

Lab Evaluation of NetApp[®] EF540 All-Flash Array and the SANtricity[®] SSD Cache Technology

Evaluation report prepared under contract with NetApp

Introduction

As flash storage options proliferate and become required in the enterprise, IT professionals must analyze various types of flash storage solutions in order to determine the best fit for many of their applications. In those cases where mission-critical applications need the fastest performance, an all-flash solution can be the right choice. In other cases, a solution that uses flash as a caching layer combined with hard disk drive technology may be the best choice.

Through its EF-Series and E-Series portfolio, NetApp provides both of these types of solutions. The EF540 all-flash array is designed to deliver extreme performance for latency-sensitive data and accelerate business-critical applications. The E-Series SANtricity SSD Cache feature is designed to work with HDD's to accelerate read IOPs.

NetApp commissioned Demartek to evaluate the performance of its EF540 flash array and the E-Series SANtricity SSD Cache technology. The EF540 system testing was performed with 24 800GB SSDs. The E-Series SSD Cache testing was done on an E5460 system with 20 NL-SAS drives and a single 800GB SSD.

Executive Summary and Key Findings

NetApp provides two solutions that address two different challenges business face today with respect to storage system performance. Both solutions offer advanced data protection features and intuitive management interfaces.

In addition, these enterprise-grade systems provide automated support capability and are supported world-wide.

NetApp EF540 All-flash Storage

The NetApp EF540 all-flash enterprise storage system provides a compact solution to meet demanding requirements. Our findings include:

- ◆ The EF540 in the all-flash configuration achieved greater than 330,000 IOPS while maintaining response times of less than 1 millisecond.
- ◆ The EF540 can scale up to nearly 40TB of all-flash capacity in 4 rack-units (4U).

NetApp E-Series SANtricity SSD Cache

The NetApp E5460 with SANtricity SSD cache provides strong read performance acceleration while leveraging lower-cost HDDs for capacity.

- ◆ The E5460 SANtricity SSD Cache achieved almost 17x better IOPS and bandwidth performance, and greater than 17x lower (better) latency after the cache was warmed.
- ◆ The E5460 SANtricity SSD Cache can be enabled with a single SSD and can grow with additional SSDs as needed.

Business Challenges

Today's IT environments continue to be faced with the dual challenges of meeting increasingly aggressive service level agreements (SLAs) while reducing costs. In order to meet these goals, storage systems need to provide excellent performance, be easy to manage and provide these benefits at low costs.

Maintaining these elevated SLAs requires storage systems that provide outstanding performance in three dimensions:

- ◆ I/Os per second (IOPS)
- ◆ Throughput or bandwidth (MBPS)
- ◆ Response time or latency measured in milliseconds

The NetApp offerings of either the EF540 all-flash array or the E-Series SSD Cache provide outstanding performance in all three areas.

The SANtricity software provides an easy-to-use interface for managing the EF540 and all of the NetApp E-series enterprise storage systems. The dashboard view provides a good overview of the storage systems at a high level, with features that allow the administrator to drill down into the extreme details of volumes and individual components.

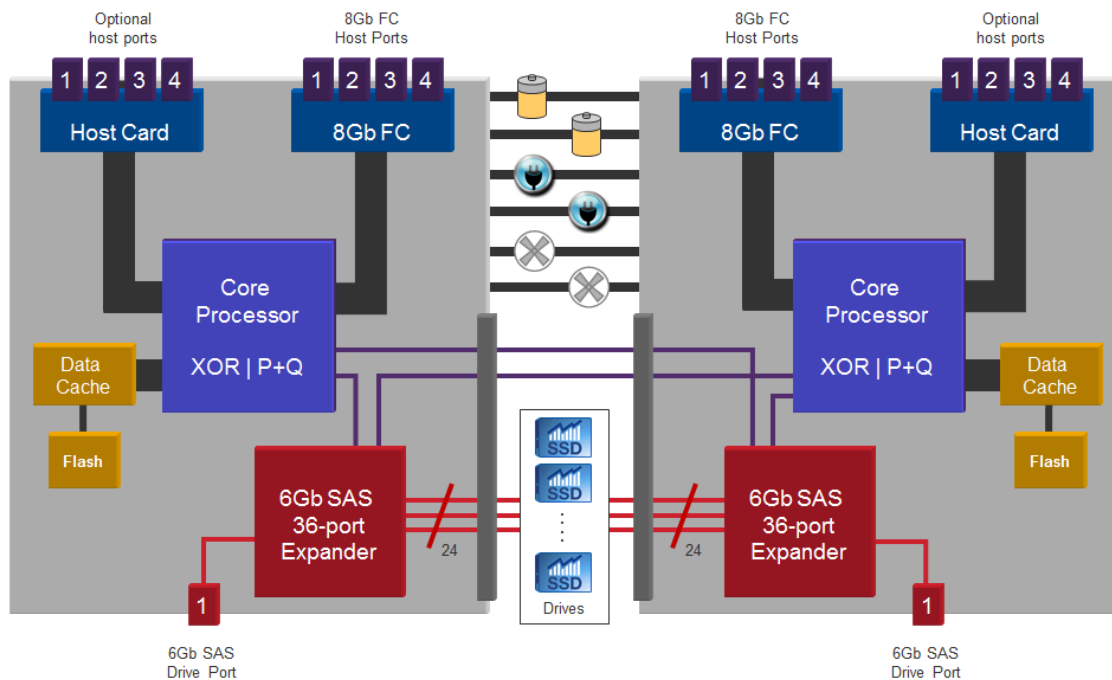
The E-Series SANtricity SSD Cache allows for a combination of SSD and HDD technology that provides accelerated performance at lower cost. The SSD Cache feature is available in all E-series products for the 2U24 or 4U60 platforms.

Architecture

The NetApp EF540 is an enterprise storage system designed for performance-driven applications that also need consistent low latency. It has a dual-controller architecture that has dedicated links between the controllers for inter-controller communications and supports a variety of host interfaces including Fibre Channel, SAS, iSCSI and InfiniBand. All the components of the EF540 are fully redundant and hot-swappable, including controllers, disk drives, power supplies and fans. Additionally, controller firmware upgrades can be performed non-disruptively.

The internal quad-core processors include integrated high-speed RAID engines that support RAID levels 0, 1, 5, 6 and 10 and global hot spares. The controller's PCI express buses between the processor and external interfaces provide enough capability to handle large-block I/O and the speed to process large amounts of random, small-block I/O. Each EF540 array provides 24GB of memory, which is battery-backed and de-staged to internal flash upon power loss.

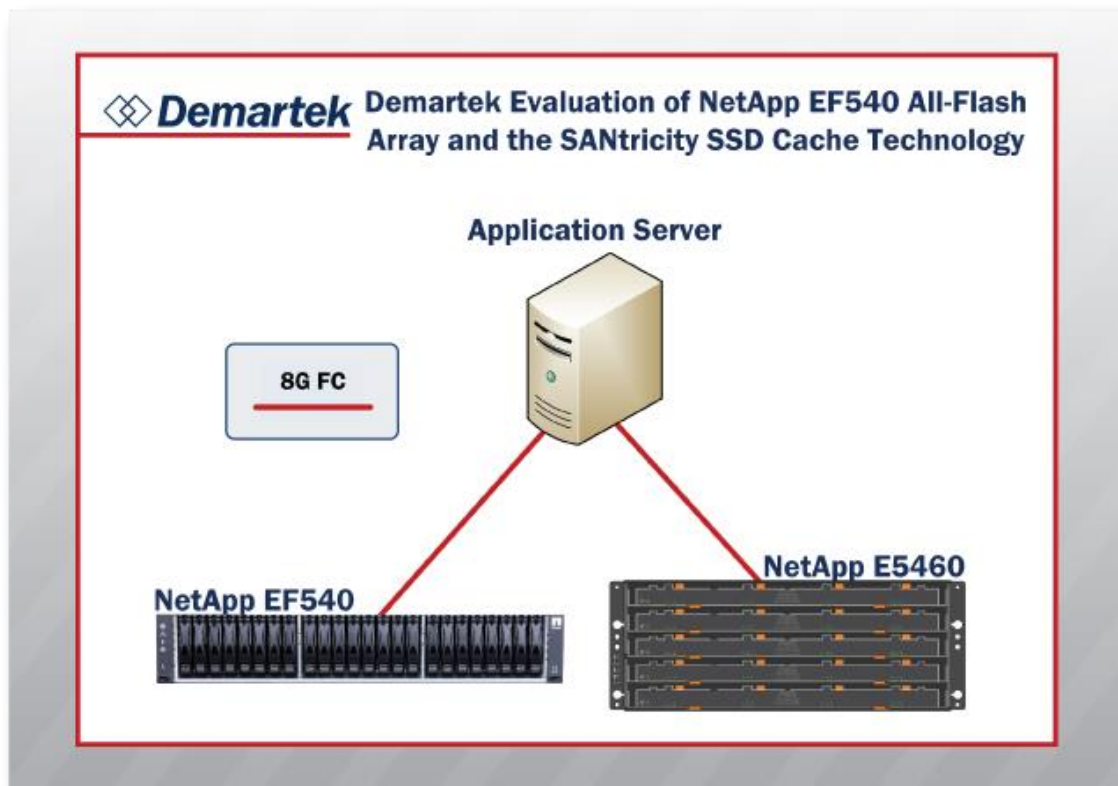
The on-board SAS expanders support 24 2.5-inch SSDs in a two rack-unit (2U) shelf that is Storage Bridge Bay compliant.



Test Configuration and Procedures

Two tests were performed; each designed to demonstrate the full capability of the products under test. In both tests, a single server running Microsoft Windows Server 2008 R2 was connected to the NetApp storage system via four 8Gb Fibre Channel links.

- ◆ The first test was the EF540 all-flash array with 24 800GB SSDs.
- ◆ The second test was performed with an E-Series E5460 with 20 2TB NL-SAS disks and a single 800GB SSD. The SSD was configured as the SSD cache.



Workloads

The workloads used for these tests were generated by IOMeter 2010. IOMeter fits into the category of synthetic I/O workload generators that can be used to perform specific I/O tests. IOMeter 2010 is an industry standard, open source I/O load generator that is available from Source Forge at <http://sourceforge.net/projects/iometer/>. Demartek catalogs the data patterns written by IOMeter and other synthetic benchmarks on the [Benchmark Output File Format](#) page on the Demartek website.

The parameters used for these IOMeter 2010 tests were:

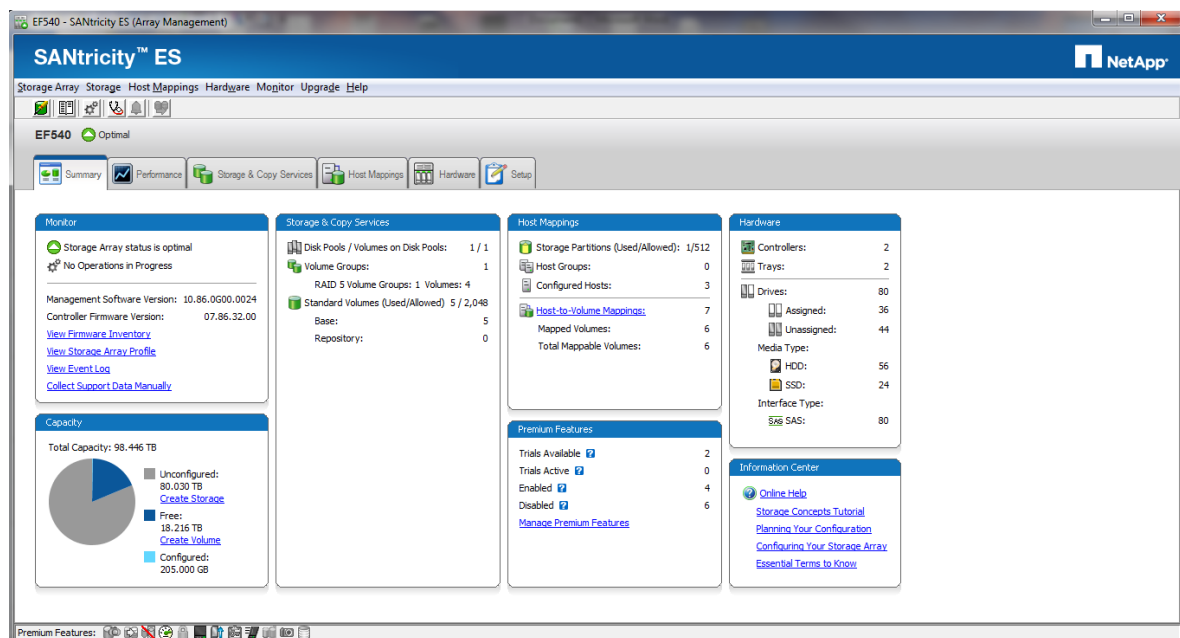
- ◆ I/O profile: 100% Random Read
- ◆ Blocksize: 4KB
- ◆ Queue Depth: 32
- ◆ Test duration: 1 hour

These tests were selected because they are one of the more intense read-heavy workloads that are commonly used for flash technology. One of the goals of these tests was to determine the performance of the storage system while maintaining a very low latency level.

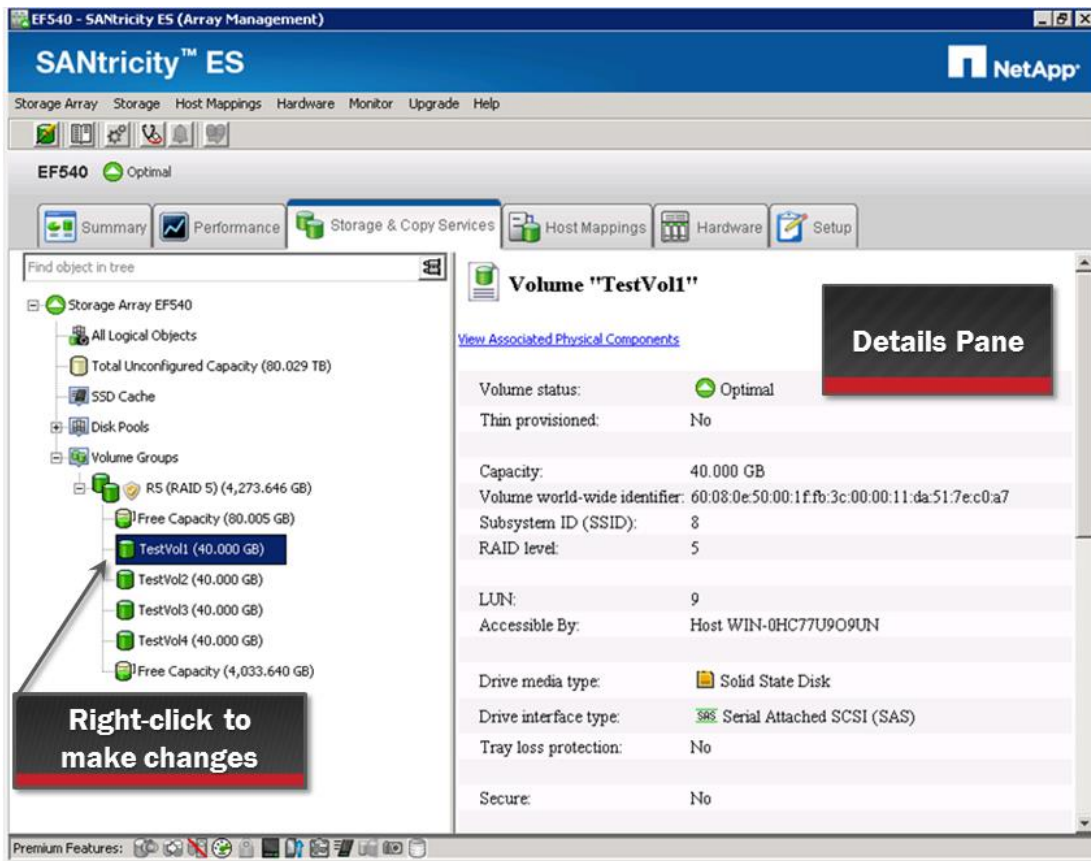
SANtricity Storage Management

SANtricity storage management software provides an easy-to-use platform for managing the EF-Series and the E-Series storage systems. Navigation is easy and intuitive with tabs to guide the user to the most common areas. Quick access icons and drop down menus are available for more advanced functions.

The first screen shown below is the storage summary or dashboard view of the system, providing high-level views of the major areas of interest to a storage administrator.



The storage administrator can view information about volumes or hardware components. For example, as shown below, the administrator can determine if a volume composed of hard disk drives (HDDs) has an SSD Cache associated with it, and can assign an SSD Cache to a volume by right-clicking on the volume and adding the volume into the SSD Cache configuration. In addition, the built-in reports indicate when additional SSD Cache capacity is needed.



SANtricity™ ES NetApp

Storage Array: EF540 (Optimal)

Find object in tree

- Storage Array EF540
 - All Logical Objects
 - Total Unconfigured Capacity (80.029 TB)
 - SSD Cache
 - Disk Pools
 - Volume Groups
 - RS (RAID 5) (4,273.646 GB)
 - Free Capacity (80.005 GB)
 - TestVol1 (40.000 GB)**
 - TestVol2 (40.000 GB)
 - TestVol3 (40.000 GB)
 - TestVol4 (40.000 GB)
 - Free Capacity (4,033.640 GB)

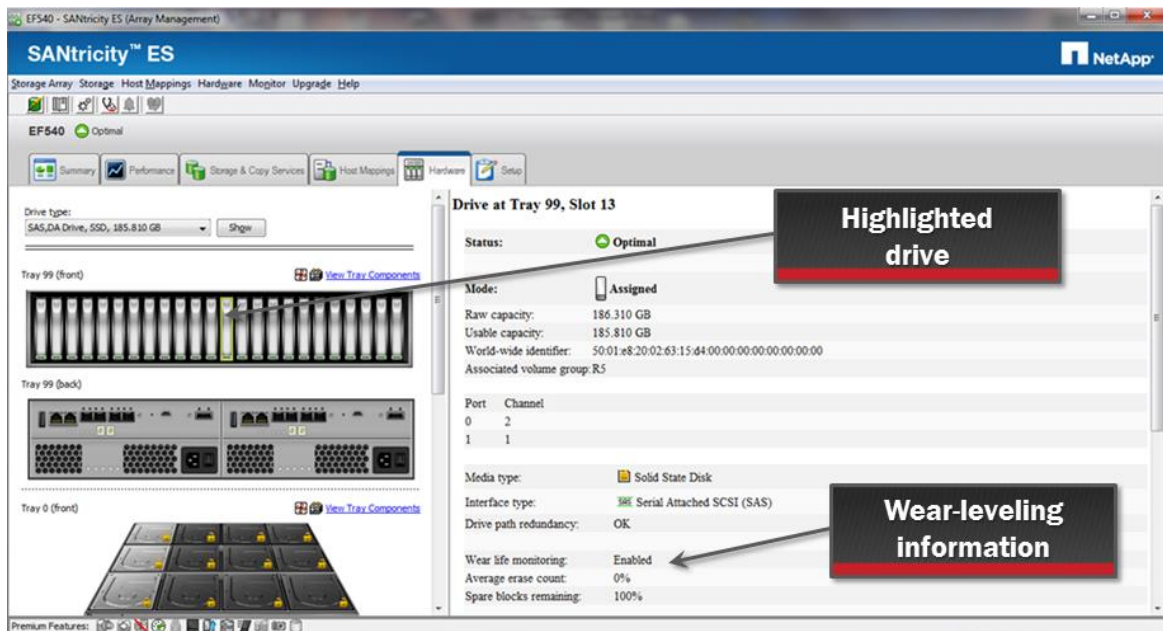
Volume "TestVol1"

[View Associated Physical Components](#)

Details Pane

Volume status:	Optimal
Thin provisioned:	No
Capacity:	40.000 GB
Volume world-wide identifier:	60:08:0e:50:00:1f:fb:3c:00:00:11:da:51:7e:c0:a7
Subsystem ID (SSID):	8
RAID level:	5
LUN:	9
Accessible By:	Host WIN-0HC77U9O9UN
Drive media type:	Solid State Disk
Drive interface type:	Serial Attached SCSI (SAS)
Tray loss protection:	No
Secure:	No

Right-click to make changes



SANtricity™ ES NetApp

Storage Array: EF540 (Optimal)

Drive type: SAS,DA Drive, SSD, 185.810 GB

Tray 99 (front)

Tray 99 (back)

Tray 0 (front)

Drive at Tray 99, Slot 13

Highlighted drive

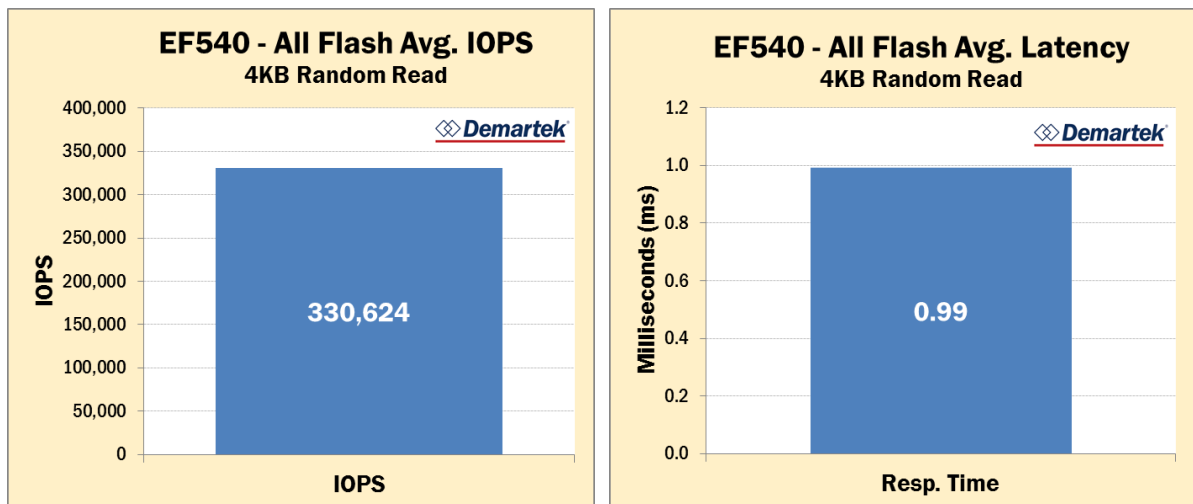
Status:	Optimal
Mode:	Assigned
Raw capacity:	186.310 GB
Usable capacity:	185.810 GB
World-wide identifier:	50:01:e8:20:02:63:15:64:00:00:00:00:00:00:00:00
Associated volume group:	RS
Port:	0 2
Channel:	1 1
Media type:	Solid State Disk
Interface type:	Serial Attached SCSI (SAS)
Drive path redundancy:	OK
Wear life monitoring:	Enabled
Average erase count:	0%
Spare blocks remaining:	100%

Wear-leveling information

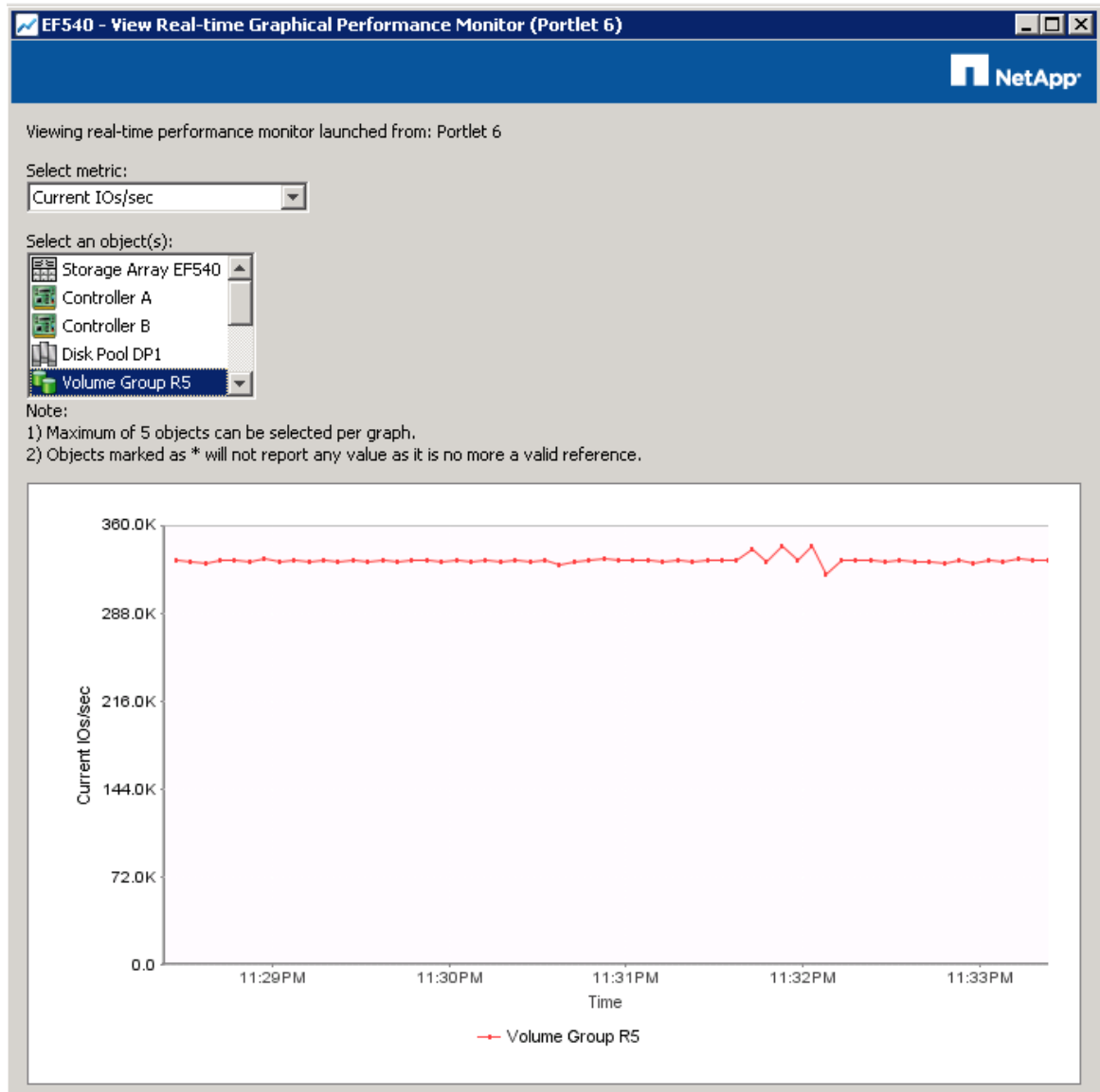
Performance – EF540 All Flash Configuration

The average IOPS achieved during this test of the EF540 all-flash array was 330,624, while maintaining an average response time of less than one (1) millisecond. To obtain this type of performance in a traditional array would require hundreds of spinning disks.

These results indicate that the EF540 enterprise storage system can satisfy mission-critical applications where both IOPS and latency are important.



The SANtricity software that manages the EF540 enterprise storage system provides performance monitoring capabilities, and during this same test, reported very similar performance as the host server.



Performance – E5460 SANtricity SSD Cache Configuration

For those who do not need an all-flash solution, but would like some of the performance benefits that flash solutions bring, the E-Series SANtricity SSD Cache feature provides very strong performance and allows a user to start with just one SSD and grow as needed. The following tests were run with the same IOMeter parameters as the EF540 all-flash solution, but the underlying storage system was changed to the E5460 with SSD Cache enabled.

The primary principle behind the SSD Cache feature is that a copy of “hot” data is placed in the cache, and repeated accesses to this data are accelerated, because they can be serviced from the SSD Cache instead of the slower HDD technology. However, because this data is a copy, the original data is fully protected by all the standard features provided by the storage system.

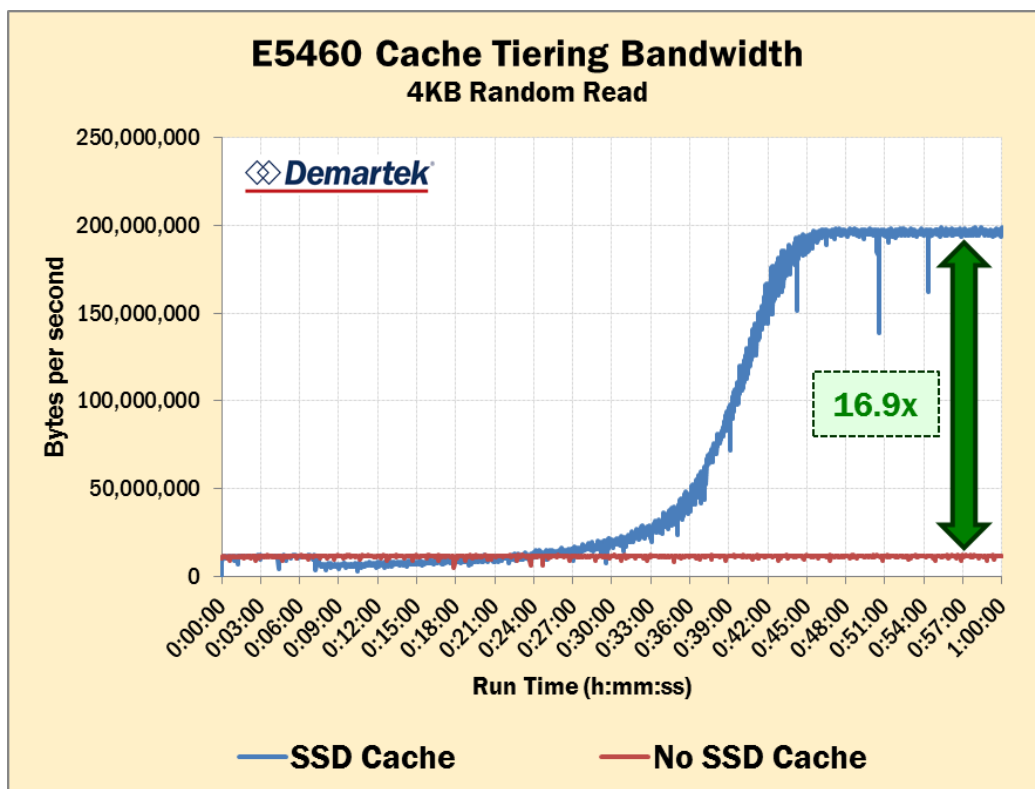
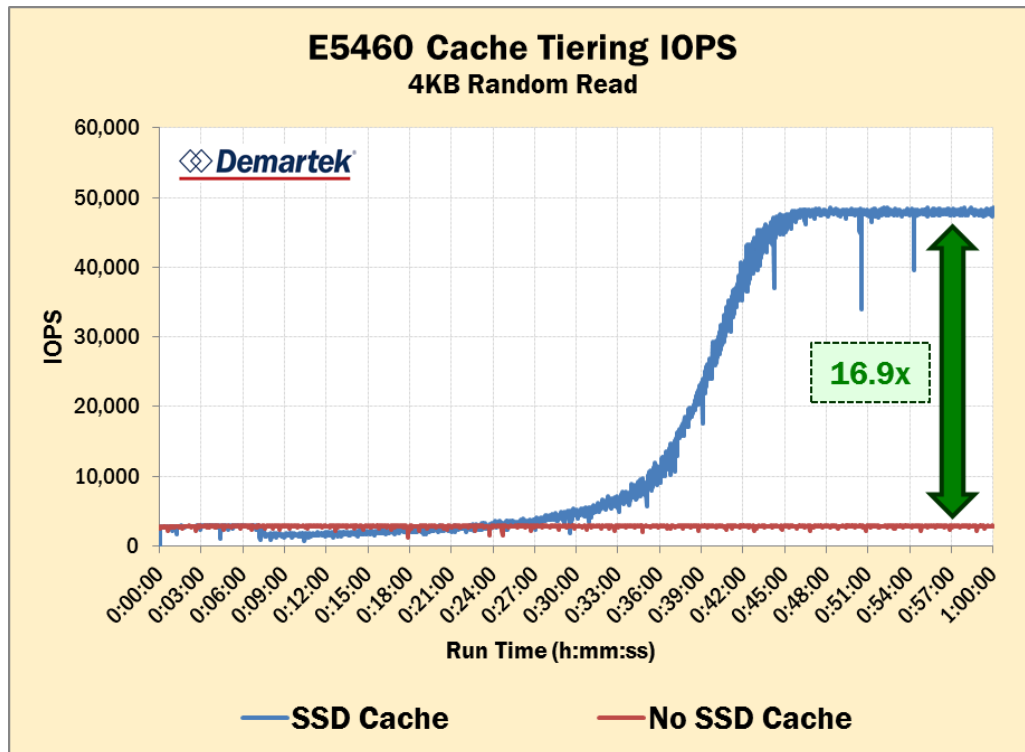
When first enabled for a volume, the SSD Cache must be “warmed”, this happens automatically as the system runs and is the process of the data being promoted into the cache as it is being read. This cache warm-up period will vary depending on the workload profile and can take minutes or hours. For our tests, the cache was fully warmed in approximately 45 minutes.

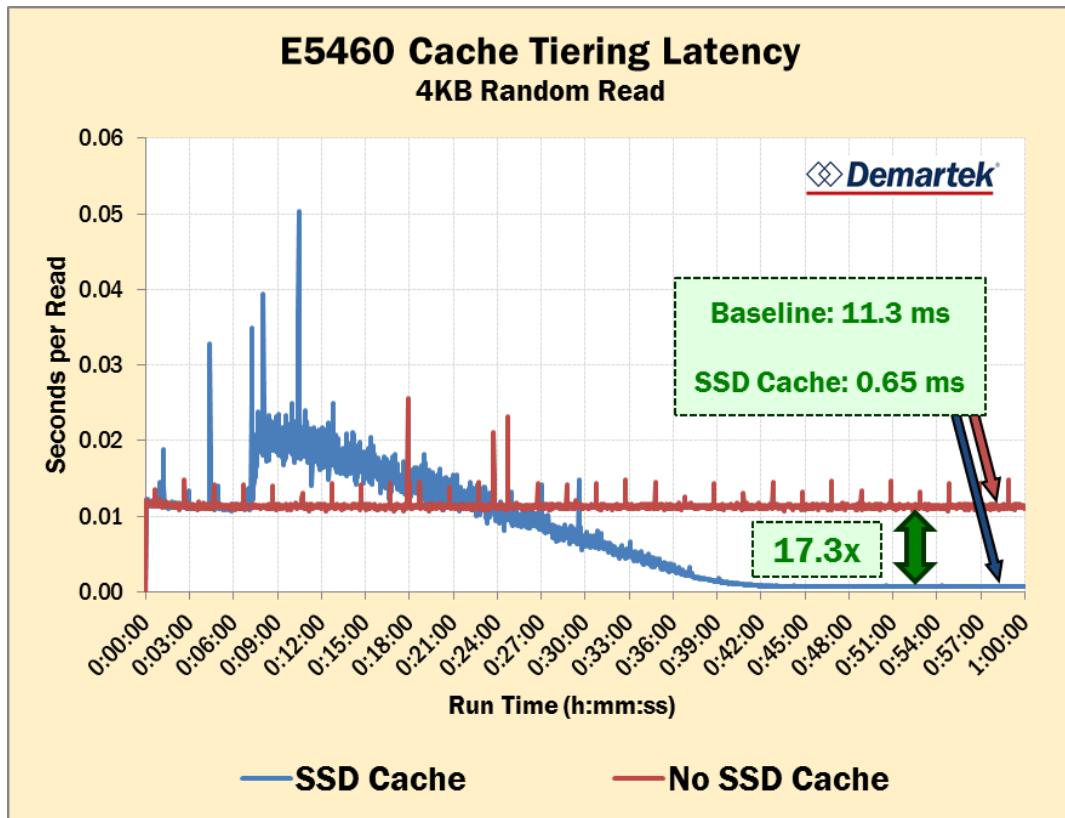
The following three charts show the storage system performance from the perspective of the host operating system, in this case, Windows Server with its native performance monitor tool (Perfmon).

Two tests were run, one without the caching to show a baseline, and one with the caching. The baseline test included only HDD technology, and the caching test included the SANtricity SSD Cache with the SSD included in the storage system.

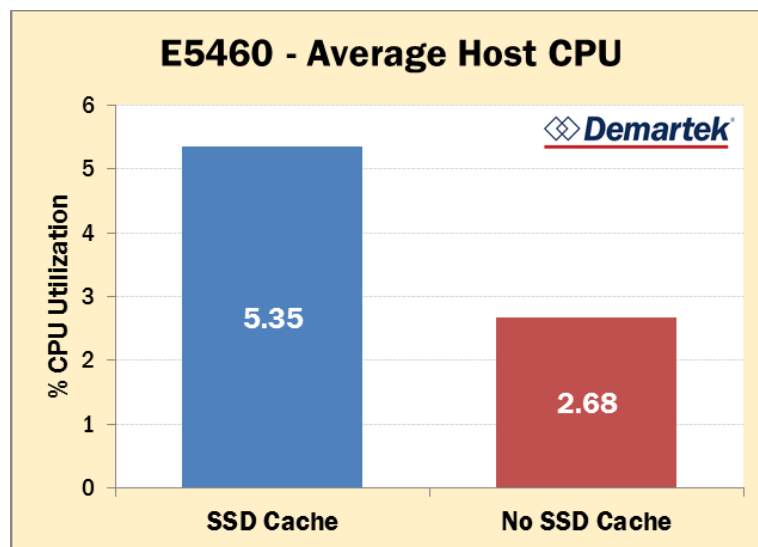
We found an improvement of 16.9x higher performance with the cache in terms of IOPS and bandwidth over the baseline tests. We found an improvement of 17.3x lower (better) in terms of response time, also known as latency.

The charts below show the cache warm-up period for these tests. The cache warm-up will vary by workload. For this workload, the cache made little difference in performance for the first thirty minutes, but then the increase was dramatic, and by approximately 45 minutes into the workload, the improvement was substantial.





One other noteworthy item was the host CPU utilization during this test. As is typical when SSDs are implemented, CPU utilization increases because more work is accomplished during the test period. The chart below shows the average host server CPU utilization during the one-hour test period.



Summary and Conclusion

The NetApp EF-Series and E-Series are well suited to meet many workload environment requirements. EF540 provides outstanding results for performance-driven applications demanding high IOPS and low latency. The E-Series SANtricity SSD Cache feature is ideal to increase application performance for read-intensive applications. We found that:

- ◆ The EF540 all-flash array achieved greater than 330,000 IOPS while maintaining response times of less than 1 millisecond. This system was a fully high availability (HA) configuration with 24 SSDs in a RAID5 configuration.
- ◆ The E-Series SANtricity SSD Cache feature increased performance almost 17x while lower latency by almost the same amount.
- ◆ The NetApp E-Series and EF-Series support a wide choice of host interfaces, including 16G Fibre Channel, 10G iSCSI, 6G SAS and 40G InfiniBand, more than most competing storage systems.

We found the SANtricity management software is easy to use and very intuitive, for configuration functions and tasks such as creating and assigning the SSD Cache.

We recommend that IT managers and administrators consider the NetApp portfolio for applications requiring the use of flash technology.

The most current version of this report is available at http://www.demartek.com/Demartek_NetApp_EF540_FlashArray_SANtricity_SSD_Cache_2013-09.html on the Demartek website.

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