A SOLIDFIRE COMPETITIVE COMPARISON

NetApp SolidFire and Pure Storage Architectural Comparison

This document includes general information about Pure Storage architecture as it compares to NetApp SolidFire. Not intended to be exhaustive, it covers architectural elements where the solutions differ and impact overall suitability for the needs of the Next Generation Data Center (NGDC).

Overview

The FlashArray series from Pure Storage is an all-flash, dual-controller storage solution, based on a traditional active/passive scale-up architecture, where capacity is scaled by adding additional drive shelves to a pair of controllers and performance is scaled by replacing the controllers with more powerful controller models.

Architectures based on storage controller pairs, also referred to as storage node pairs, have been the standard for enterprise block storage for many years. Enterprise familiarity, standard design concepts, and fast time-to-market are some of the key reasons Pure Storage designed its FlashArray off this familiar architecture. Unfortunately, dual-controller, scale-up architectures are not without their caveats, and with all-flash storage, many of those caveats become limitations.

The intention of Pure's FlashArray was to replace traditional block storage arrays with a similar architecture, the differences being that it has been designed and optimized specifically for flash with a focus on low latency. This approach not only enables Pure to directly replace legacy spinning disk with all-flash storage but also addresses application performance complaints common to block storage. While Pure has been successful at implementing key functionality such as in-line efficiencies, its focus on latency performance and fitting into the existing block storage paradigm has kept it from addressing the issue of scaling a traditional architecture and providing a way to control how flash performance is delegated to application workloads. The resultant solution from Pure is one well suited for high-performance, single-point solutions, but it is not a good fit for mixed workloads and solutions where very large performance and capacity scale is desired.

This document compares the architectural elements of the Pure FlashArray with NetApp SolidFire all-flash solutions and assesses their suitability for the needs of the Next Generation Data Center (NGDC). NetApp recommends evaluating all-flash storage solutions based on application requirements and offers a portfolio of solutions tailored to different environments, including: SolidFire SF-series systems with Element OS software; All- Flash FAS systems with ONTAP software; and EF-Series systems with SANtricity software.

Findings

As a high performance alternative to traditional block storage point solutions, Pure Storage's solutions offer high performance and an implementation familiar to the industry. The active/passive controller-centric architecture provides a familiar look to a block storage solution but carries with it many of the traditional drawbacks found in a dual-controller architecture, limiting its ability to enable a next generation data center.

Specifically

- **Agile** - SolidFire enables enterprises to cost-effectively support specific solutions and adapt on the fly to multiple workload environments without affecting the performance of existing applications. Likewise, SolidFire's shared-nothing architecture allows for the addition or removal of any model of cluster node, 1U at a time, on the fly while maintaining application-specific Quality of Service (QoS) with maximum, minimum, and burst IOPS settings independent of capacity.

  Pure solutions offer scale up of capacity but only to a point of 400 TB of effective capacity depending on the model of controllers in the individual implementation. The //m10, //m20, //m50, and m70 models each scale up through the addition of external drive shelves to offer claimed effective capacities of which Pure refers to as usable capacities of 12.5-25 TBs, 15-120 TBs, 60-250 TBs, and 150-400 TBs, respectively. After implementation, any need to scale beyond (above or below) one of the capacity ranges has historically required a disruptive "forklift" controller swap-out. With the new //m series, Pure claims that is no longer the case.

- **Scalability** - Pure's solutions follow a traditional controller-centric solution limiting the current usable capacity of deployments to 400 TB and tiered rather than linear scaling of performance. Pure's location- vs. content-addressed architecture, used in mapping content to a specific location on disk, means that expansion and/or movement of data are significantly more overhead-intensive as the array fills, negatively affecting the performance and manageability at scale.

- **Guaranteed** - A key requirement of the next generation data center is to have an environment based on repeatable, predictable performance. Designed to get to the market quickly with an all-flash replacement to traditional block storage, Pure solutions offer good speed with low latency but do not have the ability to specify QoS for individual volumes, meaning applications and users can experience inconsistent performance in multiple parallel workload environments.

  SolidFire enables enterprises to specify and guarantee minimum, maximum, and burst IOPS for individual storage volumes on the fly, independently of capacity, eliminating the "noisy neighbor" problem in mixed workload environments.

- **Automated** - Both SolidFire and Pure Storage have APIs for automating storage management, but only SolidFire offers the ability to automate every storage function of the array from the API.

- With SolidFire, data availability is also highly automated. In the unlikely event of a SolidFire node or multiple node failures, SolidFire automatically rebalances the lost node's data across all remaining nodes, restoring complete redundancy while maintaining all guaranteed QoS settings. As an added bonus, performance of SolidFire's rebalance improves as more nodes are added to the cluster!

  Pure's dual controllers, on the other hand, are deployed in an active/passive configuration. When a controller experiences a failure, the deployment fails over to the backup controller. The now-active controller becomes a single point of failure until the failing controller is manually replaced.

SolidFire vs. Pure Storage

Data addressing/management

Both SolidFire and Pure use a log-structured approach in writing to disk. This optimizes utilization and performance of SSDs, significantly improves the lifespan of SSDs, and, most importantly, enables the use of less expensive consumer-grade MLC SSDs.

The log-structured approach, or reading in of current valid data and new data and writing it to disk in a linear fashion, in essence aggregates many small writes into a large write. Compared to a fixed-block approach, the log-structured approach significantly simplifies supporting compression and variable block sizes.

One area where Pure and SolidFire architectures differ is Pure relies on the layering of metadata for functionality like deduplication, snapshots, and clones. The architecture begins with a location-addressing schema, as opposed to SolidFire's content-addressing technique, using a logical unit number (LUN) and logical block address (LBA) to tag a specific piece of data to a physical location in the array. Layered on top of this base key-value store, additional tables of block-checksum values, link values, and shared block-value tables are maintained to compare incoming data against and/or to map multiple reference pointers for deduplication, snapshots, and clones.

Differences between Pure's location-addressing architecture and SolidFire's content-addressing architecture

- In the Pure architecture all of the metadata is stored on SSDs and partially cached (as opposed to 100% at runtime for SolidFire). The net result of this tradeoff is an average of 50% (1.5 to 1) cache-miss ratio. This can lead to somewhat inconsistent read performance, particularly as the array begins to fill up.
- Any time data is moved within the array (as is frequently done in storage systems), the primary data structure must be updated. In SolidFire's content-addressing system, on the other hand, the content ID does not change, and thus there is no need for I/O intensive updates.
- Because of the need for tight coupling between multiple layers of metadata, Pure's content-addressing architecture works well in a tightly coupled dual-controller architecture but would not be well-suited for global deduplication.

Quality of Service

Clearly, Pure's all-flash systems are fast arrays with consistently low latency. However, Pure provides no Quality of Service (QoS) or performance provisioning to ensure all applications in mixed workload deployments consistently get the IOPS they need, and are protected from unpredictable application I/O usage such as noisy neighbor scenarios. Without QoS, large-scale infrastructure customers and/or those looking to consolidate multiple applications onto a single platform may find they have to buy more Pure Storage arrays or larger controllers to provide insurance against application performance variability.

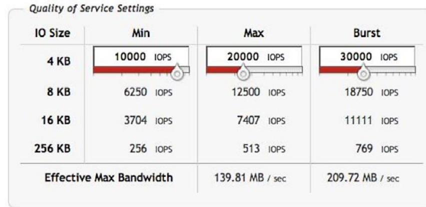

Figure 1: SolidFire QoS SolidFire architecture allows users to set minimum, maximum, and burst IOPS on a per-volume basis.

To deliver predictable and guaranteed storage performance, SolidFire leverages QoS performance virtualization of resources. Patented by SolidFire, this technology permits the management of storage performance independently from storage capacity. SolidFire architecture enables the capability to set minimum, maximum, and burst IOPs on a per-volume basis. Because performance and capacity are managed independently, SolidFire clusters are able to deliver predictable storage performance to thousands of applications within a shared infrastructure.

Scaling

SolidFire's clustered architecture enables the linear scale out of capacity and performance as nodes are added to the system, meaning each additional node provides a predictable amount of performance. This also means scaling up to 3.4 PBs of effective capacity and a potential 7.5M guaranteed IOPS.

Pure's use of a scale-up architecture means a Pure Storage array's performance and ability to scale capacity is based completely on the capabilities of the controllers in use. Increasing performance or capacity beyond the controller limit requires new, more powerful controllers or the deployment of a new Pure Storage array.

Controllers are deployed in an active/passive pair. Under normal operating conditions (i.e. without a controller issue/failure), only one of the controllers is active at any time and the second becomes active only in the event of a failure of the primary.

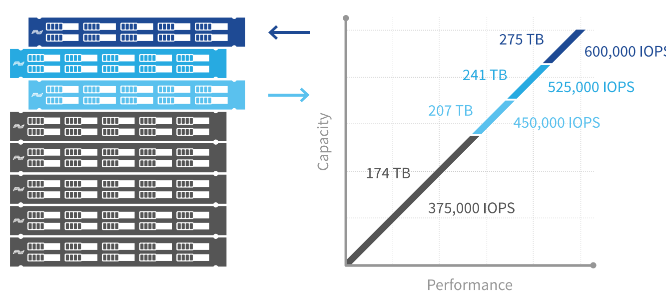

Figure 2: SolidFire Mixed-Node Scale-Out
At any point during or after deployment, nodes can be added, removed, or replaced to increase capacity and/or performance without impacting existing workloads. As nodes are added, their capacity and IOPS are aggregated into the total provisionable capacity and performance available for assignment to any existing or new volume.

Positive aspects of Pure scaling model:

- Capacity can be scaled independently of performance
- Performance is "consistent" (excluding cache-miss variations) in the event of a controller or disk failure
- Top-end performance with a relatively small amount of capacity

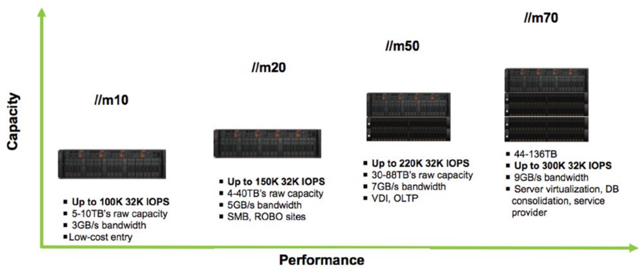

Figure 3: Pure Scale-Up vs. Scale-Out
In Pure's architecture, performance increases are achieved by means of a controller upgrade. Pure Storage claims its current largest array scales up to about 400 TB of usable capacity with 300,000 32k IOPS in 11U of rack space.

Potential negative aspects of Pure's scaling model:

- Performance upgrade is only possible by upgrading controllers
- Unplanned controller upgrades can be required if performance or capacity limits are reached
- Large environments may require deployment of multiple siloed arrays

Data assurance

Pure

Pure's solutions use a traditional shared-controller model. Historically with this type of architecture, the redundancy lives with the disk shelf in the form of dual-ported drives and redundant back planes. Due to cost considerations, dual-drive ports are not available for solid-state drives or included in Pure's design.

In the event of a Pure disk-shelf failure, RAID groups not striped across multiple shelves will be lost. Use of RAID for data protection means, at best Pure will experience longer drive rebuild times than SolidFire as the array fills up. At worst, a cascading drive failure could result.

As mentioned earlier in the I/O pathway comparison, the Pure Storage dual controllers are deployed in an active/passive configuration. At any one time when a controller experiences a failure, the deployment defaults to the backup controller. The now active controller becomes a single point of failure until the failed controller is replaced.

SolidFire

With SolidFire's RAID-less approach, there is no sharing of any hardware component in the system. Connectivity between the nodes is redundant, and the design is such that anything in the cluster can fail — any piece of hardware, any software process, any network component — and the system will continue running.

In the event of a node or multiple node failures, SolidFire automatically rebuilds redundant data across remaining nodes in minutes, restoring complete redundancy while maintaining all guaranteed QoS settings.

Efficiency and data integrity: Helix vs. Raid

RAID is commonly promoted as an advantage by other shared-disk flash architectures because it is very easy to implement dual-parity protection with acceptable capacity overhead. It is important to remember that in the SolidFire design, the shared nothing architecture means each node is a fully functional unit, removing the overhead (cost, management, and footprint) of shared controllers. SolidFire Helix takes advantage of this distributed architecture by providing an exact copy of all data in the cluster, so if a drive fails the rebuild process simply reconstructs the data that was on that drive based on the copy. Since the rebuild is simply copying the data from other drives in the cluster, rebuild times are extremely fast, there is far less wear and tear on drives, and there is no RAID overhead to impede the large scale common to scale-out clusters.

Another benefit of Helix and the SolidFire architecture is that in addition to drive failures, Helix can automatically recover from an entire node failure, enabling the nondisruptive addition or removal of nodes to/from an active cluster. When a node fails or is added to or removed from the cluster, the process of rebalancing is exactly the same as that of a drive. The advantage of SolidFire Helix is that the entire cluster takes part in the rebalancing, and everything happens automatically. This results in a very fast rebuild with very minimal performance impact and, most importantly, the elimination of any single point of failure.

Comparing SolidFire's self-healing approach to Pure's traditional RAID striping, it quickly becomes apparent that SolidFire offers flexibility and protection not found with Pure Storage. In the event of a node failure in a Pure array, the array is in a single-point-of-failure scenario until the failed node is physically removed. Pure is also unable to add or remove nodes to an array nondisruptively, limiting Pure to dual-controller silos within the data center.

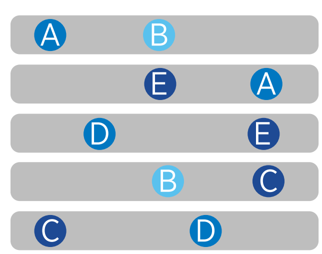

Figure 5: SolidFire Helix Automated Mesh Redundancy
When a drive fails, the rebuild process reconstructs the data that was on that drive and restores the redundancy in the system.

The bottom line

Pure Storage offers all-flash solutions built upon the traditional controller-centric, RAID-based architecture many organizations are accustomed to. Pure has been successful at providing a solution that brings the performance benefits of flash to these traditional block storage customers. Like traditional scale-up solutions, Pure's architecture is well suited for point-solution environments but is less than optimal in the areas of scale, automation, QoS, and agility for next generation data center applications, including large scale multiple/mixed workload and IT as a Service (ITaaS) deployments.

SolidFire's shared-nothing, scale-out architecture makes it ideally suited for large-scale, mixed-workload enterprise and service provider deployments. The ability to mix multiple models of nodes within clusters, scaling out performance and capacity linearly at any time (not just at initial deployment), combined with the ability to guarantee IOPS per volume means deployments can start and grow as needed without disruption to running applications or worry of stranding either performance or capacity.

SolidFire's architecture means organizations can consolidate multiple applications and workloads onto an agile, scalable, predictable, and automated, infrastructure. The flexibility of the SolidFire architecture ultimately saves customers time and money, resulting in a much lower infrastructure TCO and, consequently, a healthier bottom line.