



Technical Report

NetApp All Flash FAS Overview

Data ONTAP 8.3.2

Skip Shapiro, NetApp
April 2016 | TR-4505

Abstract

This report is an overview of the architecture of NetApp® All Flash FAS (AFF) storage systems. AFF systems are configured with 8000 series storage controllers, solid state drives (SSDs), and the Data ONTAP® 8.3 operating system. This report is based on AFF systems running the Data ONTAP 8.3.2 release and it covers the benefits of using AFF8000 storage systems and key configuration and usage considerations and recommendations.

Data Classification

Public

Version History

Version	Date	Document Version History
1.0	April 2016	Initial release

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1 Overview

Market adoption of all-flash storage arrays has grown rapidly and accelerated over the past few years. Early adopters needed very low latency storage for one or a few workloads that had modest capacity requirements. Often, these workloads were transactional database applications with high input/output operations per second (IOPS) demands where the cost premium for flash capacity was more than offset by the benefits of much faster performance. Most all-flash storage arrays deployed for these requirements offered fast performance and little else. That was acceptable because the storage arrays are typically dedicated to one or a few workloads, and most data management tasks are handled by the database or application.

Since then, solid state drive (SSD) capacity has increased eight-fold and the raw cost per terabyte (TB) has dropped, fueled by the rapid evolution of NAND flash technologies: from single-layer cell (SLC), to multi-layer cell (MLC, also known as dual-layer cell), to triple-layer cell (TLC). At the same time, all-flash arrays integrated inline storage efficiency capabilities — compression and deduplication — which make flash storage more attractive, and now arguably more cost-effective than high-performance (high-rpm) hard disk drives (HDDs).

These technology and design advances expanded the range of applications and IT environments that are able to justify and benefit from using all-flash storage, and as a result the demand for high-performance HDDs in data centers is declining quickly. However, all-flash storage arrays in these deployments must provide the same data management capabilities as the HDD-based arrays they are displacing. Key capabilities include application-integrated data protection and provisioning for key business applications and databases, as well as support for both block and file protocols (SAN and NAS).

More recently, a third use case has evolved for which all-flash storage is an excellent fit: IT-as-a-service infrastructures, sometimes referred to as cloud or 3rd Platform, that rely upon fast, agile, and highly scalable storage to meet the needs of dynamic application environments.

These three different deployment environments coexist today and no single all-flash array architecture is optimal for all of the environments. NetApp's all-flash system portfolio consists of three product families, each of which is designed to deliver maximum benefits for one of the environments.

- **NetApp AFF systems** are designed for data center deployments that require data management capabilities such as SAN and NAS support and tight integration with a broad set of widely used applications, hypervisors, server operating systems, and data protection solutions.
- **NetApp EF-Series arrays** are designed for application-centric deployments that need ultra-low latency performance at high IOPS throughput.
- **NetApp SolidFire® systems** are optimized for virtualized cloud and service provider environments where high performance with workload-level quality of service (QoS) control and agile scalability are top-level requirements.

This technical report covers the AFF8000 system architecture and key considerations when configuring, deploying, and using AFF8000 systems.

2 Requirements

NetApp All Flash FAS (AFF) systems require the following hardware and software components:

- **8000 series storage controllers in a dual controller, high-availability (HA) configuration.** Models include AFF8020, AFF8040, AFF8060 and AFF8080 EX.
- **SSDs only.** Systems are sold with 400GB, 800GB, 1.6TB or 3.8TB drives. New SSD models may have been added after this report is published; see the Hardware Universe for the current list of supported SSDs.
- **Data ONTAP 8.3 or later releases.** The releases contain special code paths and default data management policies that are implemented on AFF systems.

This technical report is based on the feature capabilities of AFF8000 systems running Data ONTAP 8.3.2, and the key configuration and usage considerations.

The most current AFF8000 system specifications are available online in the [Hardware Universe](#).

3 Architecture

The combination of hardware and software on AFF8000 systems delivers the performance, efficiency, features and complete solution integration that are needed in and beneficial for data center, private cloud and service provider deployments.

Storage controllers are configured as an active-active HA pair, and up to 12 HA pairs can be configured in a single cluster. The active-active configuration means each controller is handling data traffic independently during normal operation, which enables better performance scalability than active-passive all-flash arrays. Either controller takes over all data traffic during planned maintenance events or if a controller failure occurs.

AFF8000 controllers use multicore processors, DDR3 memory, and PCIe v3 interconnection to provide high data throughput at low latencies. As an example, the flagship AFF8080 has 20 cores and 128GB of memory per controller. Host connection through 10Gb Ethernet and 16Gb FC is provided using onboard ports, and more ports can be configured using PCIe adapter cards.

AFF8000 systems are offered with SSD models with from 400GB to 3.8TB per drive, and FIPS 140-2 validated encrypting SSDs are available in 800GB and 1.6TB capacities. SSDs are configured in the 2U-high 24-drive bay DS2246 storage enclosure.

Data ONTAP 8.3.2 is an enterprise-grade unified scale-out storage operating system, designed for virtualized shared storage IT infrastructures. It provides nondisruptive operation, storage efficiency, integrated data protection, and scalability over the lifetime of the system, including through hardware and software refreshes and upgrades.

3.1 Performance

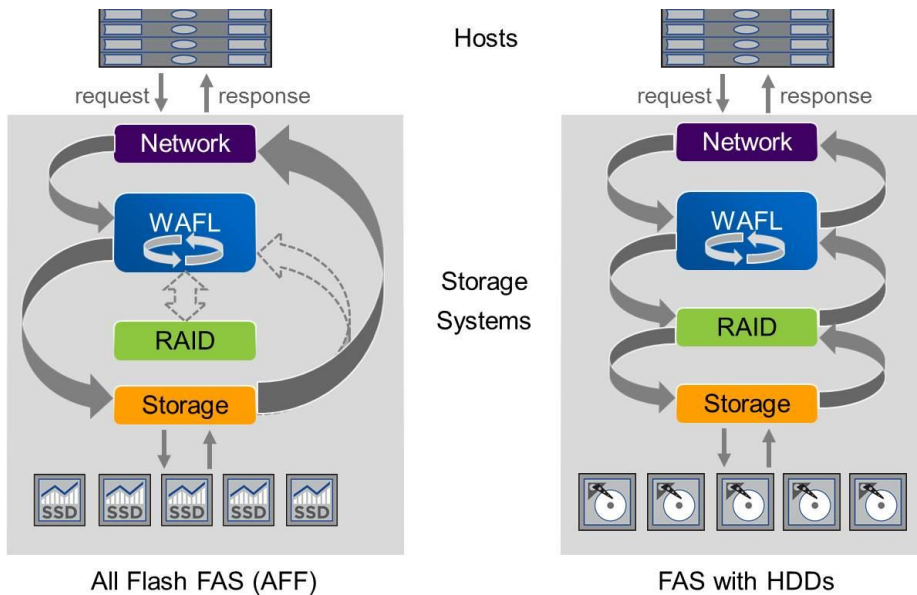
The Data ONTAP operating system delivers superb performance for both random and sequential workloads. Data ONTAP is tightly coupled with drive firmware to optimize the data layout on SSDs, which delivers a high rate of random IOPS at sub-1 millisecond (ms) latency.

Write operations are cached in memory and immediately protected in nonvolatile memory (NVRAM), which provides very fast acknowledgment back to hosts and clients. Then inline compression and deduplication are performed and the resultant logical blocks are coalesced into larger, sequential write operations to free space across multiple SSDs. The end result is fast and efficient writes to SSDs.

AFF systems use a read path optimized for SSDs that delivers high random IOPS at sub-1ms latency. Data ONTAP also has read-head algorithms that provide high throughput for sequential read operations.

Figure 1 compares the read path employed on AFF systems to the read path used on FAS systems configured with HDDs. The AFF read path is optimized to pass incoming read requests directly from the file system layer (WAFL®) to the storage subsystem, and read responses are sent directly from the storage subsystem to the networking layer. RAID and WAFL are engaged during a read response only if an error is detected that needs to be corrected by RAID.

Figure 1) Read path comparison between AFF and FAS systems.



3.2 Storage Efficiency

AFF systems employ several storage efficiency features that increase the effective storage space for application and user data. Inline compression and inline deduplication reduce the physical space needed to store incoming logical data. Thin provisioning and zero-block deduplication enable volume and LUN creation without reserving and consuming capacity until it is needed for actual data. FlexClone® technology provides instant writable copies of volumes and LUNs without physically copying the data and with no need to use deduplication. Snapshot® copies use the same process to create read-only copies of volumes for online backup and recovery.

The remainder of this section summarizes how inline compression and inline deduplication are implemented on AFF systems. These technologies are covered extensively in technical report [TR-4476: NetApp Data Compression and Deduplication](#).

Inline adaptive compression is enabled on all AFF8000 systems. Inline adaptive compression evaluates incoming data in 8KB segments, and any segment that is compressible by 50% or more is written to a 4KB block on SSD. Inline adaptive compression is optimized for database workloads that typically use 8KB I/Os, or whole number multiples (for example, 16KB), for random reads and writes.

Inline deduplication is also enabled on AFF8000 systems. Incoming blocks that contain only zeros (zero blocks) are recorded with metadata updates only, which is more efficient than traditional deduplication methods. The key benefit of zero-block deduplication is that it preserves space savings on thin provisioned LUNs and virtual machine datastores that are initialized with zeros.

Inline deduplication of nonzero blocks is enabled on AFF8000 systems as well. It is an opportunistic operation that is automatically throttled when the controller becomes busy, thereby maintaining low latency for application workloads. When this situation occurs, space savings can be realized by scheduling regularly background deduplication operations. Inline deduplication minimizes storage space consumption during operations that write a lot of common blocks, such as software patches for virtual desktop datastores. Deduplication is done within a volume; this approach preserves space savings on the

source and destination aggregates when a volume is moved or replicated using SnapMirror® replication technology.

Typical space savings on AFF8000 systems for several workload datasets — measured by comparing logical data size to physical storage used — are listed in Table 1. The savings ratios reflect a combination of both inline adaptive compression and deduplication.

Table 1) Typical space savings ratios for adaptive compression and deduplication.

Workload Dataset	Savings Ratio
Virtual desktop VMs	10:1
Virtual server VMs	3.3:1
Oracle databases ¹	1.7:1
Microsoft SQL Server Databases ¹	1.7:1
Microsoft Exchange 2010	1.7:1

Note: (1) Database savings are the result of inline adaptive compression only. Deduplication does not typically save any space with database data.

Much larger storage savings can be realized when FlexClone technology is used to create writable copies of volumes or LUNs. Database copies for test and development use or clones of virtual server or desktop machines during provisioning are examples. Savings are achieved without physically copying blocks and don't require deduplication processing.

3.3 SSD Media Durability

As described earlier in the performance section, writes operations are coalesced into larger I/Os in memory, after inline storage efficiency operations have been executed, with the result being storage- and performance-efficient writes to SSDs. This process minimizes write wear on the flash media.

In addition, Data ONTAP software and SSD firmware are tightly coupled to achieve effective wear leveling and garbage collection. This integration minimizes write amplification and enables SSDs to be used in AFF systems for many years, even with write-intensive workloads.

3.4 Scalability

Data ONTAP 8.3.2 allows performance and capacity with AFF systems to be increased in two ways. Performance can be increased by upgrading to a higher performing controller model, commonly called scale-up. Performance can also be increased by deploying additional AFF8000 HA pairs in a cluster, which is known as scaling out.

Similarly, capacity can be grown by adding storage shelves to an existing AFF8000 HA pair or by adding HA pairs to the cluster. AFF raw capacity scales up to 1.8 petabytes (PB) per HA pair, and up to 7.3 PB per eight-node cluster. NAS-only clusters scale to 24 nodes and over 21PB.

3.5 Non-disruptive Operations

The ability to perform maintenance activities and reconfiguration operations without interrupting storage services to hosts and clients is a major benefit of clustered Data ONTAP. Workloads and storage consumption can be rebalanced nondisruptively across aggregates or nodes by moving a volume or LUN within a storage virtual machine (SVM). A single SVM can include multiple storage tiers, which allows for nondisruptive movement of data between AFF nodes and hybrid storage FAS nodes configured in the same cluster.

Data ONTAP clustering also enables hardware and software upgrades to be done without service interruption, including increasing and reducing the number of HA pairs within the cluster. AFF systems can be configured as a two-node or a four-node MetroCluster™ configuration to provide continuous operation when site-wide failures or disruptions occur.

3.6 Data and Storage Management

The Data ONTAP 8.3.2 storage operating system offers comprehensive storage management and data services capabilities. Multiple HA pairs are managed as a single clustered system, and many tenants can share cluster resources securely.

Data ONTAP clusters support NFS and SMB/CIFS file access as well as FC and iSCSI block services. Online data protection and replication are fundamental capabilities of the architecture. Data ONTAP also has robust integration with widely used business applications, hypervisors, and data management software.

This rich set of data management services is available with AFF8000 systems, which makes AFF an excellent solution for enterprise data center and cloud service provider IT deployments.

More information about clustered Data ONTAP 8.3 releases can be found in [TR-3982: NetApp Clustered Data ONTAP 8.3.x and 8.2.x: An Introduction](#).

4 Interoperability

All Data ONTAP 8.3.2 features except for FlexArray® are supported with AFF8000 systems. Refer to FAS8000 systems information in the [Interoperability Matrix Tool \(IMT\)](#) on the NetApp Support site to find information about AFF8000 interoperability support.

Refer to the IMT to validate that the exact product and feature versions described in this document are supported for your specific environment. The NetApp IMT defines the product components and versions that can be used to construct configurations that are supported by NetApp. Specific results depend on each customer's installation in accordance with published specifications.

5 Performance

AFF8000 systems deliver high random IOPS throughput at low latency, which makes them excellent storage solutions for database applications and virtual desktop datastores, in addition to other workloads. Many technical reports about AFF8000 performance for specific applications are available and are listed in the “Additional Resources” section later in this report. Two reports are cited in this section.

Figure 2 shows the performance of an AFF8080 EX two-node cluster running an Oracle SLOB2 online transaction processing (OLTP) workload on Oracle 12c. The system delivers over 300,000 operations per second with less than 1ms read latency as measured at the server. More information about this test is available in [TR-4415: NetApp AFF8080 EX Performance and Server Consolidation with Oracle Database](#).

Figure 2) AFF8080 EX performance with Oracle 12c.

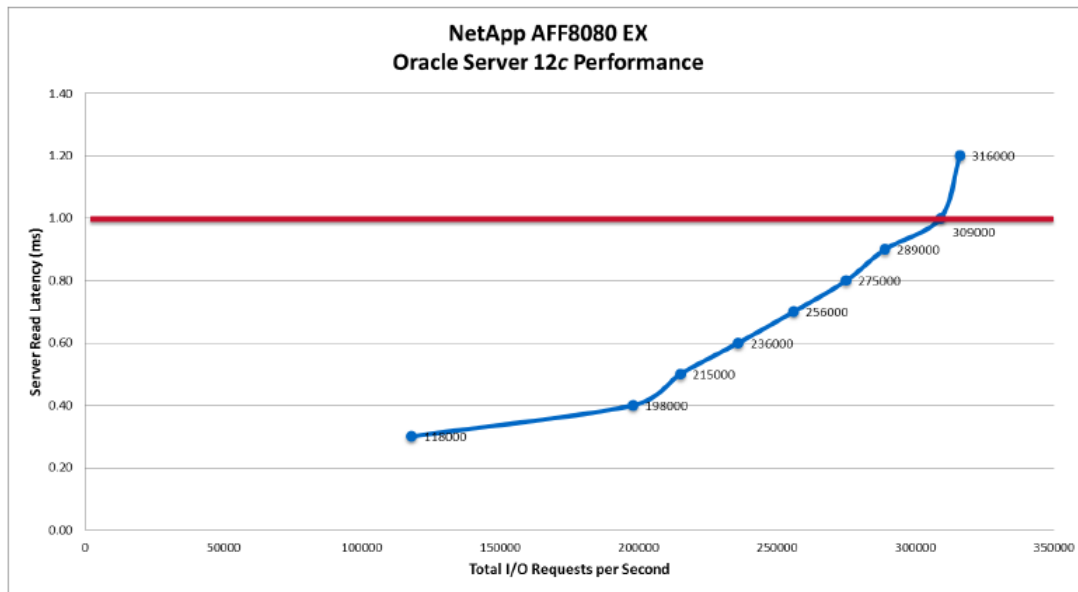
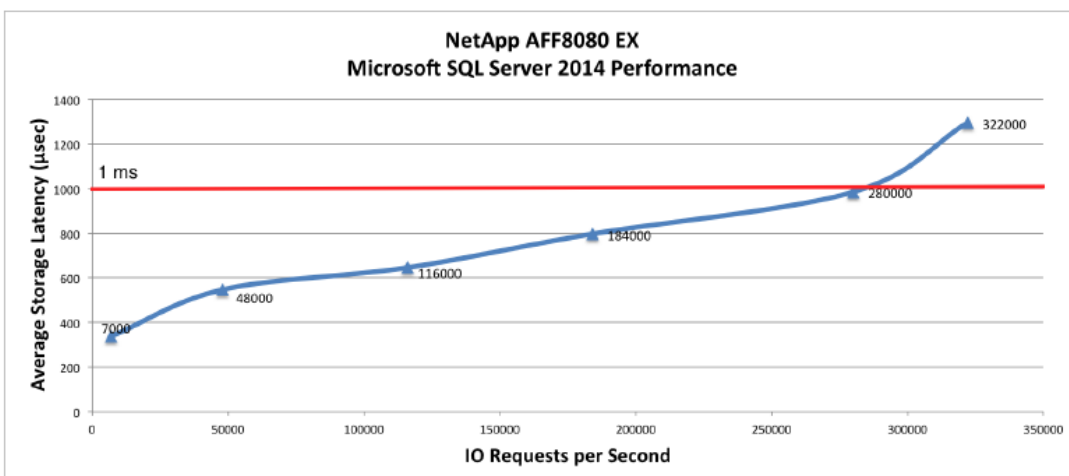


Figure 3 shows the performance of a AFF8080 EX two-node cluster running a TPC-E workload on Microsoft SQL Server 2014. The system delivers over 280,000 operations per second with less than 1ms read latency as measured at the server. More information about this test is available in [TR-4403: NetApp AFF8080 EX Performance and Server Consolidation with Microsoft SQL Server 2014](#).

Figure 3) AFF8080 EX performance with Microsoft SQL Server 2014.



6 Key Considerations and Recommendations

New AFF8000 systems are shipped with SSDs assigned to each controller and root aggregates provisioned using advanced drive partitioning (ADP). These default settings and other configuration decisions are covered in this section.

6.1 Connecting Storage Shelves

AFF8000 system storage is provided in 2U-high, 24-bay storage shelves. Standard SSD shelf configurations contain either 12 drives (a half-shelf) or 24 drives (a full shelf). Shelves are configured in stacks of up to four shelves, and each stack is connected to two SAS adapter channels (ports) on each storage controller. This configuration provides two benefits: redundant paths for fault tolerance and more channels to handle I/O between SSDs and each controller.

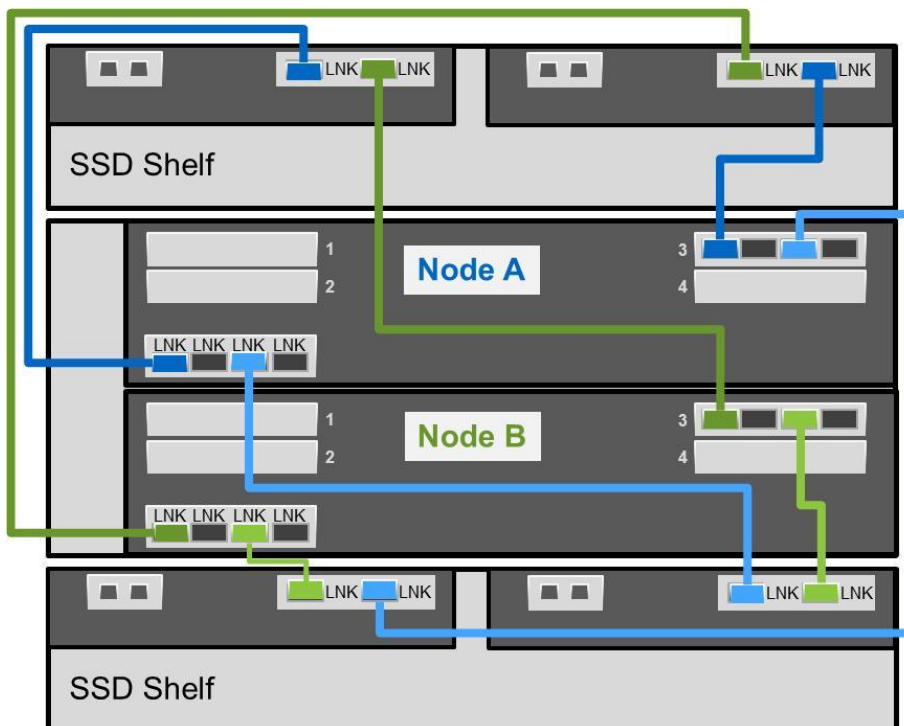
Each SAS channel consists of four 6Gb per second wide paths; in total each stack has access to 16 paths for traffic between SSDs and controllers. Only one SSD can communicate over a path at a time; thus, having many paths distributes workload and enables low latency performance.

The schematic diagram in Figure 4 depicts the recommended storage shelf configuration for a two-shelf system. The diagram applies to AFF8040 systems, and single controller chassis AFF8060 and AFF8080 EX systems, and it is a simplified version of the installation and setup instructions (ISIs) that ship with every new system. (ISIs for AFF8020 and dual-chassis AFF8060 and AFF8080 EX are slightly different.)

The two controllers are labeled as Node A and Node B, and each has four onboard SAS channels (ports, labeled LNK on the controller), and four more SAS channels on an adapter card installed in PCIe slot 3. The four onboard SAS ports are identified in Data ONTAP software as 0a to 0d, from left to right in the diagram. The four adapter ports are identified as 3a to 3d.

As shown in the diagram, the system is configured with two stacks and one shelf per stack. This layout maximizes the number of SAS channels and paths available to carry I/O. Each controller is connected to each stack using one onboard SAS port and one SAS adapter card port. The ports used are either 0a and 3a, or 0c and 3c.

Figure 4) SAS cabling for a two-shelf AFF8040, AFF8060 or AFF8080 EX system.



AFF8000 Installation and Setup Instructions are available at this URL on the NetApp Support site at <http://mysupport.netapp.com/documentation/bytypedocweb/index.html?productID=62082&subTypeID=61031>.

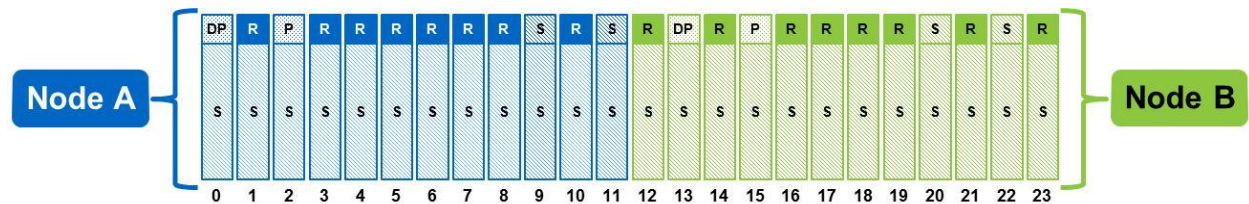
6.2 SSD Assignment and Root Aggregate Configuration

New AFF8000 systems are typically configured with at least one full shelf of SSDs. By default, one-half of the SSDs in each full shelf are assigned to each controller. The 12 left-side SSDs (numbered from 0 to 11) are assigned to one node, and the 12 right-side SSDs (numbered from 12 to 23) are assigned to the partner node in the HA pair. This “split-shelf” assignment of SSDs allows all four SAS channels connected to each shelf stack to carry an active workload, efficiently distributing I/O across all paths.

Root aggregates are provisioned on new AFF systems as shipped — one per node — using ADP. ADP root-data partitioning uses a small partition from up to 24 SSDs per node to contain root aggregate data, including RAID DP® parity and hot spare partitions. The larger partition on each SSD is shipped as a spare, ready to be used in a data aggregate.

Figure 5 depicts the default SSD, root partition, and data partition assignments for a new single-shelf AFF8000 system as shipped. The smaller square-shaped boxes represent root partitions. Root volume data is stored across the eight partitions labeled “R”, parity partitions are labeled “DP” and “P”, and hot spare partitions are shown as “S”. Root partitions are approximately 54 gibibytes (GiB) in size. The larger data partitions (which are shown as rectangles in the figure) are assigned using the same scheme as the underlying SSDs.

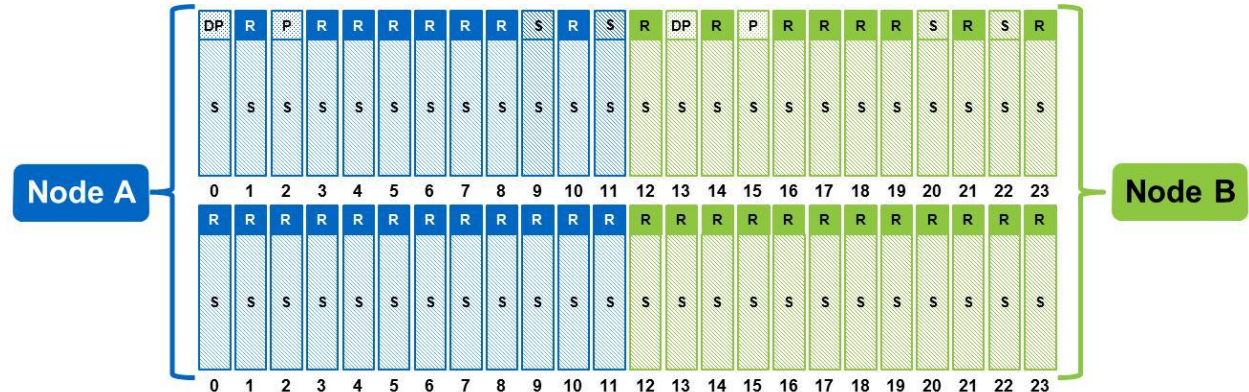
Figure 5) Single-shelf SSD assignment and root-data partitioning.



Note: Assignment of data (R), parity (DP and P) and spare (S) root partitions to SSD numbers may differ. A typical example is shown.

Figure 6 shows SSD assignments and root-data partitioning on a two-shelf AFF8000 system as shipped. Two shelves — 48 drives — is the maximum number that root-data partitioning uses. You'll notice that there are more root partitions labeled “R” in this diagram as compared to Figure 5: 20 versus 8. This means that each root partition is 2.5 times smaller (roughly 22GiB).

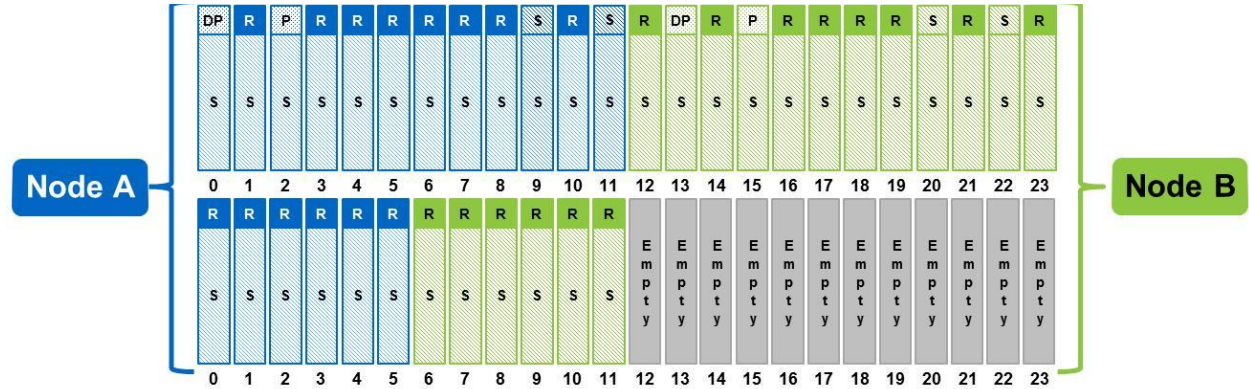
Figure 6) Two-shelf SSD assignment and root-data partitioning.



Note: Assignment of data (R), parity (DP and P) and spare (S) root partitions to SSD numbers may differ. A typical example is shown.

Figure 7 represents a third common new AFF8000 system configuration, which has 1.5 shelves attached. The half-shelf has 12 SSDs installed in bays 0 through 11, and six SSDs are assigned to each node as shown by the color-coding. The root aggregate of each node is partitioned across 18 SSDs, and root partitions are approximately 31GiB in size.

Figure 7) SSD assignment and root-data partitioning with 1.5 shelves.



Note: Assignment of data (R), parity (DP and P) and spare (S) root partitions to SSD numbers may differ. A typical example is shown.

The assignment of six data partitions to each controller from the half-shelf maintains equal capacity on both nodes. Alternatively, all data partitions can be assigned to Node A to retain the split-shelf configuration used with full shelves. When an additional 12 SSDs are installed in bays 12 through 23 they can be assigned to Node B. To change data partition ownership, see “Assigning ownership for disks partitioned for root-data partitioning” in the [Data ONTAP 8.3 Physical Storage Management Guide](#).

Split-shelf data partition assignment (and assignment of nonpartitioned SSDs when additional shelves are configured) presumes that equal numbers of like-capacity SSDs per node is the desired or acceptable HA pair configuration. If one node needs more capacity than its partner does, the recommendation is to assign all 24 data partitions or SSDs in a shelf to that node, whenever possible, to keep the configuration simple, rather than splitting SSD assignments within a shelf unevenly. In addition, a maximum of two shelves per stack is recommended when any shelf within a stack is not using the split-shelf data partition or nonpartitioned SSD assignment scheme.

6.3 Data Aggregate RAID Groups and Spares

The default RAID policy for AFF systems is RAID DP and the default RAID group size is 23. RAID DP is the only policy supported with drive partitions, and it is also recommended for RAID groups that consist of nonpartitioned SSDs.

On systems configured with three or more shelves, changing the default RAID group size to 24 is recommended. However, at least one RAID group per data aggregate will be smaller to allow for a hot spare data partition or nonpartitioned SSD per node. A general guideline is RAID groups should have at least 11 data partitions or nonpartitioned SSDs.

Table 2 shows the recommended data aggregate RAID group sizes and hot spares per node. The recommendations, in most cases, assume both nodes are configured with the same number of data partitions or nonpartitioned SSDs. The letter *d* signifies data partitions or drives and *p* signifies parity partitions or drives. Follow the pattern for odd and even numbers of shelves for systems configured with more than six shelves.

Spare root partitions are created automatically as part of root-data partitioning. One spare data partition per node is recommended when up to 48 SSDs (two shelves of drives) are partitioned.

When nonpartitioned SSDs are configured on a node, a nonpartitioned drive should be used as the hot spare. Nonpartitioned SSDs can replace a partitioned or nonpartitioned drive. However, a data partition spare can only replace a data partition; it cannot replace a nonpartitioned SSD. Generally, one spare drive per 100 SSDs per node is sufficient given the high reliability of SSDs. A second hot spare per node is recommended if it is likely to take more than three days to receive and replace a failed SSD.

Table 2) Per node data aggregate RAID group and hot spare recommendations.

Shelves	Data Aggregate RAID Groups per Node	Hot Spare per Node
1	rg0: 9d partitions + 2p partitions (each node)	1 data partition
1½	rg0: 15d partitions + 2p partitions (each node) or Node A rg0: 21d partitions + 2p partitions Node B rg0: 9d partitions + 2p partitions	1 data partition 1 data partition 1 data partition
2	rg0: 21d partitions + 2p partitions (each node)	1 data partition
2½	Node A rg0: 22d partitions + 2p partitions rg1: 9d + 2p nonpartitioned SSDs Node B rg0: 21d partitions + 2p partitions	1 nonpartitioned SSD 1 data partition
3	rg0: 22d partitions + 2p partitions (each node) rg1: 9d + 2p nonpartitioned SSDs (each node)	1 nonpartitioned SSD
4	rg0: 22d partitions + 2p partitions (each node) rg1: 21d + 2p nonpartitioned SSDs (each node)	1 nonpartitioned SSD
5	rg0: 22d partitions + 2p partitions (each node) rg1: 22d + 2p nonpartitioned SSDs (each node) rg2: 9d + 2p nonpartitioned SSDs (each node)	1 nonpartitioned SSD
6	rg0: 22d partitions + 2p partitions (each node) rg1: 22d + 2p nonpartitioned SSDs (each node) rg2: 21d + 2p nonpartitioned SSDs (each node)	1 nonpartitioned SSD

6.4 Adding Storage Shelves

Data aggregate RAID group recommendations when adding a full shelf or half-shelf to an installed AFF8000 system are similar to those for provisioning RAID groups on new systems. That said, there are additional considerations.

A general guideline is to provision data partitions and nonpartitioned SSDs in different RAID groups to avoid creating root partitions on nonpartitioned SSDs that are usable only in root aggregates. However, there are situations in which doing exactly that is recommended because it provides more usable capacity than creating a new RAID group of nonpartitioned SSDs.

In addition, a new RAID group should contain a minimum of 11 SSDs, and when an existing RAID group is expanded at least 6 SSDs should be added.

Note: If a node has one or more data partition spares, and the intent is to add a new RAID group of nonpartitioned SSDs to an existing data aggregate, select only nonpartitioned SSD spares for the new RAID group. If a data partition spare is included when creating the RAID group, the nonpartitioned SSDs are automatically partitioned to the size of the data partition.

Table 3 shows RAID group recommendations when adding a full shelf of SSDs to installed AFF systems that are configured with one, two, and three shelves. Table 4 shows recommendations when adding a half shelf of SSDs to systems configured with from one to three shelves in half-shelf increments.

Table 3) Data aggregate RAID group configurations after adding one full shelf.

Starting Shelf Quantity	Original Data Aggregate RAID Group Configuration per Node	RAID Group Configuration per Node After Adding a Full Shelf
1	rg0: 9d partitions + 2p partitions	rg0: 21d partitions + 2p partitions ¹
2	rg0: 21d partitions + 2p partitions	rg0: 21d partitions + 2p partitions rg1: 9d + 2p nonpartitioned SSDs
3	rg0: 22d partitions + 2p partitions rg1: 9d + 2p nonpartitioned SSDs	rg0: 22d partitions + 2p partitions rg1: 21d + 2p nonpartitioned SSDs

Note: (1) The 12 SSDs added to RAID group rg0 in each node's data aggregate are partitioned automatically, and the resulting root partitions become spares that are usable only by the root aggregates.

Table 4) Data aggregate RAID group configurations after adding one half-shelf.

Starting Shelf Quantity	Original Data Aggregate RAID Group Configuration per Node	RAID Group Configuration per Node After Adding a Half Shelf
1	rg0: 9d partitions + 2p partitions	rg0: 15d partitions + 2p partitions ¹
1½	rg0: 15d partitions + 2p partitions	rg0: 21d partitions + 2p partitions ¹
2	rg0: 21d partitions + 2p partitions	rg0: 21d partitions + 2p partitions rg1: 9d + 2p SSDs (Node A only) ²
2½	Node A rg0: 22d + 2p partitions rg1: 9d + 2p SSDs Node B rg0: 21d + 2p partitions	Node A rg0: 22d + 2p partitions rg1: 9d + 2p SSDs Node B rg0: 21d + 2p partitions rg1: 9d + 2p SSDs
3	rg0: 22d partitions + 2p partitions rg1: 9d + 2p nonpartitioned SSDs	rg0: 22d + 2p partitions rg1: 15d + 2p nonpartitioned SSDs

Note: (1) The 6 SSDs added to RAID group rg0 in each node's data aggregate are partitioned automatically, and the resulting root partitions become spares that are not usable by data aggregates.

Note: (2) Adding all 12 SSDs to Node A is recommended, rather than assigning 6 SSDs to each node which would result in a 3d + 2p RAID group on each node. One spare nonpartitioned SSD is needed for each node.

6.5 SAN-Optimized AFF Cluster

An AFF8000 system can be ordered with cluster setup preconfigured for SAN-only operation. Preconfiguration streamlines the cluster setup workflow and enables a cluster to begin serving data within 15 minutes after power on. Details about how a SAN-optimized AFF8000 cluster is configured are available in [TR-4480: All Flash FAS SAN-Optimized Configuration Details](#).

Note: The SAN-optimized AFF8000 configuration should be ordered only when the system is used as a new cluster and for block workloads only. A standard configuration AFF8000 system should be ordered when file services are needed – including when both file access and block access are required, and when adding an AFF8000 HA pair to an existing cluster.

6.6 AFF MetroCluster Systems

AFF8000 HA pairs used in a MetroCluster system are configured similarly to standard AFF8000 HA pairs. However, one major difference is root aggregates are provisioned on dedicated SSDs. Root-data partitioning is not supported with MetroCluster. The root aggregate fits within the capacity of an 800GB SSD so using these drives for root aggregate plexes with an AFF8000 MetroCluster system is recommended. Refer to [TR-4375: MetroCluster for Clustered Data ONTAP 8.3.2](#) for more information.

6.7 Other Considerations

- By definition, All Flash FAS systems are configured with SSD storage only. HDDs are not supported and if HDDs are connected the drives will appear as failed devices.
- When encryption of data at-rest is required, AFF8000 HA pairs are configured with NetApp Storage Encryption (NSE) SSDs only. As of March 2016, FIPS 140-2 validated 800GB and 1.6TB NSE SSDs are offered; consult the [Hardware Universe](#) for updates. Key management is performed by an off-box appliance; search for encryption key management at www.netapp.com for information about supported key management solutions.
- As noted in the interoperability section, FlexArray is not supported with AFF systems. Therefore, only supported SSDs and storage shelves can be configured. Storage LUNs from other arrays are not supported on AFF systems, even if the array LUNs are provisioned on SSDs.
- Flash Cache™ cards are not supported with AFF systems. There is no performance benefit from using Flash Cache technology with AFF systems and installing a Flash Cache card uses a PCIe slot and consumes memory resources for the cache map. Do not install Flash Cache cards in an AFF8000 system.

7 Additional Resources

- TR-3982: NetApp Clustered Data ONTAP 8.3.x and 8.2.x: An Introduction
www.netapp.com/us/media/tr-3982.pdf
- TR-4375: MetroCluster for Clustered Data ONTAP 8.3.2
www.netapp.com/us/media/tr-4375.pdf
- TR-4476: NetApp Data Compression and Deduplication
www.netapp.com/us/media/tr-4476.pdf
- TR-4480: All Flash FAS SAN-Optimized Configuration Details
www.netapp.com/us/media/tr-4480.pdf
- Hardware Universe
hwu.netapp.com
- Data ONTAP 8.3 Physical Storage Management Guide
library.netapp.com/ecm/ecm_download_file/ECMLP2427462

Database Technical Reports

- TR-4403: NetApp AFF8080 EX Performance and Server Consolidation with Microsoft SQL Server 2014
www.netapp.com/us/media/tr-4403.pdf
- TR-4415: NetApp AFF8080 EX Performance and Server Consolidation with Oracle Database
www.netapp.com/us/media/tr-4415.pdf
- TR-4435: SAP HANA on NetApp All Flash FAS Systems with NFS
www.netapp.com/us/media/tr-4435.pdf
- TR-4436: SAP HANA on NetApp All Flash FAS Systems with Fibre Channel Protocol: Configuration Guide
www.netapp.com/us/media/tr-4436.pdf
- TR-4490: Oracle Database 12c Performance: Protocol Comparison Using Clustered Data ONTAP
www.netapp.com/us/media/tr-4490.pdf
- TR-4492: MongoDB on the Data Fabric Enabled by NetApp Reference Architecture with All Flash FAS, Cloud ONTAP, and VMware vSphere
www.netapp.com/us/media/tr-4492.pdf

Virtual Desktop Technical Reports

- TR-4428: NetApp All Flash FAS Solution for VMware Horizon 6 and vSphere Virtual Volumes: A Technical Preview
www.netapp.com/us/media/tr-4428.pdf
- TR-4450: VMware Horizon Desktop as a Service on NetApp All Flash FAS
www.netapp.com/us/media/tr-4450.pdf

Electronic Design Automation (EDA) Technical Reports

- TR-4324: Electronic Device Automation (EDA) Verification Workloads and All Flash FAS (AFF) Arrays: Performance Validation of Synopsys VCS
www.netapp.com/us/media/tr-4324.pdf
- TR-4446: Electronic Device Automation (EDA) Verification Workloads and All Flash FAS (AFF) Arrays: Performance Validation of Mentor Graphics Questa
www.netapp.com/us/media/tr-4446.pdf

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