NetApp EF-Series Flash Arrays

The NetApp EF-Series Flash Arrays are all solid-state systems which use SSDs (solid-state devices) with the controllers and embedded software based off of the NetApp E-Series hybrid systems. The EF-Series consists of the EF600, and, the EF300. The same features of the E-Series models, along with the controller reliability, stability, and maturity are available with the all-SSD EF-Series models. The EF-Series is offered directly from NetApp or through its channel partners.

Competitive multi-platform distributed storage hardware systems include alternatives such as Dell EMC Unity XT all flash systems, IBM Storwize V7000F, and Hewlett Packard Enterprise (HPE) 3PAR StoreServ 9450.

Highlights

- All solid state technology storage system
- Dual active redundant controllers for high availability and performance
- Dynamic caching of data with up to 128GB of battery backed DRAM cache per dual controller system
- Flexible host modules that can be interchanged allowing for addition of 16 or 32 Gb/s Fibre Channel, 12 Gb/s SAS, and 10 or 25GigE iSCSI. 100 Gb/s InfiniBand or RoCE connections available for EF600 systems.
- Solid State Devices – 800 GB, 1.6, 3.8, 7.6, 15.3 TB SSD
- Multiple RAID level support and dynamic RAID level migration
- 2U 24-device enclosure – up to 5 enclosure for 120 devices (EF570 and EF280 only)
- Advanced features – snapshot, asynchronous and synchronous remote replication
- VAAI Support
- ALUA – Asymmetric LUN Access
- 2M IOPS at < 250µs latency
- 44 GB/s bandwidth
- Encryption with use of self-encrypting device

Figure 1: NetApp EF570 Storage System with 24 2.5” SSDs

Overview of System

NetApp has continued to provide high performance in their midrange systems with additions and upgrades to the product line. The EF-Series are all solid-state systems, built on existing controllers and embedded software designs, which support advanced features that have evolved over time to provide high-value capabilities to customers. The EF-Series meets customer needs for high performance, low-latency storage in accelerating applications such as databases, data acquisition, and data analysis. The high performance and advanced features allow the EF-Series to meet the demands of primary storage without compromising capabilities. As a high performance system, the EF-Series supports Fibre Channel, SAS, iSCSI and InfiniBand connectivity. NVMeOF host protocol is supported for the EF600 and EF300 over the InfiniBand and RoCE. The EF600 also supports NVMe over Fibre Channel.

Hardware Architecture

The EF-series, based on the hybrid E-series, is a seventh generation controller design that supports multiple interfaces with pluggable modules for advanced interface connections including 16 or 32Gb/s Fibre Channel, 10 or 25GigE iSCSI, 12 Gb/s SAS, and 100Gb/s InfiniBand with support for NVMe protocol. The dual controller system has 16 or 64GB of cache per controller. SSD ports use SAS interfaces at 12Gb/s with four lanes (wide SAS) for an aggregated 48 Gb/s. The controllers have dual RJ45 Ethernet 10/100 BaseT connectors and USB serial management and configuration ports. All interface ports are small form factor pluggable (SFPs) connector interfaces. The battery for data and cache protection is a long life (lithium Ion) battery. The EF-Series controllers have customer replaceable units (CRUs) that consist of two controllers and two power/cooling modules.

The EF-Series systems are 2U enclosures with two RAID active/active controllers with mirrored write back cache, host interface ports, and redundant power and cooling.

EF570 Controller Architecture

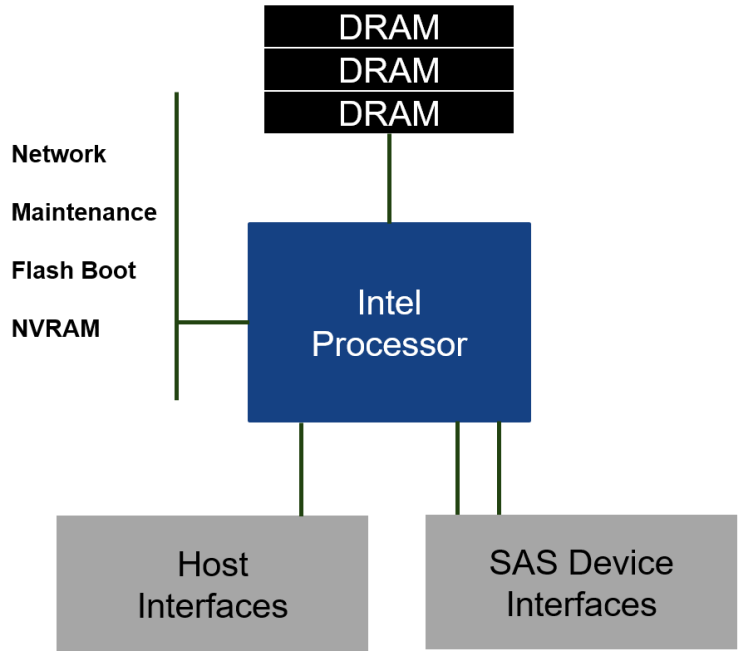

Figure 2: EF570 Controller Architecture

The NetApp EF-Series are dual controller systems with redundancy of components to enable high availability. There are dual interfaces to each device module to ensure data access. Access through the controllers uses independent host interfaces between the two controllers along with multi-pathing software on hosts.

The high performance controller design incorporates the use of high performance Intel processor, custom logic in the form of field programmable gate arrays, and a high-speed shared non-volatile memory between the controllers.

With *Dynamic Device Pools* (DDP) allocation method, storage pools are created using segments (chunks) of space on device that are distributed across 10 devices to create 8+2 RAID 6 group. With DDP, as new capacity is assigned to a volume, segments are distributed across the devices in the entire pool in the fixed 8+2 grouping based on an algorithmic distribution. The distribution algorithm is based on the work done by UC Santa Cruz called CRUSH.

Using DDP, the EF-Series systems with SANtricity 10.83 or greater code level have the advanced capabilities enabled with this storage pooling implementation:

- Thin provisioning – Volumes in a Dynamic Device Pool can be configured as fully provisioned or thin provisioned. With thin provisioning, segments are allocated only when required by write operations. Thin provisioning improves the capacity efficiency of storage by only assigning real device capacity as it is used. Asynchronous mirroring is supported for thin provisioned volumes.

- Capacity expansion – Additional device drives can be added to a pool in granularities from 1 to 12 devices at a time. The EF-Series system will automatically redistribute data across the newly added devices. The EF300 and EF600 models have additionally added support for SAS HDD expansion.
- Multiple pool support –Currently, up to 10 Dynamic Device Pools may be defined.
- Capacity rebalancing – As a background operation, the capacity utilization of the physical devices will automatically rebalanced to provide an optimal selection for the distribution of additional segments for usage. The RAID group organization is maintained during the rebalancing.
- Accelerated rebuild – With DDP, parallel device operations are used during the rebuild of a failed device drive, which greatly reduces the amount of time required for rebuild compared to traditional allocation. The rebuild is also prioritized for rebuilding cases where there are two failed drives are failed segments on two drives in the same RAID group.

Software Architecture

SANtricity Management Software

The SANtricity management software provides a dual mode that supports wizard driven actions as well as an advanced mode for more detailed actions. It is the framework for managing the EF-Series storage systems. SANtricity provides centralized administration of all EF-Series systems from any point on the network and a consistent management interface across all supported platforms. SANtricity management suite provides the following:

- Manages single or multiple E-series systems
- Configures RAID systems and volumes, assigns volumes to host
- Management of device and performance via a browser-based GUI
- Control of system-based Snapshot, Volume Copy and Remote Mirroring
- Dynamic Volume Expansion
- Event notification and Remote monitoring of E-series systems
- Collects and displays performance statistics, configuration information, and any upgrade enhancements
- Contains an optional failover driver based on MPIO technology
- SMI-S provider included with software
- Manages traditional RAID groups

Advanced Software Features

Storage Partitioning

Storage partitioning provides heterogeneous host attachment and SAN security (LUN Masking) for the EF-Series systems. LUN Masking is the ability for each LUN to specify what host, or combination of hosts, may have access to that LUN. Storage Partitioning can create up to 512 logical systems from a single storage system. With partitioning, any volumes can be mapped to a specific server.

Snapshot

Snapshot is a storage system based PIT (point-in-time) copy that can capture up to 128 point-in-time images of a LUN and retain the images independent of changes to the original data. Snapshot gives the user full-image utilizing copy-on-write technology. Snapshot allows up to 2,048 copies on the storage system. The EF series uses a copy-on-write implementation for snapshots.

Remote Mirroring

Synchronous Mirroring and Asynchronous Mirroring are both supported with the EF-Series. Features include the ability to suspend and resume synchronous mirroring. The EF-Series supports maximum number of 128 mirrored pairs and enables Snapshot operations to be performed on a remotely mirrored volume. The EF570 supports peer-to-peer remote copy (mirror) between EF600/EF570/EF300/EF280 and E5500/E5400 systems. It provides LUN replication within a Fibre Channel or iSCSI campus environment and distributed environments using synchronous and asynchronous remote copy with write order grouping for consistency.

Volume Copy

Volume Copy provides the capability to create a full volume copy of a standard volume or a Snapshot volume. The target can be any standard drive defined with a capacity equal to or greater than the source. Up to 2047 Volume Copies can be made.

Dynamic Volume Expansion

For traditionally allocated volumes where the entire space was allocated at the time a volume was created, dynamic volume expansion enables storage administrators to resize volumes without disruption real-time application users. With thickly provisioned volumes, Dynamic Volume expansion is an important feature for applications that cannot afford downtime when more storage needs to be configured and put into usage. A prime example of the usage of a dynamic volume expansion capability is that of the MS Exchange environment where users cannot afford to lose email access when more storage capacity is required.

Dynamic Capacity Expansion

Dynamic capacity expansion allows one or two drives to be added to a traditional volume group, creating additional capacity that can be used for new volumes or volume expansion.

Dynamic RAID Level Migration

For traditional RAID group allocation, dynamic RAID level migration allows a volume group to have the RAID level changed without having to migrate the data.

Dynamic Mode Switching

Dynamic mode switching is used with remote mirroring and allows a switch from one remote mirroring mode to another without suspending or breaking the mirror.

Dynamic Defragmentation

Defragmentation will defragment a volume and consolidate free capacity within a volume group.

Dynamic segment size migration

Dynamic segment size migration allows the segment size of a volume to be changed for traditionally allocated pools.

Function	Model EF570
Remote Replication - # of LUNs	128
Local copy maximum	2,047
Snapshot per volume	128
Snapshot maximum	2,048

Table 1: NetApp EF570 Feature Capabilities

Integration with Systems and Software

VMware VAAI Support

The EF570 and EF280 supports the VMware vStorage APIs for Array Integration (VAAI), which began with vSphere 4.1. VAAI is a set of mechanisms that allow processing for certain data-related services—

copying data when creating a new VM, for example—to be offloaded from the ESX host to a storage array. The intent of these APIs is to streamline the functioning of the ESX server and speed-up delivery of storage-supported services.

- **Full copy —** Enables the storage system to make full copies of data within the storage system without having the ESX host read and write the data.
- **Block zeroing —** enables storage systems to zero out a large number of blocks to speed provisioning of virtual machines.
- **Hardware-assisted locking —** The system uses an atomic test and set implementation rather than a SCSI lock/reservation to protect the metadata for VMFS cluster file systems, thereby improving the scalability of large ESX host farms sharing a Datastore.

Reliability, Availability, Serviceability Features

The EF-Series storage systems maintain data integrity and provide data availability via the following mechanisms:

- NetApp AutoSupport – integrated monitoring and reporting software
  - Includes proactive health checks and drive monitoring
- Dual controllers with failover for high availability
- Redundant, hot-swappable components:
  - Controllers
  - Fans
  - Power supplies
- RAID protection up to dual pair RAID 6 for storage devices
- Non-disruptive firmware upgrades
- Persistent cache backup in case of power outage
- Storage of configuration metadata on each device drive
- Cabling checks for mis-wire detection
- Alert thresholding

Performance

NetApp has provided the following information for the EF-Series. The performance numbers may change with new versions of software or hardware so the latest information should be checked on the Storage Performance Council website **www.storageperformance.org** to obtained published information with a standard test.

SPC-1 Performance numbers for the EF570 as of September 2017:

- 500,022 Maximum IOPs
- Capacity – 9TB
- Price - $64,212

NetApp states the maximum bandwidth is 21Gb/s.

Other vendor supplied performance data:

EF570

- 185,000 4K random write ops at <100µs
- 100,000 4K random read ops at <140µs
- 800,000 4K random read ops at <200µs
- 1,000,000 4K random read ops at <200µs

EF600

- 200,000 4k random write ops at <100µs
- 150,000 4k random read ops at <100µs
- 2,000,000 4k random read ops at <250µs

No performance data is available for the NetApp EF280 or EF300 systems.

Evaluator Group Comments

The EF-Series are all SSD systems based on a mature design with stable embedded firmware and management software. Iterative enhancements have been made by NetApp over time, which include additional advanced features, new processors for performance improvements, and improved embedded firmware. It is unusual for an all-SSD system to be offered with a full suite of advanced functions and be based on a proven system.

Strengths:

- ***All SSD system (added support for optional HDD expansion)***
- ***16Gb/s Fibre Channel, 10Gb/s iSCSI, 56Gb/s InfiniBand and 12 Gb/s SAS ports***
- ***NVMeOF support***
- ***Significant demonstrated performance***
- ***Proven system design and embedded software with advanced features in snapshot and replication***
- ***Customer enabled updating with change (swap) of individual controllers***

The flexible host interface module capability provides great opportunity to extend the connectivity of the EF-Series in the future without major system changes. As infrastructures change inside IT environments, the EF-Series systems can be updated to match.

The NetApp EF-Series continues the performance focus provided by the NetApp E-Series storage platform solutions. The EF300, and EF600 provide great economic value with the ability to use solid-state technology to accelerate applications and get more productivity from server and infrastructure. In addition to the performance gains in traditional applications and server virtualization environments, other workloads in geo-science, video and imaging, telemetry, visualization and stereo graphics, simulations will benefit from the EF-Series solid-state performance. The performance gains from the EF-Series systems will allow customers to consolidate more storage systems with greater efficiency rather that focus on over-provisioning capacity just to meet performance demands.

More detailed information is available at http://evaluatorgroup.com