ESG Lab Review

NetApp Clustered Data ONTAP 8.3.1 and All Flash FAS AFF8080 EX

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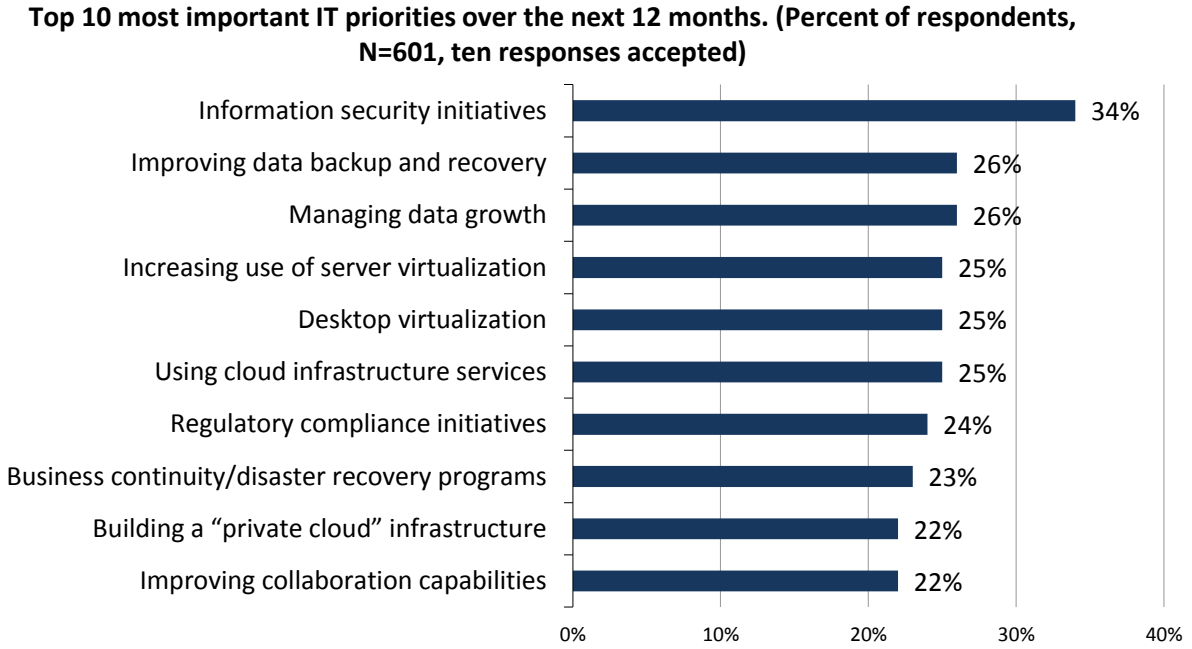
Abstract: *This ESG Lab review documents hands-on testing of the NetApp All Flash FAS 8080 EX platform running Data ONTAP 8.3.1. Testing focused on the ability of NetApp All Flash FAS in combination with Data ONTAP 8.3.1 to deliver consistently high performance at low latency, seamless scalability, and storage and operational efficiency.*

The Challenges

ESG's *2015 IT Spending Intentions Survey* revealed that, as they have been since 2010, increased use of server virtualization, improved backup and recovery, and data growth management are all in the top ten most frequently cited IT priorities among respondent organizations. The adoption of server virtualization is nearly ubiquitous among enterprise and midmarket organizations today and increased usage of the technology was identified by one in four respondents as one of their most important IT priorities for 2015.[1] In the experience of ESG Lab, virtualization presents one of the most complex and demanding storage workloads in the data center.

Figure 1. Top Ten Most Important IT Priorities for 2015



Source: Enterprise Strategy Group, 2015.

Enterprise application environments have become increasingly unpredictable as their underlying IT infrastructure grows in complexity, size, and criticality to the business. Mission-critical business application performance is very sensitive to storage performance and latency, and highly dependent on the robustness of the enterprise IT environment. All flash

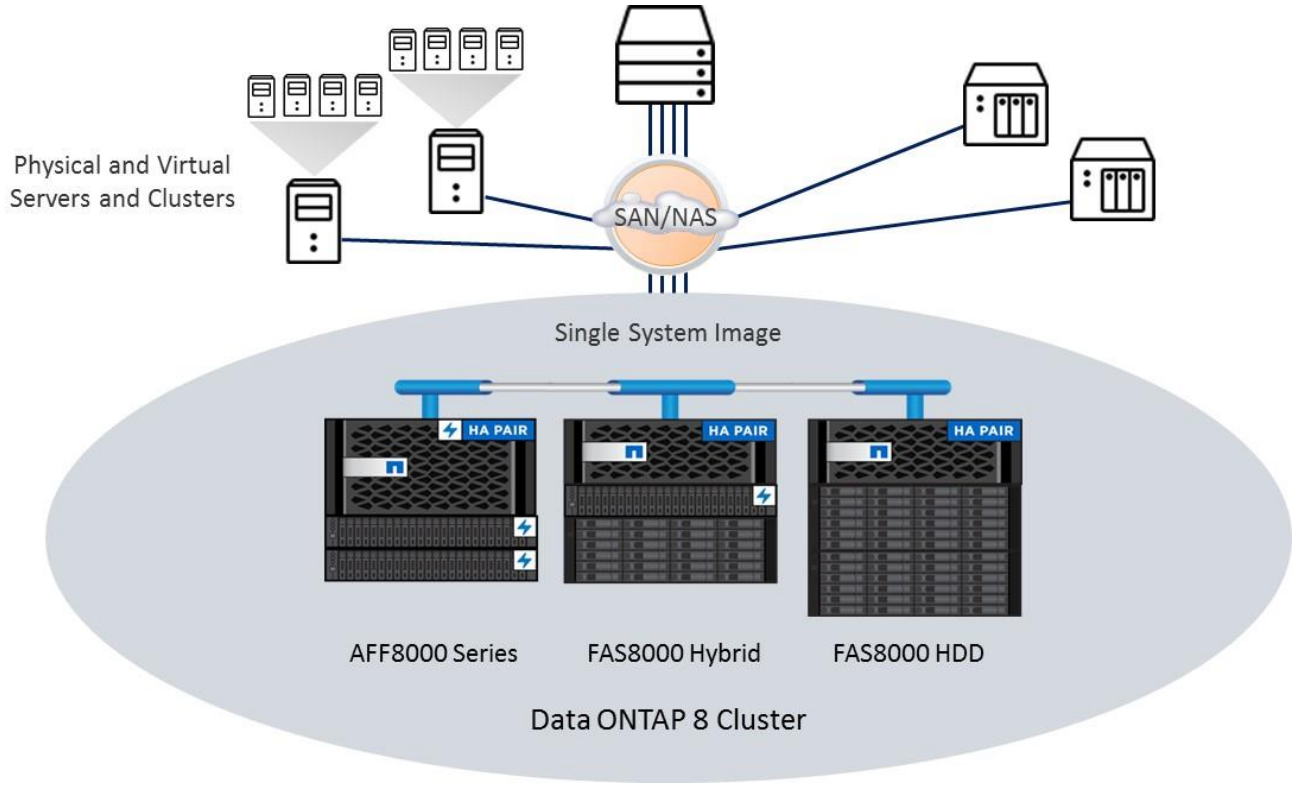
[1] Source: ESG Research Report, 2015 IT Spending Intentions Survey, February 2015

systems are becoming very interesting in these environments thanks to their ability to provide high performance at very low latency. When choosing an infrastructure platform on which to build their environments, IT organizations need the ability to maximize the value of a flash based storage solution.

NetApp Clustered Data ONTAP 8.3.1 and All Flash FAS Systems

NetApp is addressing these challenges with clustered Data ONTAP 8.3.1, designed to deliver an on-demand, highly efficient, flexible, and scalable single storage operating system to help enterprise customers manage data, application, and scale-out storage infrastructure growth. Clustered Data ONTAP 8.3.1 takes multiple NetApp storage systems and creates a massively scalable unified storage platform designed to provide non-disruptive operations, seamless scalability, and unified management from flash to disk to cloud for both enterprise and service-oriented infrastructures.

Figure 2. NetApp AFF8000 and Data ONTAP 8.3.1



NetApp AFF8000 enterprise storage systems are engineered specifically to address the demands of enterprises for high performance and rich data management capabilities using an integrated combination of high-performance hardware and scalable storage software. Leveraging the latest multi-core, multi-processor chipsets from Intel, the AFF8000 leverages NVRAM to accelerate and optimize writes along with a PCIe generation 3 I/O architecture to maximize data throughput. Flexibility and expandability are provided by dense modular packaging that utilizes unified target adapters (UTA2) for 16GFC or 10Gb Ethernet communication capabilities on the same ASIC. NetApp AFF8000 systems and Data ONTAP are architected specifically to optimize flash for performance, efficiency and robustness with FlashEssentials, which NetApp describes as encompassing their flash innovations and technologies that minimize latency, enhance media longevity and increase storage efficiency. Storage controllers handle routine SSD tasks, eliminating overhead, in-memory write coalescing and inline compression minimize wear on flash, read-ahead algorithms pull data into memory for the fastest access, and all hardware can be warrantied for up to seven years.

The NetApp WAFL file system and use of NVRAM is particularly well suited for flash. Writes to SSDs are not in the critical path, but are logged in the NVRAM in both nodes of the HA pair and are acknowledged to the client immediately. The NVRAM is battery backed-up, to prevent data loss in the event of power outage, and writes are coalesced in memory before being de-staged to SSD. When writing, traditional file systems read the existing block, write it somewhere else,

and overwrite the block with new data. WAFL simply writes the new block wherever there is room. This minimizes writes to SSD, reducing wear, and all I/O is written to disk into free areas of contiguous space, which allows any writes to be sent SSD sequentially.

AFF80000 systems are configured with dual active-active controllers running the latest generation of the Data ONTAP 8 operating system. An AFF8000 system can be deployed as a two-controller cluster, or scaled out to up to 24 nodes, leveraging the combined I/O capability of all nodes for throughput and redundancy, ensuring enterprise accessibility to business-critical data and the ability to grow in capacity and performance without disruption. A cluster of all-flash AFF8000s can scale out to 4.6PB of flash not counting space efficiencies—and over 16PB with space efficiencies enabled.

ESG Lab Tested

The SPC-1 Benchmark

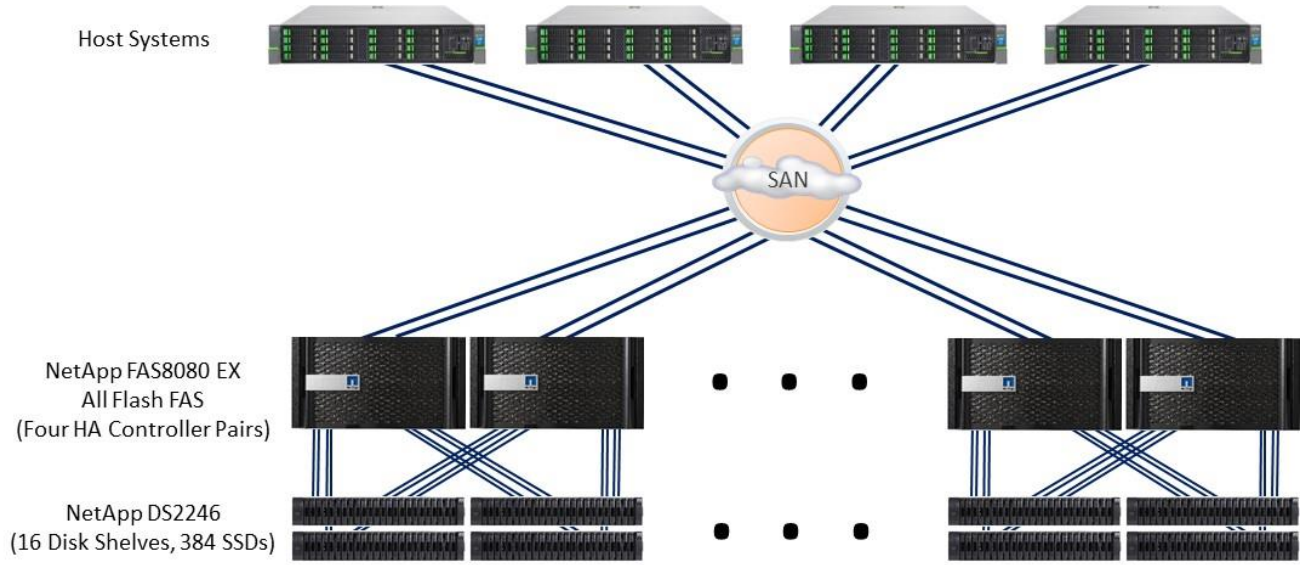
ESG Lab reviewed NetApp's published results of the SPC-1 application-level industry standard benchmark suite maintained by the Storage Performance Council[2]. SPC-1 testing generates a single workload designed to emulate the typical functions of transaction-oriented, real-world database applications. Transaction-oriented applications are generally characterized by largely random IO and generate both queries (reads) and updates (writes). Examples of these types of applications include online transaction processing (OLTP), database operations, and mail server implementations. SPC results can be roughly mapped by users into easily understood metrics. For a credit card database system, for instance, it might be the number of credit card authorizations that can be executed per second.

It is important to note that the SPC-1 benchmark consists of over 60% writes, a mix of random and sequential I/O, and a variety of block sizes. As such, the results should not be compared with marketing performance numbers consisting of 100% random reads with a homogeneous block size.

The SPC-1 Test Bed

The SPC requires full disclosure of very detailed configuration information. The test bed for the NetApp FAS8080 EX All Flash FAS[3] SPC-1 test is summarized in Figure 3.

Figure 3. The NetApp SPC-1 Test Bed



[2] http://www.storageperformance.org/results/benchmark_results_spc1

[3] Prior to Data ONTAP 8.3.1 NetApp branded systems as FAS8xxx All Flash FAS and this is how the SPC-1 result was submitted. With Data ONTAP 8.3.1 the new branding is AFF8xxx.

An additional element of SPC disclosure is the list pricing for the solution as tested. This allows for dollars per IOP comparisons of the cost-effectiveness of solutions.

SPC-1 Results

NetApp has published an excellent result[4] of 685,281 SPC-1 IO requests per second at 100% load with an average response time of only 1.23 milliseconds with the FAS8080 EX All Flash FAS. Figure 4 shows a response time/throughput curve, which visually represents the performance of the system under test as load is increased. A long, flat curve indicates better performance, as this denotes that response time stays low as IOPS increase.

Figure 4. NetApp All Flash FAS8080 EX All Flash FAS SPC-1 Results

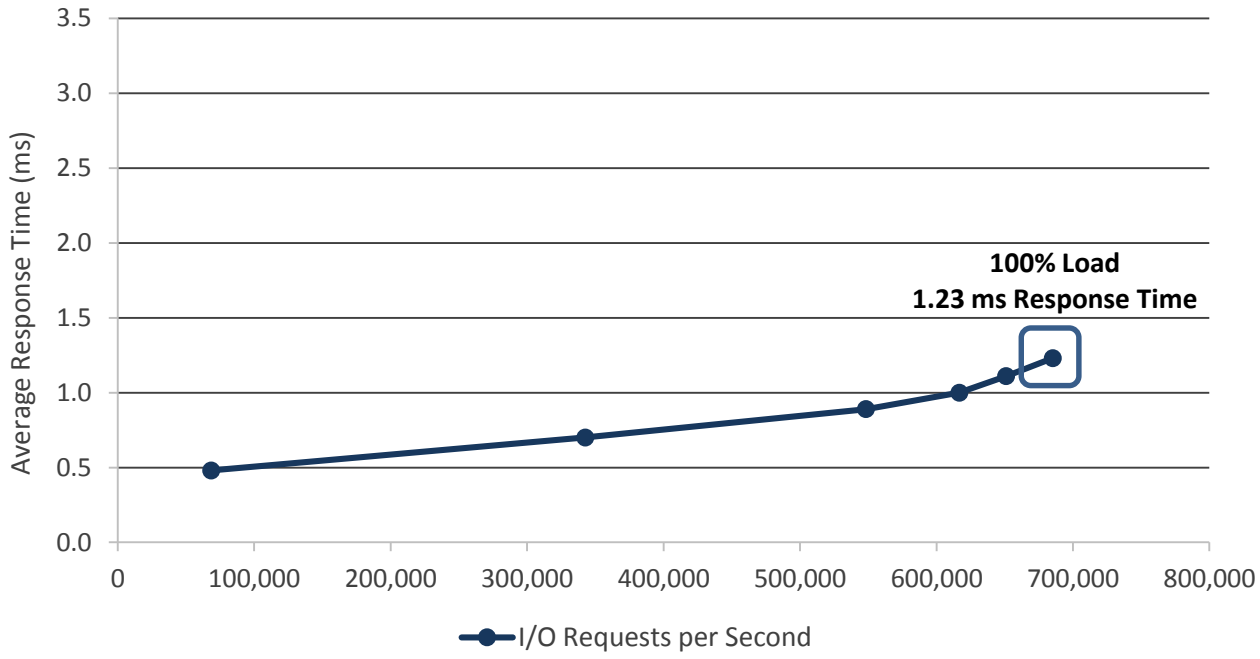


Table 1 summarizes the published results.

Table 1. SPC-1 Results Summary

SPC-1 Load	SPC-1 IOPS	Response Time	Read Response Time	Write Response Time	$/SPC-1 IOPS
10%	68,497.10	0.48 ms	0.36 ms	0.56 ms	
50%	342,546.55	0.70 ms	0.57 ms	0.78 ms	
80%	548,211.09	0.89 ms	0.76 ms	0.97 ms	
90%	616,717.59	1.00 ms	0.87 ms	1.09 ms	
95%	650,962.80	1.11 ms	0.98 ms	1.20 ms	
100%	685,281.71	1.23 ms	1.14 ms	1.29 ms	**$2.77**

[4] http://www.storageperformance.org/results/benchmark_results_spc1_active#a00154

The NetApp FAS8080 EX All Flash FAS not only posted excellent SPC-1 IOPS and response time results, with a cost in dollars per SPC-1 IOPS of just $2.77. It's interesting to note that the system scaled to 90% load before it crossed the 1ms response time threshold. Response time is an extremely important component of SPC results; it is the delay an application will experience (and pass on to users) when a storage system is stressed to its limits. While the SPC will not certify any results higher than 30 milliseconds, the generally accepted threshold for good performance in online transactional applications is 10 milliseconds, beyond which application delay begins to become apparent to users. The SPC-1 results published by NetApp proves the suitability for mission- and business-critical, response time sensitive applications.

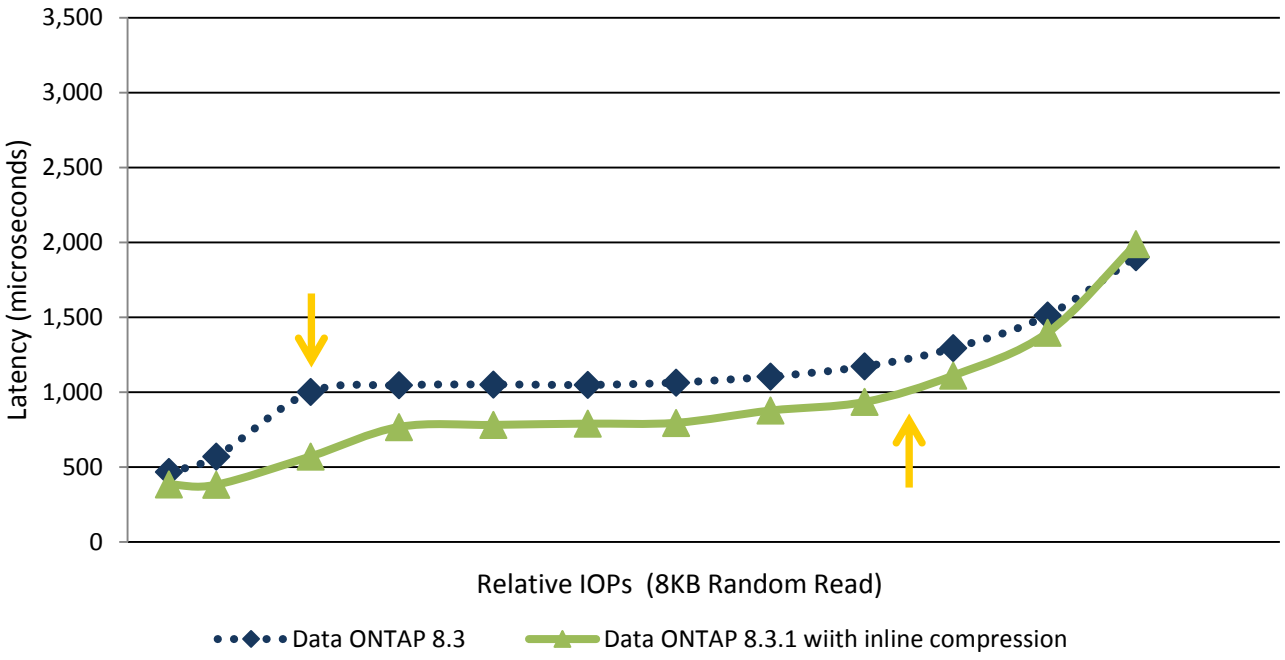
Another important component of the solution is capacity utilization. The FAS8080 EX All Flash FAS SPC-1 result used a high percentage of total capacity for the benchmark data vs the raw capacity (this is called *Application Utilization* in SPC terms). The AFF configuration utilized 60% of the available storage compared to approximately 30% in other submitted results. This shows that NetApp AFF can deliver high performance with high capacity utilization.

In a final note, the AFF SPC-1 benchmark was performed using RAID-DP—RAID6-equivalent protection—where many other vendors use RAID10 for the same benchmark to maximize their results. When comparing SPC-1 results, it's important to understand the data protection scheme used in order to understand the potential impact on real-world performance.

All Flash FAS Performance with Data ONTAP 8.3.1

NetApp released Data ONTAP 8.3.1 with announcements of performance and latency improvements for the AFF8000 family. ESG Lab looked closely at data from side by side tests of a two node AFF8080 EX HA pair. Testing was conducted using the NetApp sio workload generation engine, which is available for download in the customer and partner toolkit on the NetApp support site. The workload consisted of 100% random reads with an 8KB block size.

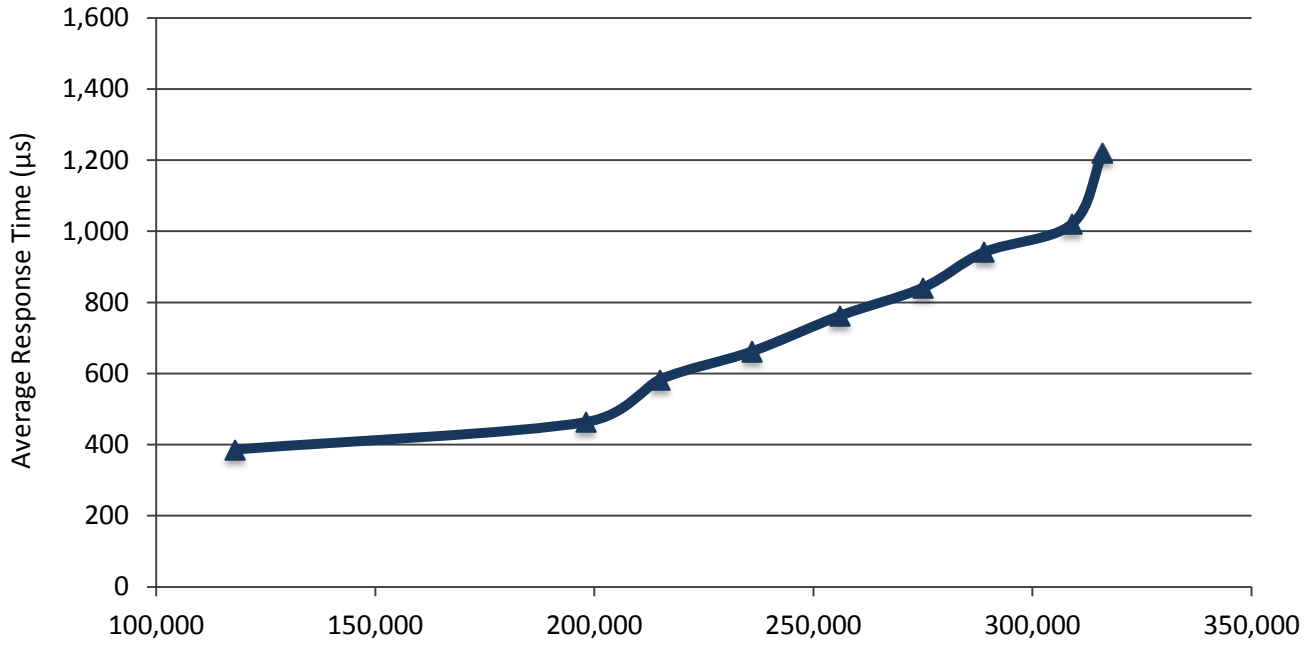
Figure 5. Improved Performance with Data ONTAP 8.3.1



ESG Lab plotted the data using the same method as seen in the previous figure. Response time is on the vertical axis, while IOPS increase as you move to the right on the horizontal axis. As seen in Figure 5, while AFF8080 EX maintained low latency as IOPS increased, the system running Data ONTAP 8.3.1 was able to push significantly more IOPS at a response time of about 1ms. ESG Lab calculated the increase in IOPS at more than 29%.

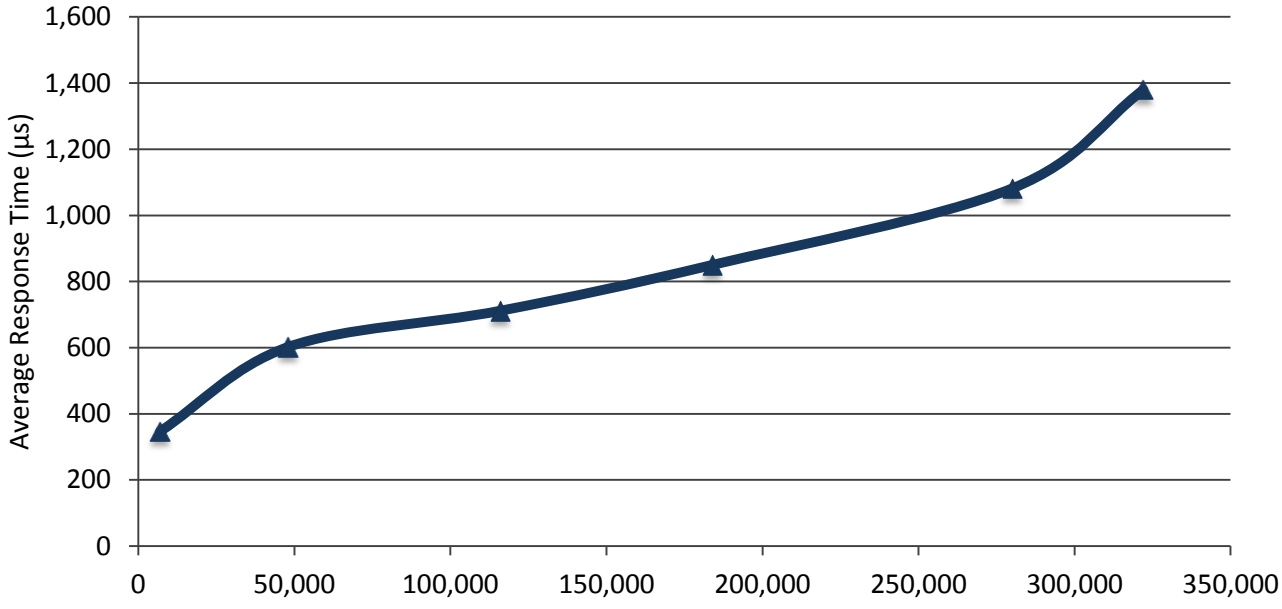
ESG Lab next looked at a number of additional workloads executed with inline compression enabled to further validate the performance of the NetApp AFF8000 series in real-world configurations. Figure 6 shows Oracle 12c OLTP performance scaling with an AFF8080 EX running clustered Data ONTAP 8.3.1. The workload consisted of 75% selects and 25% updates which translated to 80% reads and 20% writes overall.

Figure 6. AFF8080 EX HA Pair Oracle OLTP 8KB Block Performance



The system was able to sustain more than 288,000 IOPS with an average client response time of just 941µs. Next, an OLTP workload was run against a Microsoft SQL Server 2014 environment on an AFF8080 EX running clustered Data ONTAP 8.3.1. Figure 7 shows the response time/IOPS curve.

Figure 7. AFF8080 EX HA Pair SQL Server OLTP 8KB Block Performance



In this test the system sustained more than 280,000 IOPS with average response time of 1,080µs at the client. Finally, ESG Lab examined virtual desktop performance obtained using the Login VSI workload generation utility to generate typical knowledge worker activity using common desktop applications. At a workload level of 15 IOPS per user, the AFF series scales smoothly from just over 1,700 desktops for the AFF8020 to more than 5,300 desktops for the AFF8080 EX, all with response times under 1ms as seen in Figure 8. Virtual desktop workloads are among the most challenging storage workloads not only because they are generated by a large pool of independent machines running a variety of applications, but that in normal operations, the activity is typically 80% writes, which present a challenge to many storage systems.

Figure 8. AFF8080 EX HA Pair VMware Horizon View Desktops Supported

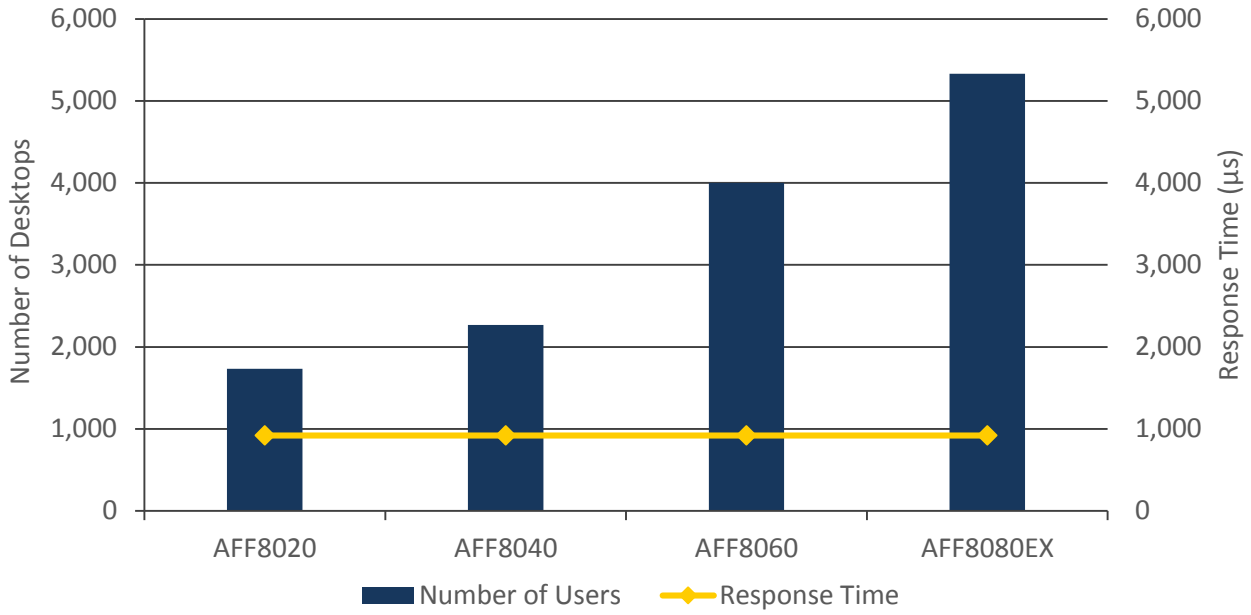


Table 2 shows a selection of detailed workload and response time data for each of the scenarios examined by ESG lab.

Table 2. Workload Characterization and Performance with Inline Compression

Use Case	Workload	IOPS	Average Storage Response Time (µs)	Average Client Response Time (µs)
Oracle 12c OLTP	75% Selects 25% Updates 8KB Average Block	288,320	890	941
SQL Server OLTP	90% Read, 10% Write, 8KB Average Block	280,000	985	1,081
VDI – 2000 Desktop Boot Storm	99% Read, 1% Write 17.5KB Average Block	156,686	1,391	1,157
VDI – 2000 Desktop Steady State	20% Read, 80% Write, 16KB Average Block	37,806	920	1,157
VDI – 2,000 Desktop Refresh Operation	80% Read, 20% Write 21.8KB Average Block	27,815	740	n/a
VDI – 2,000 Desktop Recompose Operation	80% Read, 20% Write 21.4KB Average Block	37,265	970	n/a

Why This Matters

Performance is a key concern when deploying mission critical applications in a highly consolidated modern data center environment. With pools of virtualized databases, application servers, and desktops all relying on a shared storage infrastructure, storage performance and response time become critical considerations.

Storage scalability and performance are significant challenges for the highly virtualized modern data center. Through careful examination of SPC-1 results combined with hands-on testing of multiple applications and databases, ESG Lab has verified that the NetApp AFF8080 EX can be deployed to cost-effectively provide extremely high performance storage with consistently low response times.

In addition, virtualization of servers, business applications, and desktops increases both data storage requirements and complexity as IT strives to bring applications and services to users dynamically and on-demand. IT administrators and managers were asked by ESG to list their top IT priorities for 2015 and increased use of server and desktop virtualization were once again top responses, while managing data growth and business continuity/disaster recovery also appeared in the top ten responses in the same survey.[5] 61% of organizations reported that spending on storage infrastructure and virtualization would increase in 2015. This suggests that data migrations and sensitivity to data availability will increase as storage and servers are consolidated into federated pools of IT resources.

As storage environments grow in size and complexity, so does the impact of data outages. Regardless of the number and types of hardware failures that may occur during the life of data on disk, managers, employees, and customers expect their data to be available.

NetApp AFF and FAS storage systems are designed to provide flexible, tier-one, federated storage, engineered for efficiency, performance, and multi-tenancy in support of private and public cloud delivery of storage services. In previous testing, ESG Lab non-disruptively upgraded a cluster running Data ONTAP from two nodes to four while a mixed application workload was running. The cluster scaled non-disruptively as additional virtual machines and workloads were brought online and demonstrated excellent host response time throughout the tests.

ESG Lab found the NetApp clustered Data ONTAP system able to non-disruptively fail network connections over while a server was executing live read and write I/O to the volume. ESG Lab was able to move a volume to a different aggregate and fail back on-demand, with no interruption to data access and no impact on performance.

ESG Lab has confirmed that the AFF and FAS series', combined with Data ONTAP 8.3.1, can provide an always-on, flash-optimized storage environment able to operate through planned maintenance and unplanned faults thanks to a tightly integrated, highly available architecture combined with robust cluster services.

[5] Source: ESG Research Report, 2015 IT Spending Intentions Survey, February 2015

The Bigger Truth

ESG research reveals that increased use of virtualization technologies, improved backup and recovery, and data growth management are all frequently cited important IT priorities.[6] The amount and variety of data that businesses need to store is growing rapidly, driving the growth in overall storage use and costs. To address data growth without interrupting business operations, rapid deployment of storage and IT resources in order to meet increasing demand becomes a function of scalability.

As IT continues to implement advanced capabilities and services such as virtualization, storage infrastructure becomes more complex and performance becomes more critical. Complexity is multiplied by the rapid growth in data being managed, and increases the demands on both the primary storage and the data protection and disaster recovery infrastructures. As a result, IT is feeling more pressure to provide advanced solutions that can seamlessly scale capacity and performance across different storage media and provide effective data protection.

Using NetApp AFF8000 and FAS Series storage with clustered Data ONTAP, organizations can manage all the heterogeneous storage in their environments as a single pool using a single interface with common tools. Every NetApp AFF and FAS system—whether primary or deep archive—runs Data ONTAP. Data ONTAP provides a consistent user interface and powerful storage efficiency technology. All storage can be available to applications and users over either SAN or NAS protocols, on premise or in the cloud.

The design of NetApp AFF8000 and Data ONTAP are particularly well suited for all-flash implementations. NVRAM write logging, write coalescing, and the write-anywhere layout of the WAFL file system combine to minimize wear on SSDs while optimizing availability and maximizing performance.

In addition, the AFF8000 series and Data ONTAP are engineered for scalability, including the ability to dynamically assign, promote, and retire storage, replace or upgrade disk shelves, and move data between storage controllers and tiers of storage, all without disrupting users and applications. This enables administrators to move workloads between flash and disk tiers depending on performance requirements, increase capacity while balancing workloads, and can reduce or eliminate storage I/O hot spots without the need to remount shares, modify client settings, or stop running applications. AFF8000 provides integrated data protection capabilities including Snapshot copies, SnapMirror replication, FlexClone, and application consistent SnapManager and SnapVault, creating an integrated data protection environment that enables backup administrators to protect and restore data and applications quickly and easily, from disk, leveraging automated policies.

ESG Lab recommends a serious look at the benefits that can be realized from consolidating and virtualizing storage environments with NetApp AFF8000 series running clustered Data ONTAP. NetApp continues to execute on its vision of an enterprise-grade, unified, scale-out platform, delivering seamless scalability in performance and capacity, unified management from flash to disk to cloud, and field-proven storage and operational efficiency. Through hands-on testing, that NetApp All Flash AFF8080 EX can be deployed to cost-effectively provide extremely high performance storage with consistently low response times while bringing a flexible and efficient service-oriented model to heterogeneous storage environments while eliminating performance silos and delivering a robust infrastructure foundation for shared, on-demand IT services.

[6] Source: ESG Research Report, 2015 IT Spending Intentions Survey, February 2015