HPE 3PAR StoreServ Storage: optimized for flash

Making sound flash storage decisions
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Understanding the real advantages of flash

There are good reasons to be excited about the use of flash-based storage within your enterprise. Flash-based media such as solid-state drives (SSDs) can deliver exceptional performance when used in enterprise storage systems, resulting in excellent application response times and much improved power efficiency as compared to conventional spinning disks.

This, in turn, can help organizations like yours to control operational costs by doing more with less. For example, 10 SSDs can potentially deliver performance equivalent to 500 hard disk drives (HDDs), allowing you to reduce both storage footprint and power consumption for significant OPEX savings.

Flash-based storage not only provides excellent performance and a compact footprint, but it can support your most demanding virtualized cloud environments as well as online transaction processing (OLTP), client virtualization, business analytics, and other highly specialized and demanding applications.

Yet, for those considering deploying flash-based storage within the enterprise data center, it is critical to understand that not all flash-based storage systems are created equal. The discrepancies between seemingly similar flash storage platforms may be greater than you think. For this reason, it is important to gain a clearer understanding not just of the differences between flash-based storage media implementations, but the architectures that support them. How are the systems that support them designed to take advantage of the inherent strengths and weaknesses of flash? How do they address challenges around flash-based media management? And how do these architectures fit into your near- and long-term business and data center strategies?

In this white paper, we will begin by looking at HPE's flash design strategy and how it differs from other vendors. Then we will present the architectural requirements for delivering real advantages in flash-based storage performance, efficiency, resiliency, and data mobility. We'll also unveil the technical details of the latest generation of HPE 3PAR StoreServ Storage arrays—the only family of flash arrays in the industry to deliver the performance advantages of a flash-optimized architecture without compromising Tier-1 resiliency, rich data services, or application availability.

HPE 3PAR StoreServ Storage: optimized for flash

Available in a range of models and configurations to fit your business needs, HPE 3PAR StoreServ Storage offers a single, flash-optimized architecture that gives you a choice between: all-flash arrays and all-flash starter kits; converged flash arrays that support low-cost spinning media in addition to flash; and tiered storage arrays capable of extending DRAM cache onto SSDs for application acceleration. Other storage architectures cannot offer this range of deployment options (figure 1), which provide you with a high degree of flexibility and adaptability as your needs change over time—all with the same operating system, the same management interface, and the same robust set of data protection options.

![Figure 1. HPE 3PAR StoreServ Storage Family](image)
Whether you choose a midrange model such as the all-flash 8450 or a member of the enterprise flash series such as the all-flash 20850 (figure 2), you get the only all-flash array on the market with a single operating system spanning the entire family, providing Tier-1 resiliency and the same set of enterprise-class data services across the family.

### Predictable and assured performance

Enable massive consolidation and tier-1 application performance under 600 microsecond latency

- Consistently low latency up through 2M+ IOPS
- Multi-controller scale and system-wide striping
- Quality of Service by application or tenant

![Graph showing predictable and assured performance with all-flash HPE 3PAR StoreServ 20850 Storage](image)

**Figure 2.** Predictable and assured performance with all-flash HPE 3PAR StoreServ 20850 Storage

**The flash-optimized architecture**

Some flash solutions currently targeted at enterprises come saddled with serious deficiencies. For example, one common approach takes general-purpose, enterprise-class storage arrays and retrofits them with SSDs, commonly producing performance bottlenecks that can limit performance, consolidation, and scalability. This is due to controller architectural limitations that cannot be addressed without a system redesign.

On the other hand, there are a number of companies, mostly start-up ventures that are developing or have developed purpose-built, flash-optimized appliances to address this exact limitation. This class of systems does improve performance with architectures built specifically to overcome the bottlenecks of legacy storage architectures. However, this approach poses another set of limitations. The trade-off for customers is that they must accept another completely separate and distinct storage architecture into their data centers—one that often asks them to compromise Tier-1 resiliency and rich data services. It also doesn’t take into account the implications of flash on data protection, thereby creating an additional silo and making the storage environment even more complex.

The issue is that both of these alternatives have serious and unacceptable limitations. Instead, what is needed is a flash-optimized storage architecture that does not ask organizations to compromise on performance, Tier-1 resiliency, rich data services, cost, or simplicity. An architecture optimized for flash that provides superior performance, efficiency, and media endurance without adding a layer of complexity to your data center. An architecture that takes into account the implications of flash on data protection.

“If it wasn’t evident when flash first came on the scene a few years ago, it is now clear that flash technology is not simply a replacement for spinning media. Smart introduction of flash changes everything for a business, not just for IT.”

– Arun Taneja, Founder and President, Taneja Group

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1 Data protection designed with flash in mind, Taneja Group, August 2015.
Design requirements for flash

To build a storage system designed to make the most of flash, it is first important to understand how flash is fundamentally different from spinning media. Table 1 highlights the key differences between flash (in this case, SSD) and HDD media characteristics, and the implications of those differences on storage architectures.

Table 1. HDD vs. SSD characteristics, and the architectural implications of their differences

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>SPINNING MEDIA/HDDS</th>
<th>FLASH MEDIA/SSDS</th>
<th>ARCHITECTURAL IMPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical latencies</td>
<td>In milliseconds</td>
<td>In tens of microseconds</td>
<td>Read/Write cache management</td>
</tr>
<tr>
<td>IOPS density (IOPS/GB)</td>
<td>0.2 IOPS/GB (e.g., –180 IOPS with 900 GB 10K drive)</td>
<td>100 IOPS/GB (e.g., –40,000 IOPS in 400 GB)</td>
<td>Performance scalability</td>
</tr>
<tr>
<td>$/GB</td>
<td>$0.8–$1/GB</td>
<td>5–10X HDDs (raw $/GB)</td>
<td>Storage efficiency</td>
</tr>
<tr>
<td>Media write cycle</td>
<td>Virtually unlimited (hundreds of millions)</td>
<td>5,000 to 15,000 write cycles</td>
<td>Wear handling</td>
</tr>
<tr>
<td>Failure modes</td>
<td>Mechanical/Electronic</td>
<td>Electronic/Flash</td>
<td>Failure handling and reconstruction</td>
</tr>
</tbody>
</table>

The architectural implications reveal that, to make the most of flash-based media, the storage system architecture must not only optimize the I/O path, but also take into account the media wear-out characteristics of flash. And while performance and capacity efficiency optimizations are necessary, they are not sufficient to make a system ready for deployment. Then there are the implications of flash on system resiliency and data protection. Flash enables you to massively consolidate your most demanding, often mission-critical applications thanks to superior performance, and density, but this can have the unintended consequence of raising the stakes when it comes to resiliency and data protection. With greater consolidation of mission-critical applications, it’s critical that your system features Tier-1 resiliency paired with a data protection solution that is able to protect all of this data within your given window and recover it within seconds if something goes wrong. This means rethinking data protection.

The bottom line is that, in order to make the most of flash technology—and deliver all of the associated payoffs—your storage architecture needs to meet four key design requirements: performance, efficiency, system resiliency, and data mobility (figure 3). Throughout the rest of this paper we will take a closer look at each of these areas and what is required to support data centers infrastructure as companies undergo fundamental IT shifts to support the New Style of Business.
Performance acceleration—optimizing the entire I/O path

If the storage controllers that sit between your servers and back-end flash devices can't keep up with the performance of your flash drives, they can become performance bottlenecks. Accelerated IOPS at low latencies, made possible by flash media, means little if you don't have the right architecture in place to fully realize the performance potential of your flash media. Unless you have a storage architecture that avoids bottlenecks in the entire I/O path—including controllers, cache, and firmware—your applications won't fully benefit from flash. This means that, in order to take advantage of the accelerated IOPS delivered by flash media, the architecture must scale beyond just dual-controller designs in order to provide greater headroom for performance scalability. And to serve hundreds of thousands of IOPS within a very small latency band, cache management for I/O operations becomes critical.

While legacy or traditional architectures have had a difficult time adapting their designs for flash, HPE 3PAR StoreServ Storage is the ideal architecture for flash in that the system is built to be both massively parallel and efficient, so it can take full advantage of flash-based media. With classical attributes such as multi-controller scalability, a highly virtualized operating system with three levels of abstraction, system-wide striping, and a highly specialized ASIC now in its fifth generation, HPE 3PAR StoreServ Storage is designed to take full advantage of flash-based media.

This architecture removes bottlenecks that prevent legacy storage from taking full advantage of flash, easily delivering 5–10X accelerated performance as compared to HDD-only systems, along with sub-millisecond latency\(^2\) through a flash-optimized architecture that relies on several unique HPE 3PAR StoreServ design innovations described below.

Flash-optimized cache algorithms

To drive accelerated performance at low latency, the HPE 3PAR Architecture implements several optimizations to its caching algorithms.

Adaptive Read and Write

Adaptive Read and Write is a software innovation that enables a more granular approach than with spinning media by matching host I/O size reads and writes to flash media to avoid unnecessary data reads and writes. This significantly reduces latency and optimizes back-end performance to enable more applications to be consolidated.

Adaptive Read (from Flash to Cache)

In HDD configurations, data is read into cache in fixed-block sizes of 16 KB. This is useful in an HDD world because reads are slow and once a read opportunity is available, reading more data increases the chance of future cache hits, thereby lowering the latency of future I/O. With flash media, reads are extremely fast (no spinning mechanical parts) and the penalty of a read miss is minimal. Given this attribute of reading from flash, the HPE 3PAR Architecture reads only the right amount of data into cache (figure 4). As the size of the cached data is adapted to the originating host I/O request (as opposed to the system cache page size)—the resulting benefits are:

- Greatly optimized read latency—with I/O-intensive workloads, typically true with flash environments, for a 4 KB I/O, only a 4 KB block is read in cache, not 16 KB. This reduces the time required to complete a read operation.

- More efficient back-end throughput—a smaller cache page read also optimizes back-end throughput, enabling higher IOPS without hindering the back-end throughput handling. For example, 1000 4 KB reads to flash result in 4 Mbps of back-end throughput, not 16 Mbps of throughput, which would be the case if minimum cache page read granularity was 16 KB.

\(^2\) Based on Hewlett Packard Enterprise internal testing using public domain I/O subsystem measurement and characterization tools with the HPE 3PAR StoreServ 7450 Storage System, 100 percent random read I/O, and a 4K block size.
Adaptive Write (from Cache to Flash)

The HPE 3PAR Architecture supports a granular cache page size of 16 KB. However, if a sub-16 KB write I/O hits cache, and consequently only a part of a cache page becomes dirty (is written to), only the dirty part of the cache page is written to the flash on the back end. The HPE 3PAR Architecture achieves this by keeping a bitmap for each cache page, and while writing from cache to flash, writes only the changed part of the cache page to flash media (figure 5). This optimization helps HPE 3PAR StoreServ Storage reduce writes to flash media (thereby elongating media life) and at the same time, optimizes back-end throughput with only the required amount of data being sent to the back end.
**Autonomic Cache Offload**

Autonomic Cache Offload is another flash software-based optimization that eliminates cache bottlenecks by automatically changing the frequency at which data is offloaded from cache to flash media based on utilization rate and without requiring any user intervention. This ensures consistently high performance levels as you scale workloads to hundreds of thousands of IOPS. With the HPE 3PAR Architecture, write I/O coming into the array is acknowledged to the host as soon as I/O gets written to cache (and gets mirrored for protection). That I/O sitting in cache then gets flushed to the storage media. The HPE 3PAR Architecture autonomically adjusts the rate of offload from cache to flash based on cache utilization. At higher levels of utilization, HPE 3PAR StoreServ Storage increases the frequency at which the flushers are run. This allows the storage system to deliver consistent performance without running into cache bottlenecks, even at more than a million IOPS.

Another important aspect of the cache offload algorithm is the decision around which cache data should be flushed to the back end, and which should not. HPE 3PAR StoreServ Storage keeps track of read cache hits and keeps more frequently accessed, or hot data in cache, thereby lowering latencies. In addition, for handling flash, flusher threads have been added to HPE 3PAR cache management so it can perform more operations in parallel.

**Multi-tenant I/O processing**

Multi-tenant I/O processing innovations enable performance optimization for mixed workloads and virtual desktop infrastructure (VDI) deployments by breaking large I/O into 32 KB sub-I/O blocks (figure 6). This prevents small read I/O chunks from getting held up behind large I/O requests, therefore assuring reduced latency. Breaking large sequential read I/O into sub-I/O chunks distributes these reads and lowers the possibility of smaller transactional read I/O operations getting held up because of a previous large read I/O operation, therefore ensuring consistently low latency for transactional I/O, even in mixed workload scenarios.

![Figure 6. HPE 3PAR StoreServ Storage multi-tenant I/O processing](image)

Another important aspect of the HPE 3PAR StoreServ caching algorithm is how it handles large write I/O. As mentioned earlier, writes are acknowledged to host as soon as they are written to cache (and mirrored). If the writes are large, the HPE 3PAR StoreServ caching algorithm allocates cache pages (16 KB) as the pages become available, without waiting for all the necessary pages to become available all at the same time. For example, for a 128 KB write I/O that requires eight cache pages, writes can be started even when just one cache page is available and eventually finished when all eight cache pages have been written to. This allows HPE 3PAR StoreServ Storage to improve upon its write latency, which is crucial when delivering hundreds of thousands of IOPS.

**Flash-optimized architectural elements**

In addition to the way that caching is handled, several elements of the architecture itself—from the custom-built ASICs to the highly virtualized operating system—carry flash-optimizing benefits. Two of the overarching benefits of these architectural innovation are market-leading density of 5.5 PB usable in a single floor tile and market-leading scalability in an all-flash array of up to 15 PB usable in a single system (figure 7).
Polymorphic simplicity
HPE 3PAR StoreServ Storage underscores how an effective storage architecture can work with a multitude of media types, protocols, and use cases such as HDDs/SSDs, SATA/SAS, block/file, and midrange/enterprise flash storage. This flexibility gives you the advantage of working with and managing a single storage architecture. Unlike competitors that take the approach of developing point architectures for each use case and forcing their customers to spend time and money over and over again in learning and managing all those different architectures, HPE 3PAR StoreServ Storage has a foundation that can meet all of your demands—both present and future. As a result, adding an all-flash array to your environment doesn't mean adding a whole new architecture.

And adding a flash array to your environment doesn't mean you can no longer support spinning disks. HPE 3PAR StoreServ Storage gives you a choice between all-flash arrays and converged flash arrays that offer the same architecture and performance, but with the added flexibility of supporting spinning media in addition to flash. All models also support the option to enable file protocol and object access support by enabling the File Persona via the associated software suite. With this flexibility, you obtain lower storage acquisition and maintenance costs and reduced storage complexity, and you get increased agility to support business goals.

HPE 3PAR Gen5 Thin Express ASIC
In the HPE 3PAR Architecture, transactional and throughput-intensive workloads are able to run on the same storage resources without contention thanks to the HPE 3PAR Gen5 Thin Express ASIC, which offloads some of the work of the controllers, allowing them to process smaller I/O without inordinate delay due to large block I/O. This is important, because precious CPU cycles are not wasted for data movement; instead the CPU cycles are available for delivering advanced Tier-1 data services.

In contrast to the ASIC-less architectures of traditional storage vendors, including most of today's all-flash arrays, this allows HPE 3PAR StoreServ Storage to deliver consistent performance even in mixed workload scenarios (figure 8). You benefit from consistent, accelerated performance even with simultaneous transactions and throughput-intensive workloads without compromising on service levels. ASIC-less architectures are challenged with having the necessary CPU cycles to deliver advanced data services.
The HPE 3PAR Gen5 Thin Express ASIC featured in the 8000 and 20000 series models is enhanced over previous generations and designed for solid-state performance, featuring faster communication across the cluster with double the inter-cluster bandwidth in each direction. The ASIC enables the new 20000 and 8000 series to deliver over 5X improvement in system bandwidth and faster XOR operations. It offloads CPU and evenly spreads I/O workload, ensuring lower latency. The HPE 3PAR Thin Express ASIC also comes with a new powerful data deduplication engine which powers inline deduplication for block workloads without compromising performance or scale.

Higher memory bandwidth is the result of two memory channels per ASIC (of which each node has two) and 42 Gbps peak data cache bandwidth per node—25 times that of the previous generation—which allows the ASIC to churn out larger amounts of data in shorter periods of time, contributing directly to the backend bandwidth of the array. Inter-node connectivity links have been upgraded and an additional Direct Memory Access (DMA) engine has been added to each ASIC to help accelerate RAID calculations. With DMA, the Gen5 ASIC optimizes latency associated with write I/O, which is acknowledged to the host once that I/O has been written to the local cache (where the I/O arrived) and has been mirrored to a partner node. The data mirroring happens using the high-speed PCIe links that form the full mesh. The local ASIC copies data to the ASIC on the partner node while the local CPU sends the transaction log via DMA (direct memory access) for that I/O to the partner CPU memory without interrupting the partner CPU. This DMA capability avoids the need for additional CPU interrupts, making the partner CPU a passive participant in this entire operation and consequently results in a much more latency-efficient write process.

Mesh-Active cluster

The Gen5 ASIC is responsible for spreading I/O workloads evenly across up to eight nodes in a Mesh-Active, scale out architecture designed for flash. This Mesh-Active controller design is unlike legacy controller architectures, where each volume is active on only a single controller. Instead, the Mesh-Active design allows each volume to be active on every mesh controller in the system at all times (figure 9). This design delivers robust, load-balanced performance and greater headroom for cost-effective performance scalability. A high-speed, full-mesh interconnection joins multiple controller nodes to form a cache-coherent, always active-active cluster. As a result, with this Mesh-Active design, you obtain symmetrical load balancing and utilization of all controllers and seamless performance scalability by adding more controllers to the mesh.

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3 The Gen4 ASIC has 6 DMA engines per ASIC while the Gen5 has 7. This is 16 percent more DMA engines per ASIC, therefore producing faster XOR operations.
4 As compared to the previous generation of HPE 3PAR StoreServ storage systems using the Gen4 ASIC. Max sequential large block 100 percent read bandwidth on the 10800 is 13 GB/s and 75 GB/s for the 20800, a 5.7X increase.
System-wide striping

Data and I/O for each volume are striped widely across all system resources, including CPUs, ports, cache, and drives. This wide striping enables the system to deliver accelerated and consistent performance levels (with all resources supporting each volume) while avoiding any single point of contention. Even a small volume can leverage the performance of hundreds of flash devices and all the system’s controller nodes for optimal performance.

Because the system autonomically manages this system-wide load balancing, no extra time or complexity is required to create or maintain an optimally configured system. With system-wide striping, data is distributed across all SSDs in a granular fashion, keeping the command queues low on any individual SSD. While building up the drive command queue on HDDs was a good thing (let the drive optimize the order of servicing I/O depending on the mechanical head position), having a high command queue on an SSD only adds latency. Low command queues on SSDs help lower latency. In contrast, on traditional platforms, the workloads are narrowly striped, typically on a single controller, and either on a single RAID group or on a partial set of drives. Under conditions in which accelerated IOPS are needed, this partial striping very quickly manifests itself in the form of hotspots for one resource while other resources remain underutilized. With HPE 3PAR StoreServ Storage, you obtain accelerated performance at a low, uniform latency.

Multi-level, highly virtualized storage OS

To ensure performance and maximize the utilization of physical resources, the HPE 3PAR Operating System (OS) employs a tri-level mapping methodology similar to the virtual memory architectures of the most robust enterprise operating systems on the market today. The first level of mapping virtualizes physical drives of any size into a pool of uniform-size, fine-grained “chunklets.” Complete access to every chunklet eliminates large pockets of inaccessible storage. The second level of mapping associates chunklets with logical disks (LDs), at which point RAID characteristics can be implemented. The third level of mapping associates virtual volumes (VVs) with all or portions of an underlying LD or of multiple LDs. The fine-grained, highly abstracted, tri-level virtualization scheme enables a single flash media device to support hundreds of volumes and up to a dozen RAID definitions at the same time, allowing the system to make the most efficient use of flash-based storage.

Host write latency reduction

HPE 3PAR Express Writes represent a series of optimizations aimed to improve host write latency. This is achieved via the HPE 3PAR OS by optimizing SCSI transactions and thus improving the number of interrupts per transaction, which results in improved array CPU utilization and lower host write latency. Express Writes technology enables the HPE 3PAR StoreServ array to achieve synchronous write latency below 200 microseconds. Depending on the workload, hosts may see an overall decrease in write latency of up to 20 percent, which may result in an increase in IOPS and throughput.
Multi-tenancy QoS with HPE 3PAR Priority Optimization

The HPE 3PAR Architecture can make millions of IOPS available to customers—up to 10 million IOPS in a four-system federation. However, there are few applications that can take advantage of even hundreds of thousands of IOPS on their own. Investments in flash are best realized when multiple applications are able to take advantage of the accelerated IOPS that flash delivers in a shared environment. Sharing performance, however, presents a challenge in that it is important that performance be protected from runaway or extremely hungry applications that monopolize resources.

This is where HPE 3PAR Priority Optimization comes in—to help assure quality of service (QoS), thereby enabling customers to guarantee service levels in multi-tenant environments (figure 10). It enables maximum performance thresholds for front-end IOPS or bandwidth, or both, to be configured for application workloads via HPE 3PAR Autonomic Groups (i.e., volume sets). Customers can also set latency targets for volume sets as low as 500 microseconds, and help ensure that their most critical applications get the right resources to meet their service level targets.

HPE 3PAR Priority Optimization control is implemented within HPE 3PAR StoreServ Storage, meaning that no host agents are required, nor is physical partitioning of resources within the storage array. The key benefit is that this enables the smooth deployment of HPE 3PAR StoreServ Storage in multi-tenant environments, giving your most critical applications the assured performance levels they require.

![Figure 10. HPE 3PAR Priority Optimization](image)

16 Gbps Fibre Channel support

When moving from traditional HDD storage to flash with the intent of consolidation and serving high-performance workloads, it is critical to consider the role of your storage network and confirm that it is not acting as a bottleneck. For example, a typical OLTP workload can saturate 8 Gbps host Fibre Channel (FC) bandwidth without fully utilizing all of your compute or storage resources. To ensure you receive the anticipated returns on your flash investments, you may need to consider increasing your storage networking performance. 16 Gbps FC host connectivity unleashes the potential of flash when combined with 16 Gbps end-to-end infrastructure, resulting in 50 percent fewer links, HBAs, and switch ports and up to threefold VM density increase when combining 16 Gbps Gen5 FC with flash (figure 11).

HPE 3PAR StoreServ Storage support for 16 Gbps Fibre Channel offers a simple and immediate solution. By replacing the 8 Gbps FC components with 16 Gbps FC on your FC switch and host FC HBAs, you can easily increase I/O bandwidth and IOPS by up to 35 percent and realize a 2.5X or better latency improvement, remaining significantly and consistently under a millisecond. With older 4 Gbps FC infrastructure in its end-of-support life and 8 Gbps FC infrastructure starting to end-of-life, now is the time to evaluate 16 Gbps technology for your flash deployments.

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5 Requires the use of HPE 3PAR Peer Motion software. Assuming 4 x 20800 arrays that support 25 million IOPS and 15 PBs of usable capacity, customers can configure up to 60 PBs of usable capacity that supports an aggregate of 10 million IOPS and 300 GB/s of bandwidth.

6 Evaluation Report: All-Flash HP (now HPE) 3PAR StoreServ 7450 Storage System and Generation 5 (Gen 5) 16 Gb/s Fibre Channel, Demartek, March 2015
When upgrading to 16 Gbps FC technology, you need fewer switches, adapters, cables, and optics to achieve the same aggregate bandwidth and IOPS—resulting in lower CAPEX and OPEX because fewer FC components means also means reduced rack footprint and overall services costs. Like flash, 16 Gbps technology takes advantage of the latest in ASIC technology to increase performance, resiliency, and lower power consumption.

**iSCSI connectivity**

HPE 3PAR StoreServ Storage offers a unified solution for IP-only environments for both block (over IP with iSCSI) and file (over IP with SMB/NFS). Although historically IP environments have not been considered suitable for flash, recent iSCSI connectivity enhancements to the platform including the addition of VLAN tagging give you the flexibility to deploy flash using Ethernet while preserving sub-millisecond latencies and Tier-1 resiliency and data services.

Latest iSCSI enhancements include:

- IPv6 support
- Support for more than 8,000 iSCSI initiators per system
- Support for VLAN tagging
- Enterprise iSCSI (iSCSI over DCB/lossless Ethernet)
- SendTargets discovery support
- Persistent Ports support

iSCSI VLAN tagging allows HPE 3PAR StoreServ Storage system iSCSI ports to be configured with multiple IP addresses and VLAN tags. The array supports up to 500 VLAN tags and 256 initiators per port, which helps streamline network traffic and ensure all the security protocols are intact. iSCSI VLAN tagging offers network simplification and makes array iSCSI traffic more efficient by smoothing SCSI flows and giving higher priority to iSCSI traffic. Support for IPv6 ensures that network activity of each device can potentially be tracked, thus offering an added security boost to the existing infrastructure.
Efficiency optimization—extending the life and utilization of flash media

While flash prices have fallen in recent years, when you bring flash storage arrays into your data center, it is still critical to get the most from your investment. The relative acquisition cost differences between SSDs and HDDs make flash capacity utilization and media endurance extremely important.

For example, IT managers often prepare for growth by buying and provisioning more storage capacity than is immediately needed, thus allowing excess capacity to sit idle. This is one of the reasons most legacy storage systems are massively underutilized, with average capacity utilization rates as low as 30–40 percent. This acquisition model is bad enough with spinning media, but can be particularly costly with flash, despite costs as low as $1.50 USD per usable GB. To get the greatest return on flash investments and control costs over time, every kilobyte of flash media must be used as efficiently as possible without performance degradation.

To make this happen, you need a storage architecture that is designed to make optimal use of flash from hardware all the way up through the software stack. One way of boosting efficiency is through thin storage technologies and data compaction. Another is to increase the endurance and lifespan of the media by reducing the number of times you write data to it. Since, unlike mechanical HDDs, flash is an electronic media that wears down with each write, it is also necessary to minimize writes where possible as a hedge against media wear-out. All these methodologies, while necessary, are not individually sufficient. Making optimal use of flash requires a multi-faceted approach, encompassing things like efficient page allocation, avoiding duplicate writes, getting more usable capacity from SSD media, etc. Figure 12 shows the holistic approach that the HPE 3PAR Architecture takes to bringing down the raw and usable cost of flash media.

Compaction—A multi-faceted approach to efficiency

<table>
<thead>
<tr>
<th>Minimize</th>
<th>Maximize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid duplicate writes</td>
<td></td>
</tr>
<tr>
<td>• Thin de-duplication and Thin clones</td>
<td></td>
</tr>
<tr>
<td>• Zero-page inline de-duplication</td>
<td></td>
</tr>
<tr>
<td>No reservations/pools</td>
<td></td>
</tr>
<tr>
<td>• Reservation-less Thin/Snaps</td>
<td></td>
</tr>
<tr>
<td>Fine-grained allocation</td>
<td></td>
</tr>
<tr>
<td>• 16 KB write allocation unit</td>
<td></td>
</tr>
<tr>
<td>No hot spares</td>
<td></td>
</tr>
<tr>
<td>• System-wide sparing</td>
<td></td>
</tr>
<tr>
<td>Boost raw capacity</td>
<td></td>
</tr>
<tr>
<td>• Adaptive Sparing</td>
<td></td>
</tr>
<tr>
<td>Thin reclamation</td>
<td></td>
</tr>
<tr>
<td>• With16 KB granularity</td>
<td></td>
</tr>
<tr>
<td>Wear management</td>
<td></td>
</tr>
<tr>
<td>• Adaptive wear</td>
<td></td>
</tr>
<tr>
<td>• Wear gauge for every SSD</td>
<td></td>
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</tbody>
</table>

Figure 12. Bringing down the cost of flash

The architecture incorporates the following features to maximize the efficiency of flash-based media:

Coalescing writes in memory

As previously mentioned, HPE 3PAR StoreServ Storage has been architected to cleverly get the most possible reliability and durability out of its flash SSDs. It does this in several ways. One of them is by minimizing wasted block space and program-erase cycle wear through the ability to coalesce writes in memory. This approach converts random I/O into sequential I/O to eliminate or curtail wasted block space.

Thin Deduplication with Express Indexing

The purpose-built HPE 3PAR Gen5 Thin Express ASICs at the heart of each controller node feature efficient, silicon-based mechanisms to drive inline Thin Deduplication. This implementation relies on the ASICs to generate and assign hash signatures to each unique incoming write request. HPE 3PAR StoreServ Storage employs HPE 3PAR Express Indexing, a mechanism that accelerates table lookups, for ultra-fast detection of duplicate write requests in order to prevent duplicate data from being written.
When a new I/O request comes in, Express Indexing performs instant metadata lookups in order to compare the signatures of the incoming request to signatures of data already stored in the array. When a match is found, the system flags the duplicate request and prevents it from being written to the back end. Instead, a pointer is added to the metadata table to reference the existing data blocks (figure 13). To prevent any hash collision, HPE 3PAR Thin Deduplication software relies on the controller node ASICs to perform bit-to-bit comparison before any new write update is marked as a duplicate.

With HPE 3PAR Thin Deduplication software, the CPU-intensive jobs of calculating hash signatures for incoming data and verifying reads are offloaded to the ASICs, freeing up processor cycles to deliver advanced data services and service I/O requests. This hardware-assisted approach enables inline deduplication that carries multiple benefits, including increased capacity efficiency, flash performance protection, and flash media lifespan extension.

![Figure 13. ASIC-based hash signature generation for inline deduplication](image)

**Thin Clones**

An extension of HPE 3PAR Thin Deduplication for server virtualization environments, HPE 3PAR Thin Clones software provides host-assisted deduplication for non-duplicative virtual machine (VM) clones with Microsoft® Hyper-V and VMware® ESXi. These VM clones are created instantly by leveraging copy offload for VMware VAAI (vStorage APIs for Array Integration) and Microsoft ODX (Offloaded Data Transfer) technology without increasing capacity consumption on the HPE 3PAR StoreServ Storage system.

Thin Clones leverages Thin Deduplication to update the metadata table without copying data, relying on inline deduplication technology to reduce capacity footprint as new write request come in (figure 14). Thin Clones also leverages the platform’s reservationless snapshot technology, so that clones are created on-the-fly, without pre-allocating any storage and new data is deduplicated inline. Reservationless thin snapshots are described in greater detail below.

![Figure 14. Non-duplicative VM clones leveraging inline deduplication](image)
**Zero-block inline deduplication with the HPE 3PAR Gen5 ASIC**

The HPE 3PAR StoreServ ASIC features an efficient, silicon-based zero detection mechanism. With zero detection built into the ASIC, a stream of zeroes that may be present in a write I/O can be eliminated before being written to flash. In the world of flash, where there is a penalty for every single write (in terms of media endurance), this write elimination helps elongate the life of flash-based media. You get the efficient use of existing flash storage with granular, zero-block reclamation while also enhancing the effective life of flash-based media by avoiding unnecessary writes for a double win.

**Reservationless thin snapshots**

Unlike traditional architectures, the HPE 3PAR Architecture is designed to be thin from the start. There are no pools to be created or reserved up-front for thin provisioning. In addition, reservationless, non-duplicative, copy-on-write snapshot technology allows customers to protect and share data from any application. Capacity is never reserved up-front, and changed data is never duplicated within the snapshot tree. You achieve efficient utilization of flash storage without the need for any pool creation or up-front capacity reservation.

**Fine-grained allocation unit**

Because flash represents a greater up-front investment as compared to HDDs, it is important to be extremely efficient in allocating storage to applications. A granular allocation size ensures that only the right amount of media is allocated, thereby reducing the use of flash-based media. At the same time, a very small allocation unit can generate an unmanageable amount of metadata, which can restrict the total capacity of storage that is supportable by a single storage system. The key is to achieve a balance between the need for granular allocation units and capacity scalability.

With a 16 KB write allocation unit, HPE 3PAR StoreServ Thin Technologies have broken new ground in the efficient use of storage capacity. Where the traditional storage vendors have exceedingly coarse allocation units often measured in megabytes, HPE 3PAR StoreServ Storage uses a 16 KB allocation unit that allows the optimal use of flash media. This storage efficiency comes without putting an unreasonably low limit on capacity scalability, so you gain storage efficiency without compromising scalability.

**Thin Reclamation**

The HPE 3PAR Architecture has the ability to look for pages that have been zeroed out by the host and reclaim those pages to keep capacity efficiency high over time. This reclamation capability is highly efficient since it is done with 16 KB granularity. Every block of flash storage that gets reclaimed immediately becomes available for other applications requiring space, ensuring that existing flash storage is utilized efficiently before forcing customers to purchase additional capacity.

**Media wear gauge**

The HPE 3PAR OS monitors the wear of each flash device and allows users to see the wear level of each device at any given time, thereby enabling them to monitor consumption of their flash-based media and plan for future upgrades. This keeps users informed as to the amount of media wear taking place and helps them replace SSDs in a planned fashion.

**System-wide sparing**

The HPE 3PAR Architecture reserves spare chunklets in all flash media. In contrast to traditional architectures that enforce the need to reserve dedicated spares that sit idle, the HPE 3PAR Architecture uses every single flash device, reserving spare chunklets in each of them. This ensures a balanced load and wearing across all flash media. Should there be a media failure, system-wide sparing also helps protect against performance degradation by enabling many-to-many rebuild, resulting in faster rebuilds.

**Adaptive Sparing**

Another key way that the HPE 3PAR Architecture extends SSD media utilization and endurance is through patented Adaptive Sparing technology. Using this technology, Hewlett Packard Enterprise collaborates with SSD suppliers to use capacity typically reserved by media suppliers for wear management more efficiently. As a result, Adaptive Sparing is able to increase usable drive capacity—and therefore usable system capacity—without introducing risk or compromising drive endurance. In fact, Adaptive Sparing actually extends media lifespan.

It is important to note that there are two different strategies for achieving these benefits. The first strategy extends usable drive capacity by up to 20 percent—effectively reducing the amount of spare capacity reserved by the drive (figure 15). When an SSD failure occurs, the drive typically relies on this spare or reserved capacity to recover. However, since the HPE 3PAR OS reserves spare chunklets in each of its drives rather than reserving entire spare drives, space set aside by drive manufacturers is no longer necessary or efficient. Instead, Hewlett Packard Enterprise works with drive vendors to release much of this reserved space so that the system can use it as overprovisioned capacity while still ensuring that each SSD have the necessary amount of spare capacity to perform critical operations such as garbage collection. If an SSD fails, Hewlett Packard Enterprise’s patented Adaptive Sparing technology reclaims the spare chunklets from the SSD and only once that SSD is replaced by a new one does the system release the spare chunklets back to the SSD.
With high-capacity 3.84 TB cMLC drives, Adaptive Sparing technology employs a modified strategy that does not augment raw capacity but instead makes read-intensive drives both read- and write-intensive. The result is greater system capacity and greater SSD endurance.

Multiple SSDs options, including high-density cMLCs
SSD drive technology has evolved significantly as flash has become more mainstream in the enterprise data center, and over time vendors have abandoned using single-level cell (SLC) flash drives, graduating instead to multi-level cell (MLC) drives. Flash-optimized architectures such as HPE 3PAR StoreServ have also begun transitioning to as also able to transition to other technologies, including commercial MLC (cMLC) drives. It is important to note that these enterprise-grade cMLC drives are not the same as the consumer-grade cMLC drives that are not suitable for enterprise data centers. The cMLC technology used by HPE 3PAR StoreServ Storage are enterprise-grade cMLCs, not the consumer-grade cMLCs used in personal computing (figure 16).
level—on the order of one drive write per day (DWPD), Adaptive Sparing technology actually boosts media endurance at the system level, equivalent to approximately 1 to 2.5 DWPD, for a net positive effect. As a result, Adaptive Sparing allows the system to not only lower the cost of flash through the use of CMLCs, but to extend system capacity and do this without sacrificing endurance. This is only possible with a software stack optimized for flash.

The use of these large-capacity, high-density drives is what allows the system to achieve industry-leading density of 140 TB/U for drive enclosures and industry-leading all-flash array scalability of 15 PB usable capacity on the converged flash HPE 3PAR StoreServ 20800 Storage array. All currently available HPE 3PAR StoreServ SSDs carry a five-year warranty offering unconditional replacement due to drive failure, media wear-out, or both. Hewlett Packard Enterprise is able to offer this guarantee because of the unique benefits of Adaptive Sparing and the other optimization technologies described in this and previous sections.

**System resiliency—application availability and data protection designed for flash**

If data is unavailable, your business can come to a halt. To enable reliable access to your data, flash storage solutions should be designed to work with rich data services such as clustering and multi-site replication. In enterprise environments, flash must meet all the classic high-availability and business-continuity requirements—including multi-site replication and application-integrated disaster recovery—often taken for granted with traditional Tier-1 disk systems. This is one of the reasons you can’t approach flash storage as an island within your data center.

In an online world, success depends on application performance and availability. Downtime and data inaccessibility can be extremely costly in terms of lost revenue and productivity. To deliver uninterrupted access to data, you need an architecture that allows you to protect data stored on flash-based media with the same battle-tested processes and Tier-1 capabilities as spinning media. But it is also critical to consider the impact of flash. Application consolidation is one of the major benefits of flash-based systems, but it also means greater risk if that system goes down. In addition, with flash the bar is raised across so many dimensions that users expect instant recovery if something does go wrong. Even IT expects backup speeds to match those of flash. Flash opens up many new possibilities, and the impact on data protection cannot be overlooked. Can you continue to apply traditional methods to protect data? Sure you can, but the mismatch would negate a lot of the benefits of deploying flash.

Hewlett Packard Enterprise has incorporated critical resiliency and data protection features into HPE 3PAR StoreServ Storage to ensure uninterrupted access to data and application availability optimized for flash:

**Maintaining service levels during media failures**

One of the characteristics of flash media is that its performance degrades when working with large sequential writes. Consequently, it is important for your architecture to ensure that large write I/O is not thrown at flash media. One scenario in which a large sequential write process typically starts on the back end is in the case of a media failure. After a media failure, the reconstruction process is essentially a sequential read/write process. With its system-wide sparing (figure 17), the reconstruction process in the HPE 3PAR Architecture is already fast and based on a many-to-many rebuild (instead of a many-to-one rebuild).

![Figure 17. HPE 3PAR StoreServ Storage reconstruction process](image)
HPE 3PAR StoreServ Storage handles reconstruction of flash media in a different way than it handles reconstruction of spinning media. Instead of doing large sequential reads/writes as it does for HDDs, HPE 3PAR StoreServ Storage performs 32 KB read/writes for flash media. This is an important factor that enables HPE 3PAR StoreServ Storage to provide a consistent performance level, even under situations of flash-based media failure.

**HPE 3PAR Persistent Cache**

HPE 3PAR Persistent Cache is a resiliency feature built into the HPE 3PAR OS that allows the graceful handling of an unplanned controller failure or planned maintenance of a controller node (figure 18). In dual-controller–based storage systems, a controller failure results in the storage system going into write-through mode, under which each write needs to get written to back-end media before acknowledgment to the host.

HPE 3PAR Persistent Cache eliminates the substantial performance penalties associated with write-through mode, so that HPE 3PAR StoreServ Storage can maintain high and predictable service levels even in the event of a cache or controller node failure. Persistent Cache dynamically re-mirrors the cache of the remaining controller node in the original pair with another controller in the cluster, thereby remaining in a mirrored cache mode. HPE 3PAR Persistent Cache is supported on all quad-node and larger HPE 3PAR StoreServ Storage systems. This avoids the latency penalty and IOPS degradation of the write-through mode.

**HPE 3PAR Persistent Ports**

HPE 3PAR Persistent Ports is a Tier-1 resiliency feature that allows for a completely non-disruptive software upgrade environment, in which dependence on host-based multipathing software is completely avoided during a software upgrade process (figure 18). In addition, HPE 3PAR Persistent Ports technology renders an array node failure transparent to the host using the array, which eliminates the need for the host’s multipathing software to maintain host connectivity for node failure recovery. You obtain completely non-disruptive software upgrades with no application downtime.

HPE 3PAR Persistent Ports technology also detects loss of laser at front-end 3PAR ports, and seamlessly enables its partner ports to take over I/O servicing, without any disruption to the hosts. This capability is available for all connectivity options on 3PAR StoreServ including FC, iSCSI and FCoE, and protects users against wrong cable-pull scenarios, or lose connections to front end ports.

**HPE 3PAR Peer Persistence**

HPE 3PAR Peer Persistence software enables HPE 3PAR StoreServ Storage systems located within metropolitan distances to act as peers to each other for delivering a high-availability, transparent failover solution for the hosts/servers connected to them (figure 18). HPE 3PAR Peer Persistence allows an array-level, high-availability solution between two sites or data centers, where failover and failback remain completely transparent to the hosts and applications running on those hosts. You achieve federated high availability at metropolitan distances for uninterrupted business operations.
Persistent Checksum
HPE 3PAR StoreServ Storage systems ensure data integrity through 3PAR Gen5 Thin Express ASIC support for Persistent Checksum (figure 18), which uses T10-PI (Protection Information), an industry standard for end-to-end data protection. Persistent Checksum is an important Tier-1 feature that protects against silent data corruption that might occur while data is either being read from or written to flash media, and is an example of how the array optimizes the entire IO path for flash. As implemented on the array, Persistent Checksum is completely transparent to applications and host operating systems. This feature is enabled via integration with host HBAs and HPE drivers, which enables data checks from the host to HPE 3PAR StoreServ back-end.

T10-PI is a SCSI standard that adds a layer of data protection to data storage by appending an eight-byte record called the Data Integrity Field to each disk sector. Without it, the data received from a successful disk read is assumed to be correct and passed on to the requesting host. T10-PI provides a method to validate the data returned by the disk drive before sending the data to the host. For a write I/O, T10-PI support ensures that data being written to the flash media is exactly the data that was requested to be written by the host. In the case of data corruption, the HPE 3PAR OS simply replies to the host with an error, which triggers a fresh write request from the host side.

Lack of T10-PI support can be extremely costly for enterprises running their applications on flash storage. Silent data corruption can force applications to be brought down and severely impact business. In addition, without T10-PI support, any backup taken for that data may have bad data and cannot be trusted.

Asynchronous Streaming replication
HPE 3PAR StoreServ Storage offers the most complete set of Disaster Recover solutions in the industry. The latest addition to this arsenal is Asynchronous Streaming replication for HPE 3PAR Remote Copy. Now you have four different replication options to choose from with the same license—and across midrange, enterprise-flash, and all-flash arrays of any model.

With traditional spinning media, where performance is measured in tens of milliseconds, creating an exact copy of data over an extended distance adds some latency that is still acceptable in terms of meeting service level agreements. However, with flash, this can be problematic since performance is now measured in sub-milliseconds. Keeping an exact copy of your data can therefore impact performance, which is why HPE 3PAR Remote Copy software supports keeping a near-exact copy via the Asynchronous Streaming replication mode. This mode means no compromises on performance versus data protection since you are now able to protect against disasters over hundreds or thousands of miles plus the ability to get your applications back up and running fast.

Flat backup with flash-optimized data protection integration
Flash is all about enhanced SLAs, which Hewlett Packard Enterprise believes should not just stop at your applications, but extend to your backups as well. HPE 3PAR StoreServ offers full enterprise-class resiliency, which means that you’ve covered several of the top causes of application outages. However, to deliver the comprehensive data protection that your business-critical applications require, your HPE 3PAR StoreServ Storage arrays requires a second line of defense against application failures. This is where integration with the HPE StoreOnce System family of hardware and software comes in.

Flash-based HPE 3PAR StoreServ Storage lets you do more, faster—meaning that if you go down, fast recovery time is even more critical. In addition, flash enables you to consolidate massively (with better performance, scale, and compaction), thus raising the data protection stakes. With greater information density, it’s critical that your data protection solution be able to back up all of this data within your given window and recover it within seconds if something goes wrong. Additionally, in a flash environment, you need a data protection solution that not only accelerates your apps, backup, and restores, but minimizes the impact of backups (and copies) on your apps.

HPE StoreOnce Express Protect technology delivers flat backup between HPE StoreOnce physical or virtual backup appliances and your flash array (figure 19). Whether you choose to deploy a physical appliance or a Virtual Storage Appliance (VSA), HPE StoreOnce protects your applications against file loss or application corruption beyond the oldest snapshot stored on your primary array as well as protecting your applications against storage platform outages. With flat backup, data bypasses media servers and goes directly to your protection storage from the array. When a backup software agent doesn’t have to run on the primary storage, this reduces the impact of backups on your applications, which helps support your goals for deploying flash in the first place. And with snapshots, only incremental changes are sent over to your backup appliance (snap diffs), which also means that less bandwidth is needed to move the data. Elimination of the media server and associated backup software also means greater simplicity and significantly lower cost as there is no capacity-based licensing involved.
With flat backup, application recovery is incredibly fast. This is because a fully synthetic backup is created in the backup appliance using the incremental changes (snap diffs), which are sent over from the primary array. This process is ongoing; so when it's time to recover, you effectively have a full snapshot ready and waiting—meaning you don’t have to rely on backup software to perform the restore. With this approach, there is no load on the primary array, no media server, and no backup software to complicate or slow down the process, which reduces RTOs to seconds or minutes. This applies to physical as well as virtual backup appliances. Flash-integrated data protection provides simple, fast, application-consistent backups of VMs and crash-consistent backups of databases and other critical workloads for near-instantaneous recovery. Integration with leading software solutions, including mainstream business infrastructure applications and backup solutions, simplify management and give your application owners greater control. Today this is limited to VMware, but integration with other applications is under development.

Figure 19. Flat backup with Express Protect

Encryption
With the majority of flash systems serving mission-critical applications, security and encryption are also key requirements for flash arrays. HPE 3PAR StoreServ Storage complies with the standards set forth by the National Institute of Standards and Technology (NIST) and FIPS 140-2 (Federal Information Processing Standard) and features Data at Rest (DAR) encryption that helps protect valuable data through self-encrypting drive (SED) technology. SED drives are HDDs and SSDs with a circuit (ASIC) built into the drive's controller chipset that automatically encrypts and decrypts all data being written to and read from the media.

HPE 3PAR StoreServ Storage supports Full Disk Encryption (FDE) based on the Advanced Encryption Standard (AES) 256 industry standard. The encryption is part of a hash code that is stored internally on physical media. All encryption and decryption is handled at the drive level and needs no other external mechanism.

Authentication keys are set by the user and can be changed at any time. The Local Key Manager (LKM) included with the HPE 3PAR StoreServ Storage encryption license is used to manage all drive encryption keys within the array and provides a simple management interface. In the event of a drive failure or the theft of a drive, a proper key sequence needs to be entered to gain access to the data stored within the drive. When an SED drive is no longer powered on, the drive goes into a locked state and requires an authentication key to unlock the drive when power is restored. In the event of a drive failure or theft, a proper key sequence needs to be entered to gain access to the data stored within the drive. Without the key, access to the data on the SED is not possible.

Hewlett Packard Enterprise also offers the enhanced encryption support on the HPE 3PAR StoreServ Storage systems by offering FIPS 140-2-compliant SED drives that provides the ability to use an external Enterprise Secure Key Manager (ESKM). ESKM is deployed whenever customers use encrypted storage or communication methods to protect their sensitive information. Within the manager, users can store and serve keys to unlock the data stored on FIPS 140-2-compliant drives within the HPE 3PAR StoreServ Storage systems with strong access controls and security. Key Management on the array with either LKM or ESKM coupled with FIPS drives, offers customers a safe, Tier-1 environment in which to securely store their data.
Data mobility—optimize resources at the data center level

In today’s information-driven world, data must move seamlessly and non-disruptively between applications, systems, storage tiers, and physical locations. The ability to move data non-disruptively between types and tiers of storage can help your organization increase revenue by accelerating transaction throughput on your applications that are experiencing spikes in demand, such as an e-commerce application during a major holiday or a financial application at the end of a quarter. At the same time, this dynamic response, enabled by transparent and non-disruptive data mobility, allows you to save money by storing data on the most cost-effective media. In addition, you need to deploy an architecture that can enable load balancing and technology refresh without disrupting critical applications.

This data mobility is one of the keys to IT and business agility. For your business to deliver consistently great application performance at an affordable cost, your storage architecture must allow data to move easily to keep up with the pace of change. At times of peak demand on certain applications, you want the associated data on your fastest storage technology—namely flash media—either on backend storage, or, in some cases, at the host level in a server. At other times, when demand on the application is lower, you may want to move the same data to a lower-cost tier of storage and save your flash capacity for other applications that could benefit from the performance boost.

Hewlett Packard Enterprise’s approach to non-disruptive data mobility is implemented via storage federation rather than storage (or SAN) virtualization. SAN virtualization relies on external appliances such as EMC VPLEX and IBM SVC to virtualize attached storage arrays, thus requiring additional hardware accompanied by device management overhead, which is inserted upstream of the storage arrays. This hierarchical, appliance-based approach leads to additional cost and complexity on several fronts: additional hardware and management; data path interruption and performance degradation; ongoing software license costs; complex device support requirements; and lack of scalability. Not only that, but once in place, it is extremely time-consuming, laborious, and expensive to remove. So while solving data immobility issues, SAN virtualization is not suited to dynamic and unpredictable demands.

Hewlett Packard Enterprise takes a different approach by building non-disruptive data movement capabilities into the array. Data services implemented in software enable multiple systems to be “federated” into is collection of independent, autonomous resources that can communicate based on peer-to-peer, native capabilities. These native capabilities include seamless and automated data movement between systems and managed from the same interface. On HPE 3PAR StoreServ Storage arrays, federated data services allow you to make the most out of flash investments by enabling a range of use cases for non-disruptive data movement using HPE 3PAR Peer Motion software, HPE 3PAR Online Import software, and HPE 3PAR Peer Persistence.

Peer Motion

HPE 3PAR Peer Motion software enables the seamless movement of data between HPE 3PAR StoreServ Storage systems of any model, enabling one-click workload balancing. Up to four systems can be pooled into the same federation to support up to 60 PB of usable capacity and 10 million IOPS. Multi-array, bi-directional non-disruptive data mobility across systems enables you to load balance at will, refresh technology seamlessly, reduce costs of asset lifecycle management, and lower technology refresh CAPEX.

HPE 3PAR Peer Motion Software is a non-disruptive, do-it-yourself (DIY) data mobility tool for enterprise block storage that does not require any external appliance to be included in the data path, nor does it introduce any additional overhead on the host resources. Unlike traditional block migration approaches, the HPE 3PAR Peer Motion Software enables non-disruptive data mobility of storage volumes between any HPE 3PAR StoreServ system that is part of a storage federation, and without complex planning or dependency on extra tools (figure 20).

Federated multi-array, bi-directional data mobility between HPE 3PAR StoreServ Storage systems is easy to implement and manage via the HPE 3PAR StoreServ Management Console (SSMC). Simple predefined workflows have been implemented within SSMC that give you the ability to move data—for example, moving all volumes associated with a host from one HPE 3PAR StoreServ Storage system to another or moving individual volumes for workload balancing purposes—all with just a single click.

7 Configuration based on four 20800 arrays that each support 2.5 million IOPS and 15 PBs of usable capacity.
Online Import

With HPE 3PAR Online Import software, you can move data non-disruptively from legacy storage to an HPE 3PAR StoreServ Storage array, typically as part of a technology refresh, data center consolidation initiative, or modernizing your traditional storage by replacing it with a flash array (figure 21). Support includes HPE Enterprise Virtual Array (EVA) as well as EMC VMAX, EMC VNX, EMC CLARiiON CX4, HDS TagmaStore Network Storage Controller (NSC), HDS TagmaStore Universal Storage Platform (USP), HDS Universal Storage Platform V (USPV), HDS Universal Storage Platform VM (USPVM), and HDS Virtual Storage Platform (VSP). HPE 3PAR Online Import software is provided at no charge for one year as part of the HPE 3PAR OS Suite, so you can perform self-directed migration that doesn't require professional services, hardware appliances, or consumption of host resources.

Figure 20. Manage resources at the data center level via HPE 3PAR Peer Motion

Figure 21. Non-disruptive migration with Online Import
Peer Persistence
HPE 3PAR Peer Persistence software enables HPE 3PAR StoreServ Storage systems located within a metropolitan distance to act as peers to each other for delivering a high-availability, transparent failover solution for the connected VMware vSphere, Microsoft Hyper-V, Microsoft Windows® clusters, Red Hat® Enterprise Linux® (RHEL), and HPE-UX. HPE 3PAR Peer Persistence allows an array-level, high-availability solution between two sites or data centers where failover and failback remains completely transparent to the hosts and applications running on those hosts. Unlike traditional disaster recovery models where the hosts (and applications) must be restarted upon failover, HPE 3PAR Peer Persistence allows hosts to remain online serving their business applications, even when the serving of the I/O workload migrates transparently from the primary array to the secondary array, resulting in zero downtime. In an HPE 3PAR Peer Persistence configuration, a host cluster would be deployed across two sites and an HPE 3PAR StoreServ Storage system would be deployed at each site. All hosts in the cluster would be connected to both of the HPE 3PAR StoreServ Storage systems. These HPE 3PAR StoreServ systems present the same set of VVs and VLUNs with same volume WWN to the hosts in that cluster. The VVs are synchronously replicated at the block level so that each HPE 3PAR StoreServ Storage system has a synchronous copy of the volume. A given volume would be primary on a given HPE 3PAR StoreServ Storage system at any one time. Using Asymmetric Logical Unit Access (ALUA), HPE 3PAR Peer Persistence presents the paths from the primary array (HPE 3PAR StoreServ Storage system on which the VV is primary) as “active/optimized” and the paths from the secondary array as standby paths. Issuing a switchover command on the array results in the relationship of the arrays to swap, and this is reflected back to the host by swapping the state of the paths from active to standby and vice versa. Under this configuration, both HPE 3PAR StoreServ Storage systems can be actively serving I/O under normal operation (albeit on separate volumes).

Why Hewlett Packard Enterprise?
The New Style of Business is upon us, and Hewlett Packard Enterprise is leading the way with innovations that revolutionize storage with converged storage that delivers simplicity for any need at any scale.

Storage without boundaries
HPE Converged Storage accelerates your ROI by eliminating the physical, logical and management boundaries that have traditionally separated storage from the rest of IT. The HPE Converged Storage vision is to provide you with a single architecture to span your platform needs, from low to high, with converged protocol access across block, object, and file. HPE Converged Storage innovations free you to focus on your own innovations.

Respond to new demands
Unpredictable workloads require agile storage that adjusts quickly without bottlenecks. Through HPE innovations such as flash optimization, storage federation, scale-out architectures, and storage for the software-defined data center, Hewlett Packard Enterprise enables businesses like yours to respond to new demands efficiently.

Simplify storage complexity
Growing capacity without growing complexity is a challenge for every storage environment. With equipment and contracts from multiple vendors, you’re probably losing time and money by having to reinvent the wheel again and again. Storage technology services that combine technical expertise with multi-vendor expertise can help you operate more efficiently and strategically, while also delivering measurable ROI-based results.
Resources
To get more information about HPE 3PAR StoreServ Storage, download the HPE 3PAR StoreServ Architecture technical white paper

Learn more at
hpe.com/storage/flash