of a particular storage array a decade ago are just as relevant today as they were then. Affordability, availability, storage capacity, performance, reliability, resiliency, scalability and vendor support remain key criteria that organizations routinely evaluate before they purchase any new storage array. Yet before organizations can evaluate any of these criteria, they must first take an extra step in order to make a decision as to which type of storage array they want to introduce into their environment.

The Trade-Offs between HDD-based, Hybrid and All-flash Storage Arrays

The extra step that organizations need to take before evaluating these criteria is to first understand the underlying technologies that make-up each of the three storage array types shipping today and the potential trade-offs associated with each one. Consider how these storage arrays differ:

- **HDD-based storage arrays.** These are the original storage arrays upon which today’s new hybrid and all-flash storage arrays are often based. These HDD-based storage arrays primarily consist of hard disk drives (HDDs) with varying amounts of cache to accelerate reads and writes. The upside of these arrays is that they offer lots of capacity ranging from hundreds of terabytes to potentially petabytes of capacity at a comparatively low cost per GB. Further, since many of these arrays have been used for 10 years or more, they typically offer more mature data and storage management software services such as application programming interfaces (APIs), LUN and/or volume management, replication, thin provisioning, user admin GUIs and VMware vSphere integration.

The cautionary note with these arrays is that while they provide acceptable levels of performance for some applications, they have limited or no ability to deliver high levels of performance which is now defined as one millisecond or less response times.

- **Hybrid storage arrays.** Hybrid storage arrays seek to deliver the best of what both all-flash and HDD-based storage arrays have to offer at an affordable price point. By combining both technologies into a single array, the claim is that organizations get much higher levels of capacity than what is found in an all-flash array and much higher levels of performance than what is found on HDD-based array. These features are then delivered at a price per GB that is generally more than HDD-based storage arrays but far less than all-flash storage arrays.

The catch with hybrid storage arrays is that the quality of their data and storage software management services can be difficult to ascertain leaving organizations uncertain about their short and long term viability.

To optimize capacity and performance utilization, hybrid storage arrays use various algorithms to balance data placement across flash and HDDs. The efficiency and effectiveness of these algorithms typically cannot be known until the hybrid storage array is used in production. Further, the efficiency and effectiveness of data placement may vary over time as application workloads change or more data is added to the storage array.

- **All-flash storage arrays.** All-flash storage arrays theoretically remove all question marks about performance as all data is written and read from flash to ensure consistently high levels of application performance at all times.

These high levels of performance come with multiple trade-offs with the most obvious being price as the cost per GB of all-flash storage arrays is up to 10X more than HDD-based storage arrays. To lower these costs, a number of all-flash storage arrays offer different grades of flash memory as well as data compression and deduplication technologies to increase their usable capacity.

All-flash storage arrays are like hybrid storage arrays in that they both share the same concerns about the maturity of their data and storage management software services. Many of the all-flash storage arrays have been introduced in the last five years giving their software little time to mature or even be used in production environments.
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The trade-offs associated with these various storage arrays prompt organizations to acquire specific storage arrays that align with their various application requirements. They choose:

- HDD-based storage arrays for general purpose applications such as internal facing apps that have higher capacity requirements with low to moderate performance requirements.
- Hybrid storage arrays to achieve higher levels of capacity and performance at a lower cost per GB where data and storage management software services are not a primary concern.
- All-flash storage arrays to host high performance applications such as databases and/or virtual desktop infrastructure (VDI) initiatives.

Yet by following this bifurcated path, they inadvertently recreate the problem of data and storage silos. Organizations ideally want to create a private storage cloud so they can easily place or move data on/to the most cost-effective storage tier. Placing data on these different types of storage arrays negates this ideal.

A Perfect Storage World is All-flash

Eliminating these storage silos while simplifying the storage array buying decision is why, in a perfect world, many organizations view all-flash storage arrays as the ideal solution to their storage problems. These arrays already deliver the high levels of performance needed to meet the requirements of even the most demanding applications. However the costs and immature data and storage management software services associated with them still prompt many organizations to primarily use all-flash storage arrays as point solutions.

To transition from being a point solution to being used more broadly and even exclusively in data center environments, all-flash storage arrays must:

- Maintain their high levels of performance short and long term
- Drive their cost per GB down to where it is about the same price as a HDD-based storage array
- Scale their capacity into the hundreds of TBs or even petabytes
- Deliver mature data and storage management software services
- Facilitate the non-disruptive movement of existing data from HDD-based storage arrays (where most of today's data resides) to the all-flash storage array
- Be backed by enterprise level hardware and software support

Any all-flash storage array that can successfully incorporate all of these features into its product offering will immediately be ready to assume a broader role in, and be more warmly welcomed into, production data center environments.
The All-Flash Storage Array Product Landscape

Existing all-flash storage arrays as a group generally share the following four characteristics in common.

- **Cost more on a per-GB basis.** The average starting list price for all-flash storage arrays is typically at least US$50,000 with many storage vendors reporting that a fully configured all-flash storage array may top US$100,000. Further aggravating this price disparity, all-flash storage arrays typically ship with much less storage capacity than an HDD-based array. This can result in the cost per GB of an all-flash storage array being at least 2X and potentially as much as 10X more than an HDD-based storage array.

- **Highly available.** All of the all-flash storage arrays evaluated by DCIG ship in a highly available configuration with 81 percent of them able to configure their controllers as “Active-Active.”

- **High levels of performance.** While DCIG does not test or directly measure performance in its storage array assessment, many third party test results exist. Based on these publically available results, one may reasonably conclude that an all-flash storage array will outperform an HDD-based storage array by a factor of least 2X with some able to achieve performance multiples over HDD-based arrays of 10X, 50X and even higher.

- **Reliable flash management.** All of the all-flash storage arrays use a number of techniques to manage the specific idiosyncrasies of flash such as wear leveling and write amplification. Whether they use solid state drives (SSDs) or natively host and then manage the flash memory using their own software, they each take the appropriate steps to preserve data integrity.

It is in examining the individual attributes of each of the all-flash storage arrays that other disparities emerge that permit these storage arrays to be generally grouped as follows:

### Speed Demons

All-flash storage arrays that fall into the Speed Demon category deliver high levels of performance. However they are primarily intended for use by a single, performance hungry application such as a database whose performance can be analyzed with real-time analytics.

These all-flash storage arrays will have limited data and storage management software services. For example, many of these arrays offer limited or no integration with the VMware vSphere APIs for Array Integration (VAAI) or the vSphere APIs for Storage Awareness (VASA). Many also offer no options for data compression or deduplication and most only support the use of one storage network protocol at a time.

These all-flash storage arrays will also typically support lower maximum amounts of raw storage capacity. While all of them scale to support at least six TBs of raw capacity, the maximum for most of the all-flash storage arrays in the Speed Demon category is in the 30 – 70 TB range though at least one does scale to support 720 TBs of raw storage capacity in a clustered configuration. Examples of all-flash storage arrays that fall into this Speed Demon category are shown in the table below.

<table>
<thead>
<tr>
<th>Active-Active</th>
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<tr>
<td>Active-Standby</td>
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<tr>
<td>Dual Active</td>
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### Feature Rich Next Gen Flash Arrays

Like the all-flash storage arrays in the Speed Demon category, the all-flash storage arrays in the Feature Rich Next Gen Flash category are also optimized for performance. However these all-flash storage arrays differ in that they significantly increase the number of features supported by their respective data and storage management software services.

Products in this category typically support at least two storage network protocols such as iSCSI and FC and may even support them concurrently. Many of these all-flash storage arrays also support the VMware APIs (both VAAI and VASA.) Finally, data deduplication appears more regularly with about 50 percent of the models in this category offering this data reduction technology as an option.

The cautionary note with the Feature Rich Next Gen Flash category is the maturity of the data and storage
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Representative Feature Rich Next Gen Flash Arrays

<table>
<thead>
<tr>
<th>Array Name</th>
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<tbody>
<tr>
<td>Cisco Invicta</td>
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<tr>
<td>EMC XtremIO X-Brick</td>
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<tr>
<td>HP 3PAR StoreServ 7450</td>
</tr>
<tr>
<td>NetApp EF550</td>
</tr>
<tr>
<td>Nimbus Data Gemini F600</td>
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<tr>
<td>PureStorage FA-450</td>
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<tr>
<td>SolidFire SF9010</td>
</tr>
<tr>
<td>Tegile Zebi HA2800</td>
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<tr>
<td>Violin Memory Violin 6264</td>
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Representative General Purpose Arrays that Support SSDs

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<th>Raw Capacity (Max)</th>
<th>EMC VNX-F</th>
<th>HDS HUS VM</th>
<th>IBM Storwize v7000</th>
<th>NetApp FAS3250</th>
<th>AFA</th>
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Performance and Management Go Hand-in-Hand

Unfortunately data centers do not have the luxury of selecting only performance or only data and storage management software services and ignoring the other, especially if they want an all-flash storage array to serve in a multifaceted role. They need one that delivers on all of these features.

The all-flash storage arrays that better optimize flash’s performance capabilities typically have immature data and storage management software services. Those that offer more mature data and storage management software services typically have storage architectures that are less well suited to optimize flash’s performance and manage its particular idiosyncrasies.

The key for organizations is to identify which all-flash storage array is architected to optimize flash’s performance and deliver the most mature data and storage management services they need. To do so requires a deeper look into the architectures being used to deliver all-flash storage array solutions.

Tuning Flash for Long Lasting, High Levels of Performance

Delivering a high level of performance is typically the primary motivation for organizations wanting to acquire an all-flash storage array. This alone explains why many organizations opt for all-flash storage array models that use newer storage management software services on these models. As a number of these all-flash storage array models have been shipping for only a couple of years, organizations should verify how well the features work on each of these products and if they will hold up when hosting multiple applications in a production environment.

General Purpose Arrays that Support SSDs

The General Purpose category reflects those all-flash storage arrays that got their start as HDD-based storage arrays and now ship an all-flash model fully populated with SSDs. The upside here is that these storage arrays bring forward their existing data and storage management software services from their HDD-based storage array origins.

This maturity of this software is reflected below. Every one of these models supports both VAAI and VASA. With the exception of the IBM Storwize v7000, they also all support FC, iSCSI, concurrent SAN (FC and iSCSI) connectivity as well as a concurrent NAS/SAN configuration.

The catch with these all-flash storage arrays is that their controllers are generally not as well optimized and tuned for flash as the other next generation all-flash storage array models found in the other two categories. While the all-flash storage arrays in this category will still deliver superior performance over HDD-based arrays, they may significantly lag in the levels of performance that all-flash storage arrays in the other two categories can deliver.
architectures which are optimized to deliver high levels of performance for long periods of time. These array architectures optimize performance in at least two ways.

First, their storage array controllers use high bandwidth, low latency connections to the flash residing behind the controllers. These low latency interconnects facilitate the rapid access and retrieval of the data from the flash so the data may be quickly served up to the application requesting it. However, due to flash’s particular idiosyncrasies, improperly implementing flash can result in its available storage capacity being rapidly consumed and then the flash media quickly wearing out due to frequent rewrites of the media.

To counter this downside of flash, these all-flash storage arrays employ various technologies to manage and mitigate them. For example, one issue that all-flash storage arrays must manage is write amplification. Write amplification occurs on flash memory because of how it stores and updates data. Unlike HDDs, which can store small chunks of data on small, variable sized blocks of disk, flash memory must store data in a fixed block size. This could result in small blocks of data potentially consuming much larger amounts of available flash memory space.

To eliminate wasting so much space, all-flash storage arrays package multiple writes together into one larger block of data that matches, or aligns as closely as possible with, the fixed block size of flash memory. Packaging all of this data together and then writing it to the same block of flash memory minimizes or even eliminates the amount of space that is wasted. Block sizes as small as 4 – 8K on the latest generation of SSDs partially fix this problem as they minimize the amount of wasted space in a flash memory block that occurs during the initial write. However, the issue of write amplification re-emerges along with the potential for write endurance issues if data in the same flash memory block is constantly changed and updated.

Once data is written to a block of flash memory, data on that block cannot be changed or updated without first erasing and then rewriting the entire block with the updated data. This increases or amplifies the number of writes that can slow application performance. Further, over time, constantly writing, erasing and rewriting data can wear out a particular block of flash memory as each block is only rated to handle a certain number of writes.

The task of increasing the life of individual blocks of the flash memory again falls to the all-flash storage array. By monitoring how often writes, updates and rewrites occur to a particular block of flash memory and then employing wear leveling which spreads out the writes among all of the blocks on the flash memory storage, the storage array can increase the effective life of the flash memory.

By employing techniques like these, all-flash storage arrays can:

- Better optimize and deliver on the performance characteristics of flash memory
- Extend the life of the flash memory storage
- Preserve the integrity of the data stored on it

Examining Feature Rich Next Gen All-Flash Storage Arrays

Next generation, all-flash storage arrays are best positioned to deliver and optimize flash’s performance while delivering the full set of data and storage management software services that enterprises need. Products that are representative of this next generation of all-flash storage arrays include:

- Cisco UCS Invicta C3124A
- EMC XtremIO X-Brick
- HP 3PAR StoreServ 7450
- Pure Storage FA-450
- SolidFire SF9010
- Violin Memory Violin 6264

The features on these all-flash storage arrays reflect how utilizing flash exclusively and then tuning the controllers to manage and optimize flash can dramatically increase their performance. Whereas “Great” performance on an HDD-based storage array is considered to be in the 50 – 100,000 IOPs range, the published performance numbers of these representative next-gen all-flash storage arrays start at 200,000 IOPs and go as high at 7.5 million IOPs when deployed in a scale-out node design.

Granted, in most cases, the published performance numbers for these all-flash storage arrays are based on performance metrics and storage configurations that can rarely be achieved in real world deployments. However, these numbers do illustrate just how much better all-flash storage arrays perform than HDD-based storage arrays.
The features supported on these representative all-flash storage arrays also reveal the steps that these providers take to remove the cost and risks associated with flash. By supporting technologies such as data deduplication, wear leveling and wear monitoring, these all-flash storage arrays drive down flash’s cost by leveraging these technologies to store more data on the same amount of storage capacity while taking the appropriate steps to ensure data integrity.

Cautionary Notes

The cautionary note to anyone looking at all of these performance numbers and features is that organizations should not assume they will be able to achieve a particular performance benchmark and simultaneously increase their effective capacity as they may not be able to turn on supported data reduction features.

For instance, the EMC XtremIO with 8 X-Brick claims to be able to achieve up to 2 million IOPs. But to do so, organizations must have all 8 X-Bricks deployed, turn deduplication “Off” and then only run applications that do 4K reads. Likewise, to achieve 7.5 million IOPs using the SolidFire SF9010, an organization needs to deploy 100 SolidFire nodes, again using applications that only do 4K block reads with it. In this case, it is unclear but unlikely that it can achieve these performance benchmarks with deduplication turned “On.”

Part of the reason these all-flash storage arrays turn off data reduction features such as compression and deduplication is the overhead associated with performing them. While these technologies increase the effective capacity of these arrays, they can adversely affect performance by 20 percent or more. Further, some of these technologies are forced to switch to post-process when their controllers cannot keep up with the host IO demands.
Turning on compression and deduplication may even affect the scalability of these arrays over the long term. While a few all-flash storage arrays scale into the hundreds of TBs, many do not because of the requirement to keep the deduplication metadata database in memory. Due to the size of these deduplication metadata databases, these all-flash storage arrays place an upper limit on how much storage capacity they can support short and long term.

Another takeaway that organizations need to keep in mind is that all of these all-flash storage arrays are primarily intended for deployment in environments where block storage is used. Among these representative all-flash storage arrays, only the Cisco and HP all-flash storage arrays provide both NAS and SAN support.

Then even among these representative all-flash storage arrays that do support block storage protocols, they may not support all of them or may not support them concurrently. For instance, the SolidFire SF9010 currently only supports iSCSI (FC support for the SF9010 has been announced but not yet delivered.) Other all-flash storage arrays support both FC and iSCSI but may not support both of them concurrently.

The potential challenges with this representative set of next-gen all-flash storage arrays only continue to grow when the maturity and robustness of their data and storage management software is scrutinized. For instance, organizations may only be able to connect applications hosted on operating systems such as Red Hat Linux, Windows and/or VMware to these all-flash arrays.

While it is true that many if not most organizations run their applications on those three platforms, many midsize and enterprise shops still run some version of UNIX, other hypervisors such as Citrix XenServer, other versions of Linux such as SUSE Linux and potentially even an instance or two of OpenVMS. If running multiple operating systems, it behooves organizations to first verify they can connect them to the all-flash storage array in question as the HP 3PAR StoreServ 7450 is one of the few that supports all of them.

### Storage Network Protocols

<table>
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<tr>
<th>Storage Network Protocols</th>
<th>HP 3PAR StoreServ 7450</th>
<th>Cisco UCS Invicta C3124A</th>
<th>EMC XtremlIO 8 X-Brick Cluster</th>
<th>IBM FlashSystem 840</th>
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<th>SolidFire SF9010</th>
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### Operating Systems

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Finally, organizations should quantify the number of options these all-flash storage arrays provide for managing the array itself. As organizations continue to centralize and automate more of their data center management tasks, all-flash storage arrays are also subject to these same requirements. In these environments, simply having client/server applications, storage array consoles or Web-based GUIs may be insufficient. These environments need all-flash storage arrays that offer command line interfaces (CLIs), integration with VMware vCenter, support for OpenStack and REST APIs and potentially even access to a mobile application so they can meet these internal corporate mandates.

<table>
<thead>
<tr>
<th>Management Interfaces</th>
<th>HP 3PAR StoreServ 7450</th>
<th>Cisco UCS C3124A</th>
<th>EMC XtremIO 8 X-Brick Cluster</th>
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<td>✓</td>
<td>✓</td>
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</tbody>
</table>

**General Purpose Arrays that Support SSDs with a Proven Architecture**

Despite the large number of new all-flash storage arrays that are specifically architected to accommodate flash, existing general purpose storage arrays with proven architectures can still be configured as all-flash by populating their existing HDD slots with SSDs. Examples of products that do this include:

- EMC VNX-F
- HDS HUS VM
- NetApp E550 Flash Array

There are two major upsides of adopting this approach. First, the SSDs themselves internally handle the management of flash idiosyncrasies such as write amplification and write endurance alleviating the need of the array’s controllers to manage these tasks.

Second, and maybe more importantly, their existing, more mature data and storage management software services carry forward. Organizations can continue to use it to configure LUNs, create volumes, support multiple applications and operating systems, replicate data, create snapshots and essentially manage their data and storage in the same way that they did before the advent of flash.

While this approach sounds good on the surface, it quickly breaks down in real world deployments for the following three reasons:

- **Storage array controllers become performance bottlenecks.** The controllers on these arrays were designed to manage disk, not flash. As such, they cannot process data as quickly as the SSDs can store or deliver it. This results in significantly lower levels of performance than what a storage array architected for flash can deliver.

- **Limited to no ability to deliver next-gen data and storage management software services.** Features such as data compression and deduplication are rapidly becoming viewed as prerequisites on all-flash storage arrays to both increase flash’s effective capacity while lowering its cost per GB. However with the performance on these storage controllers already taxed by simply trying to keep up with the flash’s high levels of performance, this leaves little or no processing power for them to effectively and efficiently perform these tasks.
• **Storage array operating systems intended for management of HDDs—not SSDs/flash.** Array operating systems perform many background tasks that organizations rarely if ever see such as monitoring HDDs for errors, sparing out failed HDDs and maintaining RAID sets. While important functions, the need to run these routine and important background tasks to manage and maintain HDDs may be diminished or even non-existent when SSDs are installed.

**The All-Flash Predicament**

The trade-offs associated with these two general categories of all-flash storage arrays—next-gen all-flash arrays and HDD-based storage arrays populated with SSDs—illustrate the predicament that organizations find themselves in today. They want to implement the performance of flash into their environment but they also want the assurance that the all-flash storage array can be broadly used by the applications and operating systems in their environment.

The vast majority of all-flash storage arrays do not satisfy both of these criteria. As such, organizations often move ahead with a mix of point storage solutions consisting of all-flash, HDD-based and hybrid storage arrays until they can identify a single all-flash storage array that can satisfy all of these various concerns that they possess.

**HP 3PAR StoreServ: Next Gen Architecture with Proven Data and Storage Management Software Services**

A notable exception to the other storage arrays available on the market is the HP 3PAR StoreServ. Unlike other all-flash models, the HP 3PAR StoreServ has since its inception used an extensible, next generation storage architecture that can manage and optimize both current and future storage hardware technologies.

The extensible architecture of the HP 3PAR StoreServ makes it possible for it to manage SSDs without having to rewrite its entire storage array operating system or even introduce a new line of storage arrays. Since it uses application-specific integrated circuits (ASICs) to do storage processing, these ASICs can be programatically updated to recognize and capitalize on the performance features of flash.

Most of the other competitive storage arrays (both HDD-based and next-gen, all-flash storage arrays) on the market solely use Intel processors to handle storage processing. On the surface, using Intel processors would seem to make sense. By capitalizing on Moore’s Law the performance of Intel processors doubles approximately every 18 months providing a fairly predictable growth curve for storage processing while powering the array with a processor that is relatively economical.

The challenge that confronts storage arrays solely based on Intel processors is that these processors have limited to no awareness of the data or any means to inspect it. As a result, the responsibility of these tasks fall to the array controllers creating overhead as well as processing and scaling issues that are not easily addressed with the simple introduction of new software code.

The HP 3PAR StoreServ architecture avoids this shortcoming of arrays that solely use Intel processors. While the HP 3PAR StoreServ also uses Intel-based processors, it also includes ASICs. These ASICs ensure that capacity efficiencies such as zero block and thin deduplication can be efficiently delivered to manage and work with any type of storage technology. This creates an adaptable, future proof architecture as evidenced by the following.

**The HP 3PAR StoreServ’s Adaptability**

**Optimizing HDDs**

An example of the HP 3PAR StoreServ’s adaptability is evidenced in how it manages the particular idiosyncrasies of either HDDs or SSDs.

On the HDD side, the HP 3PAR StoreServ recognizes all of the available storage capacity on HDDs. Once recognized, it creates chunklets out of the available capacity on the HDDs and then combines the chunklets that reside on HDDs across the array to form individual virtual volumes.

As the chunklets in each of these virtual volumes may consist of capacity on most or all of the HDDs in the HP 3PAR StoreServ array, organizations experience benefits such as:

• **Improved performance.** Application performance is improved as each virtual volume utilizes the collective performance of all of the array’s HDDs. Since each virtual volume consists of chunklets that reside on each of these HDDs, data is spread across all of them improving read and write performance.
Making the Right Flash Memory Storage Array Buying Decision: HP 3PAR StoreServ 7450 Delivers the Best of Modern, Next Gen Flash Memory Architectures and Proven Data and Storage Management Software Services

- **Faster HDD recoveries.** All HDDs fail from time to time and every enterprise storage array accounts for that eventually. However, rather than reserving one or more HDDs as hot spares, the HP 3PAR StoreServ OS reserves a certain amount of capacity on each HDD for hot sparing.

In this manner, all of the performance on each of the HDDs is harnessed while still providing a means to safely recover from the occasional HDD failure. This technique actually facilitates faster HDD rebuilds should an HDD fail with less performance impact since all of the HDDs in the HP 3PAR StoreServ participate in the rebuild of a failed drive.

**Optimizing SSDs**

In the same way that the HP 3PAR StoreServ arrays optimizes data placement on HDDs according to the specific requirements of HDDs, the HP 3PAR StoreServ 7450 accounts for, manages and even takes advantage of the specific idiosyncrasies of SSDs.

For example, SSDs ship from the manufacturer with extra, pre-reserved internal storage capacity to handle tasks such as wear leveling and recovering from the internal failure of small blocks of flash memory. Since each SSD in the array handles these routine maintenance tasks, the HP 3PAR StoreServ 7450 can better optimize the available capacity on each SSD.

To do so, HP first worked with SSD suppliers to reduce the amount of overprovisioned space on the SSDs that are used inside of the HP 3PAR StoreServ 7450. The HP 3PAR StoreServ 7450 then uses its system wide sparing technology to release additional space on each SSD to manage its wear. Using this technique, organizations get up to 20 percent more SSD capacity without paying a price in terms of wear endurance.

The ASICs on the HP 3PAR StoreServ 7450 then complement the native wear-leveling algorithms found inside the SSDs to help extend their life. By using its chunklet technology, it spreads write-intensive blocks of data across the SSDs in the system so a single SSD is never overwhelmed or worn out too quickly. Rather, SSDs wear out more evenly to ensure a longer life for all of them.

**Making cMLC SSDs Enterprise Ready**

The HP 3PAR StoreServ 7450 has for some time supported SLC (single level cell), MLC (multi-level cell), and eMLC (commercial grade multi-level cell) SSDs to help extend their life. By using its chunklet technology to spread data across all of the cMLC SSDs in storage arrays used in enterprise environments.

<table>
<thead>
<tr>
<th>SSD</th>
<th>Cost/GB</th>
<th>Write Endurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLC</td>
<td>$20-25/GB</td>
<td>Up to 300,000 writes</td>
</tr>
<tr>
<td>eMLC</td>
<td>$7-9/GB</td>
<td>Up to 30,000 writes</td>
</tr>
<tr>
<td>cMLC</td>
<td>$3-5/GB</td>
<td>Up to 3,000 writes</td>
</tr>
</tbody>
</table>

Source: Red Herring®

The significance of the HP 3PAR StoreServ 7450’s support for cMLC SSDs is two-fold. First, at $3/GB, cMLC SSDs cost about one third to one half of what eMLC SSDs cost and about one seventh of what SLC SSDs cost. This dramatically lowers the price point at which organizations can introduce flash technology into the HP 3PAR StoreServ 7450.

Second, the HP 3PAR StoreServ 7450 manages the writes to these cMLC SSDs to maximize their life expectancy. cMLC SSDs have a much lower write endurance cycle than the other SSD types (one tenth to one hundredth) which makes them prone to wearing out more quickly in write intensive environments.

To decrease the odds that these cMLC SSDs wear out, the HP 3PAR StoreServ 7450’s system wide striping technology is used to spread data across all of the cMLC SSDs in the system. In this way, all of the cMLC SSDs wear equally. Write I/Os to each cMLC SSD are then optimized using the HP 3PAR Adaptive Write technology with each cMLC’s endurance further improved using the HP 3PAR’s Adaptive Sparing technology. By coupling these technologies with the write endurance features already present in the cMLC SSDs, the life of each cMLC SSD is significantly increased.

**A Longer Life is the New Reality**

Despite all of the concerns raised about the durability of each SSD type (SLC, eMLC or cMLC,) the early feedback indicates that SSDs are up to 3X more reliable than HDDs as they fail 1.5 percent of the time or less as opposed to HDDs which fail about 5 percent of the time.2 The biggest

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factor contributing to this increased SSD reliability is that they have no moving parts. This makes them less prone to break since they do not vibrate and generate less heat than HDDs.

This improved SSD reliability may also give all-flash storage array providers new motivation to lengthen their SSD product warranties. Most organizations are still transitioning from HDD-based arrays, where performance is measured in milliseconds, to all-flash arrays where performance is measured in microseconds. This provides little motivation to upgrade in the near term solely for the purpose of improving performance.

As such, organizations may want longer standard warranties for the array’s flash drives to match their expected longer life. While a number of providers offer extended warranties for a price, only the HP 3PAR StoreServ 7450 now includes a standard 5 year warranty for its SSDs to match their longer life expectancies.

This 5 year warranty includes the replacement of cMLC drives. HP can make this guarantee based on how well the HP 3PAR StoreServ 7450 manages wear leveling. This 5 year replacement guarantee exceeds even what the cMLC SSD manufacturers offer.

### Flash Drive Warranties

<table>
<thead>
<tr>
<th>Model</th>
<th>Warranty</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP 3PAR StoreServ 7450</td>
<td>5 Years</td>
</tr>
<tr>
<td>Cisco UCS Invicta C3124A</td>
<td>1 Year</td>
</tr>
<tr>
<td>EMC VNX-F</td>
<td>3 Years</td>
</tr>
<tr>
<td>EMC XtremIO 8 X-Brick Cluster</td>
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<td>HDS HUS VM</td>
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<td>IBM FlashSystem 840</td>
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<tr>
<td>NetApp E550 Flash Array</td>
<td>3 Years</td>
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<td>Pure Storage FA-450</td>
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<td>Violin Memory Violin 6264</td>
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### The Challenges of Delivering Inline Data Reduction on a High Performance Production Storage Array

The use of data reduction technologies such as compression and deduplication to reduce storage costs are nothing new. Tape drives have used compression for decades to increase backup data densities on tape while many modern deduplicating backup appliances use compression and deduplication to also reduce backup data stores. Even a select number of existing HDD-based storage arrays use data compression and deduplication to minimize data stores for large amounts of file data stored in archives or on networked attached file servers.

The challenges of using these two technologies change when they are implemented in high performance environments. The more predictable data access patterns with lots of redundant data that exist in archive, backup, and, to some extent, file serving environments are replaced in high performance environments with applications that potentially have highly random data access patterns where data does not deduplicate as well. Capacity reductions of production data are not as significant (maybe in the 2 – 3X range) as in backup which can achieve deduplication ratios of up to 8 – 20X or even higher.

Aggravating the situation, there is little to no tolerance for performance interruptions in the processing of production data – raw or deduplicated. While organizations may tolerate the occasional slow periods of deduplication performance for archive, backup and file servers, data stores, consistently high levels of application performance with no interruptions are the expectations when used in production.

Yet when it comes to deduplicating data, there is a large potential for a performance hit. In high performance production environments with high data change rates and few or no periods of application inactivity, all deduplication must be done inline. This requires the analysis of incoming data by breaking packets of data apart into smaller chunks, creating a hash and comparing that hash to existing hashes in the deduplication metadata database to determine if that chunk of data is unique or a duplicate.

If the array determines a chunk of data is a duplicate, there is also a very small chance that a hash collision could occur. Should the all-flash array fail to detect and appropriately handle this collision, data may be compromised.

These expectations for high levels of data integrity and performance requires large amount of cache or DRAM to host the deduplication metadata. Yet all-flash storage arrays only contain fixed amounts of DRAM. This may limit the maximum amount of flash storage capacity on the array as it makes no sense for the array to offer flash storage capacity beyond the amount of data that it can effectively deduplicate.

These all-flash array capacity limits are reflected in the results of the most recent DCIG 2014-15 Flash Memory Storage Array Buyer’s Guide. Of the 36 all-flash array models evaluated, only 42 percent of them could scale to 100 TB or more of flash capacity. Of these models that could scale to more than 100 TB, they:

- Did not support the use of data deduplication at the time the Guide was published
- Did not publicly publish any performance data with deduplication turned “On” implying that they recommend turning deduplication “Off” when hosting performance sensitive applications
- Use scale-out architectures with high node counts (up to 100) that are unlikely to be used in most production environments

The need to scale to 100 TBs or more of flash storage capacity is quickly becoming a priority. HP reports that already 25% of its HP 3PAR StoreServ 7450 all-flash arrays ship with 80TBs or more of raw capacity as its customers want to move more than just their high performance production data from HDDs to flash. They want to store all of their production data on flash. Further, turning deduplication off for any reason when hosting high performance application on these arrays is counterintuitive since these arrays are specifically designed and intended to host high performance applications.
HP 3PAR StoreServ 7450 Lets Organizations Turn Deduplication “On”

Perhaps the one feature that organizations want to utilize on all-flash storage arrays more than any other is deduplication. Due to the relatively high per GB cost of flash, deduplication can increase flash’s effective capacity utilization by up to 3X or more which, in turn, reduces flash’s effective cost per GB by the same multiplier.

Already 33 percent of all-flash storage array models support inline, block-level deduplication. However offering deduplication as a feature on an all-flash storage array and having the flexibility to turn it “On” without negatively impacting high performance workloads are very different issues.

The HP 3PAR StoreServ 7450 now implements inline, block-level deduplication in such a way that organizations may turn it “On” without negatively impacting performance. To make this possible, the HP 3PAR StoreServ 7450 includes four key features to make this a reality:

1. **ASIC natively generates a hash signature.** The ASIC used in the HP 3PAR StoreServ 7450 has always natively included the capability to generate the hash signatures that deduplication algorithms need to assess data uniqueness. HP is now turning this hashing capability “On” as there are now business and technical demands for this feature functionality.

2. **Uses a fixed 16KB block size for deduplication.** One of the many challenges associated with deduplication is establishing the “right” size block or chunk of data to deduplicate. Make the chunk size too large and the data does not deduplicate well or at all. Make the chunk too small and there are too many matches which creates a deduplicating metadata database that is too large to store in cache. Using a 16KB block size keeps the deduplication metadata database manageable while still achieving a data reduction ratio of about 4:1 in most environments.

3. **Fast, proven metadata database management.** Data deduplication creates a large metadata database that associates a unique hash with a chunk of deduplicated data. This results in two performance hits. First, when a hash is calculated on incoming data. Second, when a lookup for a hash match in the metadata database occurs.

4. **Application performance without compromising data integrity.** An ASIC that natively does deduplication coupled with an in-memory deduplication metadata database takes an all-flash storage array 99 percent or more of the way toward being able to deliver the type of inline deduplication experience that high performance applications expect.

The ASIC’s built-in XOR and Zero Detection technology on the HP 3PAR StoreServ 7450 allows it to fully verify a dedupe hit by doing an inline bit-to-bit compare before marking a new write update as a duplicate. This is done by reading the match on the SSD and performing an XOR with the potential duplicate in cache. If equal, the XOR will produce a page of zeros. This page is detected inline by the ASIC with the new write update marked as a deduplication hit and no data written to the backend.

The net result of using these four pre-existing technologies that have been a part of the HP 3PAR StoreServ 7450 for many years and coupling them with deduplication means that organizations can confidently turn deduplication “On” in the high-performance environments into which the HP 3PAR StoreServ 7450 array is being deployed.

Most other all-flash storage arrays are, in most cases, attempting to do metadata database management for the first time. Conversely, the HP 3PAR StoreServ has a relatively long history of metadata database management. It has for years used a metadata database to handle the management of its thin provisioning technology without any discernable impact on application performance.

To accomplish this feat for both its thin provisioning and its deduplication metadata databases, the HP 3PAR StoreServ 7450 stores the deduplication metadata database in its available cache while reserving a portion of the SSD capacity for overflow should the metadata database exceed the size of its available cache. By the ASIC first doing the hash calculation and then immediately checking to see if the hash exists in the metadata database, the HP 3PAR StoreServ 7450 can do inline deduplication with no discernable application performance impact.
Making the Right Flash Memory Storage Array Buying Decision: HP 3PAR StoreServ 7450 Delivers the Best of Modern, Next Gen Flash Memory Architectures and Proven Data and Storage Management Software Services

Enterprise data center infrastructures have just undergone a huge transition by moving from the physical world of the early 2000’s to the largely virtual world of today. Now they are about to experience a similarly transformative experience as they move from the HDD-based storage world of the early 2010’s to the high performance, all-flash based storage world that will predominate in the late 2010’s and beyond.

Turning deduplication “On” in the HP 3PAR StoreServ 7450 immediately gives organizations access to a 4X and potentially up to a 10X increase in logical capacity. Proven Data and Storage Management Software Services Come Along for the Ride

Achieving up to a 10X increase in the total amount of logical capacity available on the HP 3PAR StoreServ 7450 opens the door for organizations to utilize it for more than just high performance applications. The combination of cMLC SSDs, deduplication and thin provisioning technologies brings the HP 3PAR StoreServ7450 down to a per GB price point that is on par with HDD-based arrays with performance that is 3 – 10X greater. Further, with how it manages its deduplication metadata database, organizations can affordably scale its logical capacity to a point that meets and exceeds even what HDD-based arrays can deliver.

It is as organizations look to use the HP 3PAR StoreServ 7450 in this broader context that they will want it to deliver other features beyond it being just highly available, highly performing and highly reliable to host their applications. They also want it to be:

- Manageable
- Multi-protocol
- VMware compatible
- Proven

In other words, organizations want their storage array to work in the background without incident. The HP 3PAR StoreServ 7450 fits this storage system profile. It carries forward the same full-featured, mature and proven data and storage management software services that have been used for over a decade in highly available, mission critical, virtualized data centers around the world.

Its data and storage management software offers the full gamut of features that organizations expect an enterprise ready storage array to deliver. It includes array diagnostics, is fully certified with a wide breadth of both operating systems and hypervisors and offers some of the most robust replication and snapshot software available on storage arrays.

Among its peers in these arrays, it continually tops the list. DCIG consistently awards both HP 3PAR StoreServ’s data and storage management software services and its integration with VMware vSphere Best-in-Class or Recommended ranking in nearly every storage array-related Buyer’s Guide released by DCIG.

Performance without Compromise: The HP 3PAR StoreServ 7450

The HP 3PAR StoreServ 7450 includes the proven data and storage management services that organizations need to justify hosting more than just a few high performance applications on it. The availability of its Priority Optimization software, which gives organizations the flexibility to prioritize and manage the workloads associated with different applications, and Peer Persistence software, which frees organizations to move hosts and data across data centers without impacting business applications, ensures...
that organizations get more than just flash’s high levels of performance. They get a storage platform upon which they can build their business.

With its unique single architecture strategy, HP offers flash-focused optimizations to its entire 3PAR portfolio. Consequently, 3PAR 7200 and 3PAR 7400 are equally capable and flash-optimized arrays as the 3PAR 7450, the only difference being in terms of performance scalability. The HP 3PAR StoreServ 7450 delivers 900,000 IOPS, while the HP 3PAR StoreServ 7400 delivers 600,000 IOPS and the HP 3PAR StoreServ 7200 delivers 250,000 IOPS, all at sub-millisecond latencies.

Organizations no longer have to wait months or years to deploy an all-flash storage array into their environment to host their applications. The technologies in this most recent iteration of the HP 3PAR StoreServ 7450 ensure that organizations get the performance they need, the cost at which they need it and the platform stability to offer it up to as many applications as they see fit. By taking advantage of the HP 3PAR StoreServ 7450 platform, organizations may confidently begin their journey into the all-flash world of tomorrow today with the knowledge that it will meet their various manageability, performance and scalability requirements along the way.