Accelerate Database Performance With All-Flash Storage

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For many database applications—from high-frequency trading to real-time risk management—microseconds translate to opportunities created or opportunities lost.

Since the speed with which I/O can be completed is critical to database performance, enterprises are increasingly turning to all-flash storage to minimize I/O latency and accelerate transactional performance.

Choosing the right all-flash storage translates directly to the bottom line with big improvements in processing time, less server hardware needed, lower database licensing costs, and significant savings in floor space and energy usage. (For more on this check out Flash Delivers Storage Performance for an Impatient World in this issue.)

Driving Maximum Database Performance

For years, database administrators (DBAs) have carefully planned and controlled data storage to squeeze out the best possible performance from relatively slow disks, with best practices that included running busy log files on fast, mirrored drives to deliver the best available performance.Â DBAs also favored dedicated, over-provisioned infrastructure to avoid “noisy neighbor” contention and unpredictable response times.

All-flash arrays substitute solid-state disks (SSDs) for slow, mechanical disks. The results are dramatic for every element of performance. A flash SSD delivers hundreds of times more IOPS than a hard disk drive (HDD) and slashes access latency from milliseconds to microseconds.

But there are important architectural differences that make various all-flash arrays more or less well suited for high-performance database workloads. A clean, optimized data path is essential to take full advantage of flash latencies measured in

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Explore

More on the EF560

Find out what people are saying about the new EF560 in the following blog posts:

- NetApp EF560 All-Flash Array Enhances Multi-Core Performance
- NetApp Posts Top Ten SPC-1 Price-Performance
- Does the All-Flash Array Really Make Sense?
- New! NetApp EF560 and E5600 Performance Arrays

About the SPC-1 Benchmark

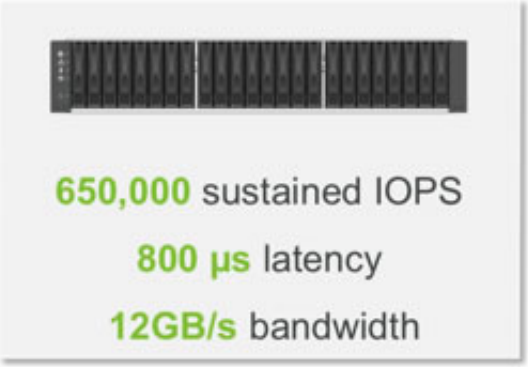
SPC-1 is an industry-standard, audited SAN benchmark from the Storage Performance Council, which stresses storage with a mix of predominately random I/O of various sizes. The workload includes both queries and update operations characteristic of applications such as OLTP and database. The SPC-1 benchmark is far more demanding than the usual small-block read workload. In fact, about 60% of the workload is writes, making the benchmark very challenging for flash storage.

DDP Critical Segment Rebuilds

Both EF-Series and E-Series feature dynamic disk pool (DDP) technology, which distributes data, parity information, and spare capacity evenly across an entire pool of drives—simplifying setup, eliminating hot spots, and maximizing capacity utilization.
The latest SANtricity release adds critical segment rebuilds to DDP. If two drives fail

microseconds. It is critical that storage services don't get in the way of fast, consistent performance.

NetApp EF560



The new NetApp® EF560® all-flash array is ideally suited to deliver maximum all-flash performance for business-critical databases. This new platform delivers state-of-the-art performance results for both absolute and consistent performance. With up to 650K IOPS in a compact 2U form factor and average response times of 800 microseconds or less, the EF560 shows the importance of storage system design. Furthermore, the EF560 includes the proven reliability and availability developed over eight generations of the SANtricity operating system.

The EF560 is designed to satisfy the best practices of the high-performance DBA. Storage CPUs are dedicated to fast read and write activity while host resources are used for compression. Nothing in the code path gets in the way of processing I/O, so the array not only delivers latency measured in microseconds under load, it delivers the same latency on day 1,001 as it did on day 1—with no unexpected spikes.

For DBAs, this dedicated performance is consistent with the drive to realize consistent predictable results. We've characterized the performance and price/performance of the EF560 with a variety of internal benchmarks (IOPS and throughput) plus the SPC-1 benchmark, and the results are exceptional.

IOPS Performance

First, let's look at how the EF560 performs on a read workload—the type that is most often reported for all-flash arrays. The EF560 delivers 650,000 sustained I/O operations per second at 800 microsecond latency from just 2U of rack space. That's a 62.5% bump over the EF550. If we take 500 microseconds as a performance threshold, the EF560 can still deliver 628,000 IOPS.

We've taken the characterization of EF560 IOPS performance a step further to help better predict performance for the workload you intend to run. (The system under test was an EF560 with 48 SSDs, RAID 5, and 8KB block size.)

Table 1) EF560 IOPS performance under various read/write workloads.

% Reads	Under 1ms	Under .5ms
100%	650,000	628,000
75%	314,000	281,000
50%	195,000	168,000
25%	144,000	133,000
0%	117,000	102,000

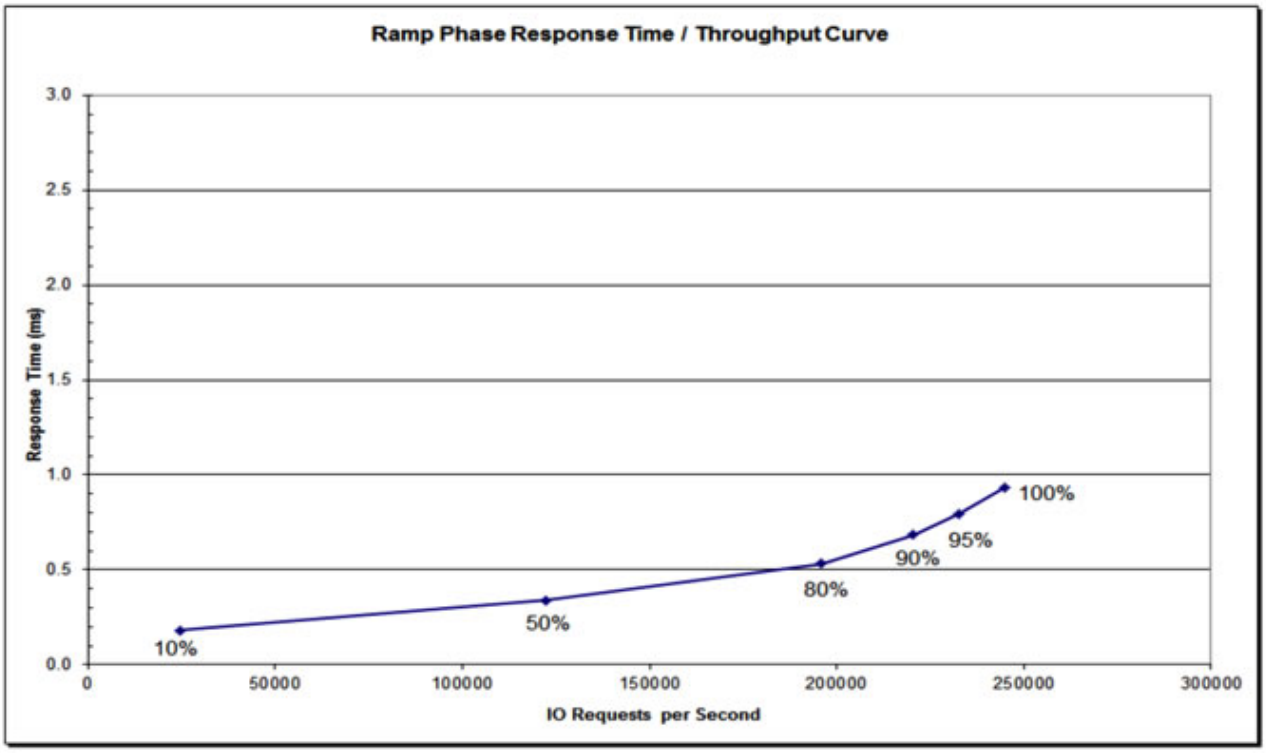
Source: NetApp, 2015

at the same time, SANtricity automatically identifies those segments that have data stripes on both failed drives and rebuilds those first to minimize exposure.

SPC-1 Benchmark Performance

To provide additional validation, we have published results for the EF560 running the Storage Performance Council's SPC-1 benchmark, which does a good job of simulating the demands of a high-performance database with a high percentage of writes as well as reads. (See sidebar *About the SPC-1 Benchmark* for details.) In this audited test, the EF560 delivers 245,011.76 SPC-1 IOPS™ with an average response time (ART, measured at 100% load) of 0.93 milliseconds or 930 microseconds. If we consider 500 microseconds as a threshold, the EF560 delivers 196,008.41 SPC-1 IOPS at 0.53 milliseconds (530 microseconds) response time. The typical customer has a requirement for 80-120K IOPS—well within the capabilities of the EF560.

Figure 1) EF560 SPC-1 response-time curve.



Source: SPC-1 Benchmark EF560 Executive Summary

The EF560 offers the lowest SPC-1 Least Response Time, or LRT (measured at 10% load) of any configuration on the SPC-1 "Top Ten" lists at 0.18 milliseconds (180 microseconds). SPC-1 LRT represents the minimum response time possible from a storage system. View the EF560 SPC-1 executive summary or the full report.

20x Latency Improvement with 70% Reduction in Rack Space
Do high IOPS and latencies measured in microseconds make a difference? A global online retailer needed consistent low latency to accelerate payment transactions and increase customer satisfaction. The retailer also required very high system reliability since each minute of downtime translates to significant lost revenue. The EF-Series improved the performance of the Oracle databases governing purchase profiles and transactions 20 times what was previously possible. Read success story.

SPC-1 Price/Performance

A primary aspect of the SPC-1 benchmark is that it provides price performance in terms of $/SPC-1 IOPS for each configuration tested. The EF560 comes in at $0.54 per SPC-1 IOPS, that puts the EF560 at #2 overall on the "Top Ten" list for SPC-1 Price-Performance™. If you look at results with average response time under 1 millisecond, the EF560 is the #1 array.

For a deep-dive on the EF560 SPC-1 results, check out this blog post from Dimitris Krekoukias on RecoveryMonkey.org.

Throughput

Throughput or bandwidth is another important aspect of flash array performance. While it's talked about less frequently than IOPS, throughput is a measure of how well an array can read or write sequential—rather than random—data. All databases have an important sequential component (think log files). Analytics workloads and in-memory databases can see huge benefits from fast streaming for data ingest.

This is another area where the EF560 stands out. Where other flash competitors brag about 4GB/sec or 8GB/sec read throughput, the EF560 can sustain 12GB/sec read throughput and more than 6GB/sec write throughput.

Turning Throughput into Business Advantage

Ingest Every Second. The CIO of a contract oil drilling customer wanted to accelerate the ingest of oil rig data to once per second from once per minute, a 60x increase. The EF-Series enables the company to realize this goal, providing more detailed data, and up to the second, real-time analytics to support better decisions.

4X Increased Reporting. A real estate analytics application captures and repackages nationwide real estate data for use by the banking, finance, and real estate industries. This real estateÂ company needed to speed up the performance of its database to accelerate service. With the EF-Series, the company is now able to provide valuation updates four times a day versus once a day previously, resulting in more up-to-date data, shorter approval times for home loans, and greatly increased customer satisfaction. Read success story.

EF560 Performance Enhancements

The EF560 takes advantage of four new performance enhancements:

1. **New Faster CPUs.** The EF560 introduces new 2.2GHz 6-core Intel Xeon processors that nearly Â double the IOPS.Â Â
2. **Multi-Core SANtricity Support.** We've optimized the latest SANtricity 8.20 software by splitting workloads across cores. This further speeds up response times by 50%, as evidenced in our latest benchmark results.
3. **Lower latency SSDs.** We continue to leverage the impressive improvements in SSD technology as we increase the capacity and reduce latencies to realize among the lowest $/IOP in the industry.
4. **Support for the Fastest Fabric Connections.** The EF560 features an expanded set of host connectivity options for 8x 12Gb SAS and 4x 56Gb InfiniBand, in addition to our 8x 16Gb Fibre Channel and 8x 10Gb iSCSI offerings.

EF560 Manageability and Availability Enhancements

EF560 manageability and availability improvements include:

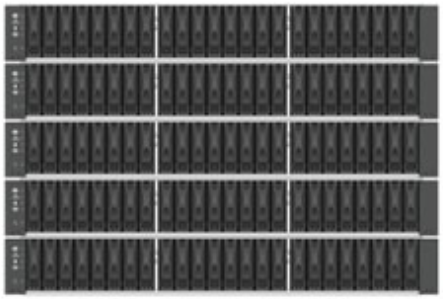
- Online drive firmware upgrades
- Drive evacuator (copy data off a failing drive)
- DDP critical segment rebuild (more on this shortly)

The EF560 features dual-active controllers housed in a 2U shelf and configured with up to 120 SSDs (currently in 400GB, 800GB, and 1.6TB capacities). A single array delivers up to 192TB of raw capacity. SSDs are configured in volumes using either Dynamic Disk Pools (DDP) or RAID 0, 1, 5, 6, and 10.

Figure 2) EF560 specifications.

Expandable	Up to 120 drives (192TB)
SSD Options	400GB 800GB (encryption option) 1.6TB
I/O Interface Options	(8) 16Gb FC (8) 10Gb iSCSI (8) 12Gb SAS (4) 56Gb IB
Storage Software	SANtricity® OS 8.20 SANtricity Storage Manager 11.20
Key Features	Online administration Dynamic disk pools Thin provisioning Snapshot copies Volume copy Remote mirroring

- Start with as few as 6 SSDs, or as many as 24 in 2U shelf



- Online scalability up to 120 SSDs when requirements change

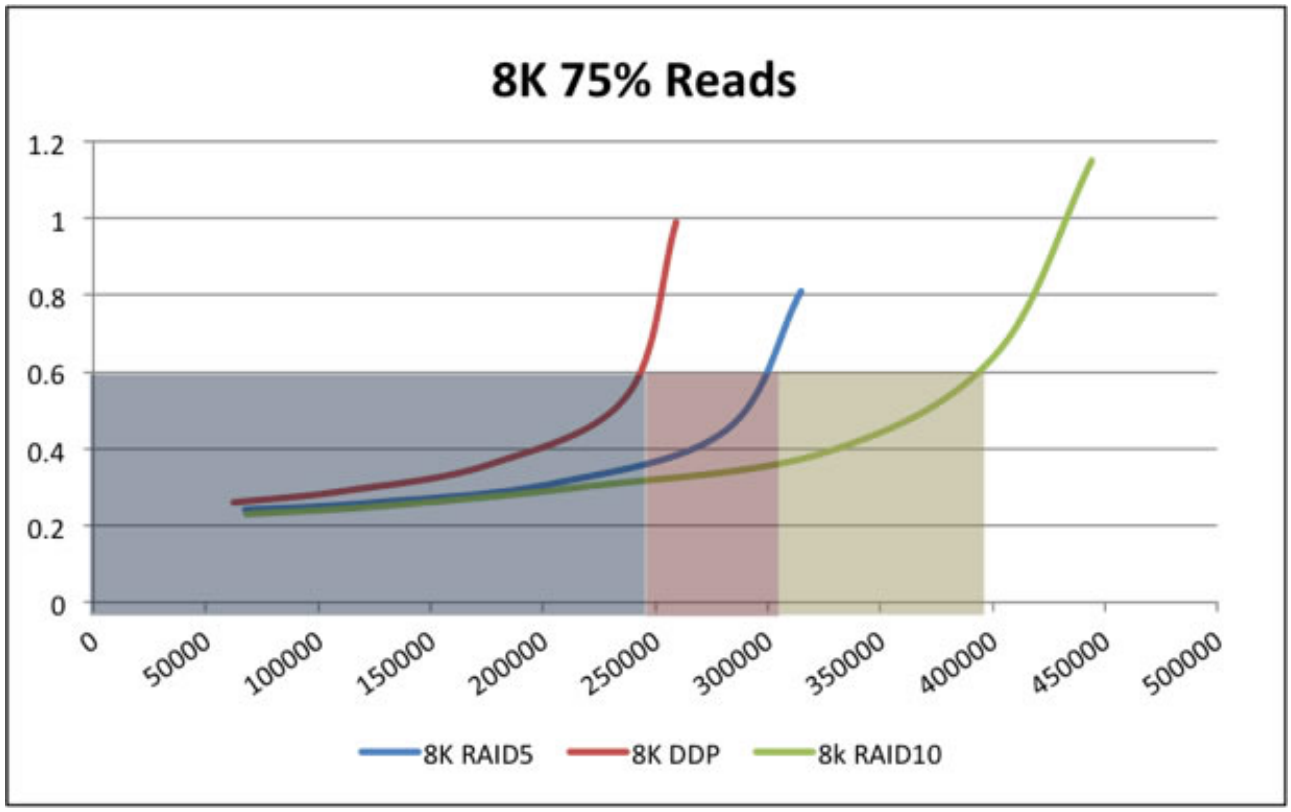
Source: NetApp, 2015

Choosing a Data Protection Method

One of our goals for the EF560 was to fully characterize performance and operations to make it easy for you to choose the best configuration for your needs. With DDP growing rapidly in popularity—35% of EF-Series deployments already use it—this includes guidance on when to choose DDP versus another RAID level.

To choose the right data protection, look at your requirements and imagine each of the possible protection schemes as performance zones as shown in Figure 2. Then choose the level of protection that delivers the performance and capacity you need.

Figure 3) EF560 performance using RAID5, DDP, and RAID 10.



Source: NetApp, 2015

Keep in mind that this figure is based on a workload with 8KB block size, 75% reads and 25% writes, and a latency ceiling of 0.6 milliseconds (600 microseconds). Increasing the percentage of writes moves the dividing lines down for each technology.

The DBA's Choice for Database Performance

If you're looking for fast, consistent performance from an all-flash array, look carefully at the architecture. The EF560 all-flash array features a dedicated performance architecture that is ideal for business-critical high-performance databases. With a legacy approaching 1 million installed storage systems and a reliability of more than five 9s, The EF560 has an architecture that performance DBAs can rely on.

Resources

- FlexPod Select for High-Performance Oracle RAC
- SAS Technical Report: Performance and Tuning Considerations for SAS on NetApp EF550 Flash Array
- TR-4305: Extreme Performance Solution for Oracle Database
- TR-4259: Best Practice Guide for Microsoft SQL Server 2012 with NetApp EF-Series

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Paul joined NetApp in 2005 and is currently responsible for solid-state technology marketing. He was previously responsible for core NetApp software, including Data ONTAP, secure multi-tenancy, and storage efficiency. Paul has more than 30 years of experience in product management, sales, marketing, and executive management. Prior to joining NetApp, Paul worked at Data General, Digital Equipment Corporation, MSI Consulting, and SEPATON. He holds a Bachelor of Science degree from Boston University and an MBA from Babson College.

Mike joined NetApp in April of 2012 and is currently product manager for the EF-Series. In his previous role as a technical marketing engineer, Mike tested, wrote, trained, and presented on many of the advanced features of the E-Series and EF-Series products. He's worked extensively with SSD Cache, dynamic disk pools, and asynchronous remote volume mirroring.