Lab Validation Report

NexGen N5 SPX Hybrid Flash Array

Optimizing SQL Server Clusters with End-to-end Flash Hybrid Storage

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ESG Lab Reports

The goal of ESG Lab reports is to educate IT professionals about data center technology products for companies of all types and sizes. ESG Lab reports are not meant to replace the evaluation process that should be conducted before making purchasing decisions, but rather to provide insight into these emerging technologies. Our objective is to go over some of the more valuable feature/functions of products, show how they can be used to solve real customer problems and identify any areas needing improvement. ESG Lab's expert third-party perspective is based on our own hands-on testing as well as on interviews with customers who use these products in production environments. This ESG Lab report was sponsored by NexGen Storage.

Introduction

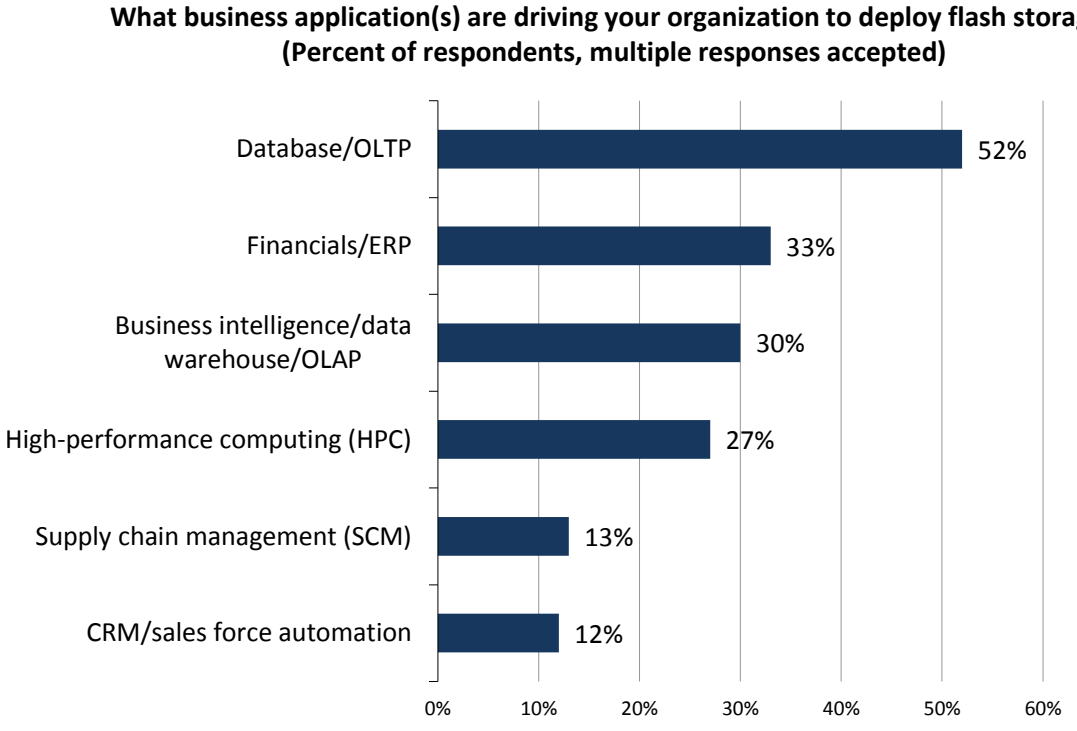
This ESG Lab Validation report documents hands-on testing and validation of NexGen's N5 SPX end-to-end flash hybrid storage solution. Testing was designed to confirm the ease of use, manageability, and performance benefits that can be achieved in a clustered Microsoft SQL Server environment with PCIe flash technology at both the storage array and server level.

End-to-end Flash Adoption

Flash storage has become a staple in the modern data center. This is due not just to the declining prices, but also to the increased number of implementation options. More organizations are finding ideal locations to use flash technology to meet their application requirements. In an ESG survey, nearly half of the respondents reported leveraging flash technology designed to fit in external storage systems. This makes sense considering that it was one of the first flash implementation types leveraged by enterprises. Since that time, flash storage has made its way closer to where the application is run: at the server. This falls in line with the fact that nearly an identical percentage of surveyed end-users reported leveraging the benefits of flash within servers (48%).[1]

The reason for flash storage's move closer to the application is primarily due to the application users, who will always want more performance, higher efficiency, and an overall improvement to their application experience. In fact, 62% percent of ESG research's respondent organizations that purchased flash storage reported doing so to address performance concerns associated with a specific business application. And it is not just one type of application that demands the performance benefits of flash technology. When ESG asked which business applications were driving organizations to deploy flash technology, the responses varied widely (see Figure 1), but the one application that stood above the rest was database/OLTP applications, which was identified by 52% of respondents as one of the business applications driving their flash storage deployment.[2]

Figure 1. Top Six Business Applications Diving Flash Adoption

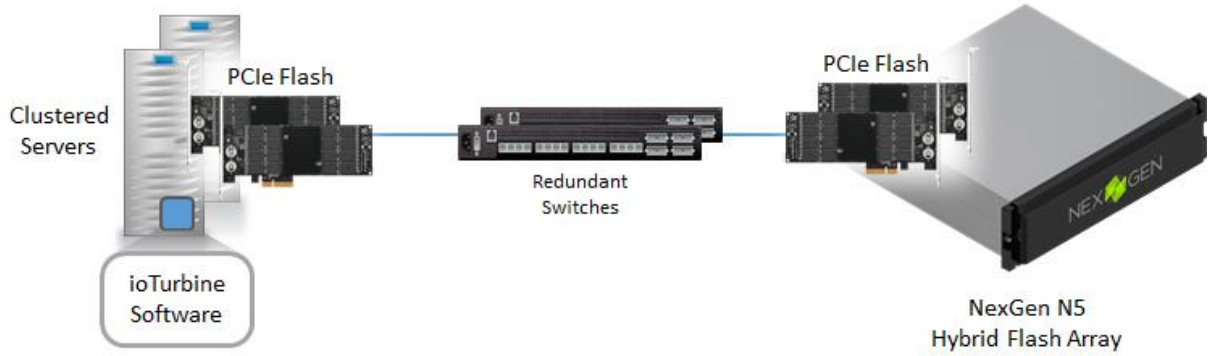


[1] Source: ESG Research Brief, *Solid-state: Not Just for Storage Systems Anymore*, December 2012.
[2] Source: ESG Research Report, *Solid-state Storage Market Trends*, November 2011.

NexGen N5 SPX Hybrid Flash Storage

NexGen Server Performance Extensions (SPX) is an end-to-end flash storage solution designed for data-intensive and virtualized workloads that require high performance, low latency, and the benefits of shared storage (higher storage utilization, high availability, data protection and centralized management). The integrated solution combines intelligent ioMemory and ioTurbine server cache for maximum application performance and minimal latency with NexGen flash-first Hybrid Storage, ensuring that both reads and writes gain the benefits of flash performance.

Figure 2. NexGen End-to-end Flash Hybrid Storage



The SPX solution is purchased and supported as a single product offering and includes three key components:

Extended ioMemory Server Cache: A Fusion ioMemory PCIe card is configured in the server, with 3.2TB flash capacity for the two-server application cluster solution. Read workloads are cached to the application server's flash capacity, ensuring extremely fast performance and offloading reads from the storage array. This solution is scalable up to 32 servers each with their own PCIe flash memory.

ioTurbine Software: With ioTurbine software, read workloads are offloaded from the storage array to faster ioMemory server-based flash, resulting in improved performance, high application density, and an overall more efficient storage infrastructure. Quality of service and real-time monitoring ensure guaranteed application performance levels.

NexGen N5 Hybrid Storage: The NexGen hybrid Flash N5-150 storage appliance used in this particular SPX configuration comes standard with 48TB raw disk capacity and 2.4TB ioMemory flash capacity, scalable to 192TB raw disk capacity and 4.8TB of ioMemory flash. The high-end NexGen N5 SPX solution comes standard with 64TB raw disk capacity and 10.4TB ioMemory flash capacity, scalable to 256TB raw disk capacity and 15.6TB of ioMemory flash. Active-active storage processors, each configured with a PCIe Memory card, ensure maximum performance and availability. All write workloads land on flash first and are mirrored between the ioMemory cards in the storage processors to ensure high availability.

By putting the flash capability on the PCIe bus instead of in a flash disk, NexGen eliminates the potential bottleneck that can occur when storage controllers and protocols are in the data path between the application and the flash memory. SPX starts in a two-server application cluster offering or three-host VMware cluster solution offering, and offers 475K IOs per second(IOPS). This solution provides organizations with three key capabilities that work seamlessly together to deliver predictable, scalable performance:

- *Control of Performance* – NexGen N5 SPX speeds application performance differently from other solutions because of its ability to focus flash performance where it is needed with both server-side and shared storage-side flash.
- *Quality of Service (QoS)* – NexGen N5 SPX provides quality of service, with guaranteed minimum IOPS, throughput, and not-to-exceed latency for each volume that can be monitored in real time. This ensures that performance is predictable by workload. In addition, volumes can be defined as mission-critical, business-critical or non-critical, with service level guarantees attached to each designation.
- *Dynamic Data Placement* – NexGen uses its QoS engine to move data between flash and disk based on real-time monitoring, ensuring that applications with a higher QoS target get a higher percentage of blocks in flash, while those with a lower QoS setting have more blocks on disk.

ESG Lab Validation

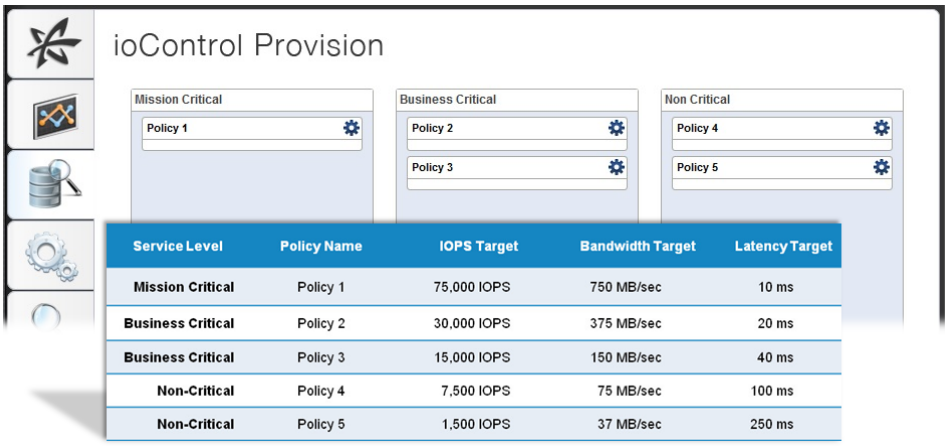
ESG Lab performed hands-on evaluation and testing of NexGen N5 and NexGen N5 SPX at Fusion-io's Data Propulsion Lab facility in Salt Lake City, Utah. Testing was designed to highlight the ease of deployment, manageability, and performance improvements realized when using a NexGen hybrid flash storage solution that leverages end-to-end PCIe flash technology. ESG Lab focused on comparing the performance and cost of NexGen's solution with a traditional SAN architecture with a goal of showing the benefits of strategically utilizing PCIe flash in a clustered, mission-critical SQL Server application environment.

Ease of Deployment and Management

Testing began by touring NexGen's user interface, which was used to easily configure storage networking, provision storage performance and capacity, and manage application performance. ESG Lab learned about NexGen's quality of service (QoS) that comes standard with every NexGen N5 and NexGen N5 SPX storage solution. The QoS engine is used to ensure minimum application performance for a specific volume by prioritizing I/O within the storage system. This functionality guarantees application performance by monitoring the response time, throughput, and IOPS of the system and isolating individual workloads on the array.

Figure 3 shows the *NexGen Provision* management interface along with the three service level tiers: mission-critical, business-critical, and non-critical. Five policies are predefined and fall within these three service levels. Each of the policies have differing IOPS, bandwidth, and latency targets.

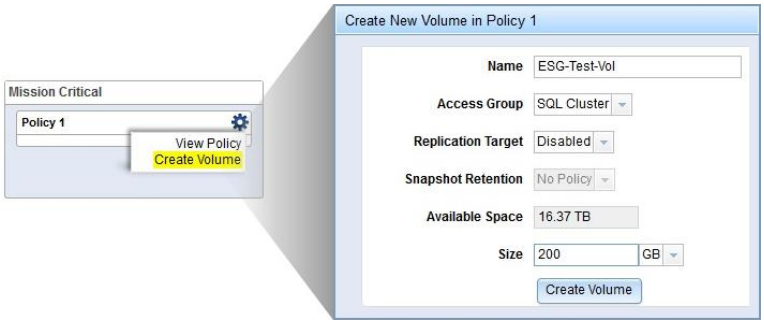
Figure 3. NexGen Quality of Service



Service Level	Policy Name	IOPS Target	Bandwidth Target	Latency Target
Mission Critical	Policy 1	75,000 IOPS	750 MB/sec	10 ms
Business Critical	Policy 2	30,000 IOPS	375 MB/sec	20 ms
Business Critical	Policy 3	15,000 IOPS	150 MB/sec	40 ms
Non-Critical	Policy 4	7,500 IOPS	75 MB/sec	100 ms
Non-Critical	Policy 5	1,500 IOPS	37 MB/sec	250 ms

From the *NexGen Provision* screen where the predefined policies are shown, ESG Lab created a new volume. The new volume utilized Policy 1, which fell within the mission-critical service level, guaranteeing 75,000 IOPS, 750 MB/sec, and less than 10ms latency. ESG Lab specified common volume attributes, such as volume name and size. Also, ESG Lab assigned *SQL Cluster* as the access group for the volume with a goal of eventually placing a SQL Server database on the 200GB volume.

Figure 4. Provisioning NexGen Storage



After learning the minimal steps required to assign a QoS level and provision a volume, ESG Lab viewed the central NexGen Dashboard. The dashboard consisted of three main areas as shown in Figure 5. Along the left side are icons that help with different configuration tasks. The large tiles in the center of the screen show real-time throughput, IOPS, response time performance and available system head room. Finally, at the very bottom of the screen, system capacity information is shown.

Figure 5. NexGen Dashboard

Why This Matters

With the increasing demands on IT, users have less tolerance for poor application performance. This has led to predictable, scalable performance being a critical concern for IT administrators, especially in environments where a mix of applications share an underlying storage system. As a poor attempt to combat the problem, organizations add more hardware and software to the IT infrastructure or overprovision storage, but with that comes higher costs and increased complexity.

ESG Lab has confirmed that being able to provision storage performance by applying a desired performance policy with NexGen was quick and easy. By managing array performance along with capacity, the NexGen array resources can be spread out among multiple mission-critical applications, and is not limited to a single high-IOPS application as with conventional storage arrays. By utilizing storage array QoS and predefined service levels, performance is guaranteed even in the event of competing application IOPS or a component failure.

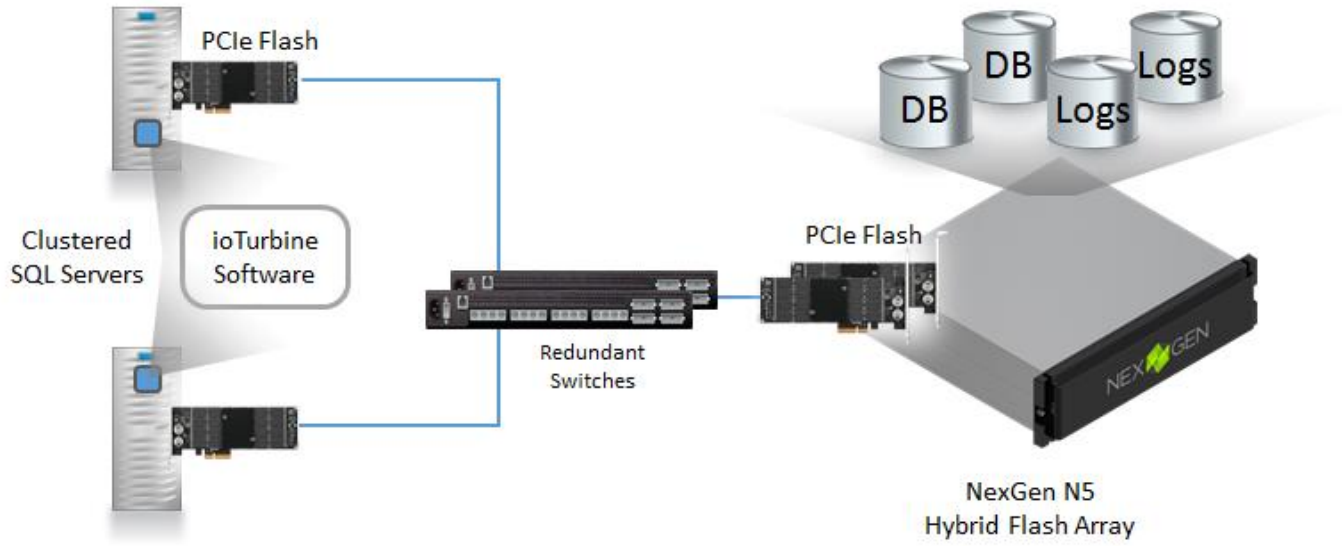
Performance

This section of the report presents the results of ESG Lab testing with a goal of showing the performance benefits of NexGen N5 and NexGen N5 SPX solutions compared with a traditional SAN solution that does not leverage flash storage. The differences between server-based flash and flash that resides in the hybrid storage system are examined as well. The goal of this comparison was to first understand how IOPS can be offloaded from the storage system to the server-based flash card. Secondly, ESG Lab wanted to understand the performance gains of servicing IOPS closer to where the application resides on the server.

ESG Lab tested three scenarios with the same configuration and utilized as many similar components as possible. Four LUNS were created and presented as NTFS volumes to two servers. The three scenarios ESG Lab tested include:

- ***Traditional***: SAN attached array with SAS hard drives with no flash.
- ***NexGen N5***: SAN attached hybrid appliance with SAS drives and PCIe flash
- ***NexGen N5 SPX***: End-to-end flash hybrid storage solution using PCIe ioMemory flash and ioTurbine software in a pair of servers and a SAN attached NexGen appliance with PCIe ioMemory flash and SAS hard drives. [3]

Figure 6. ESG Lab Test Bed



ESG Lab tested each configuration using two methods. First, Iometer was used to stress each configuration from a pure storage standpoint. Then an OLTP database workload was simulated with SQL Server to show what type of performance a customer could expect in a real-world environment.

The industry-standard Iometer tool was used to simulate an OLTP workload, which was configured to generate response-time sensitive database traffic. The workload consisted of a 4KB 100% random workload with a read/write distribution of 67%/33%. Two 10GB file sets were created on each server and the total number of IOPS and response times were measured as the number of outstanding requests increased from one to 128. Figure 7 and Table 1 highlight the Iometer IOPS performance results.

[3] Additional details about the test bed can be found in the Appendix.

Figure 7. Performance Analysis – IOPS

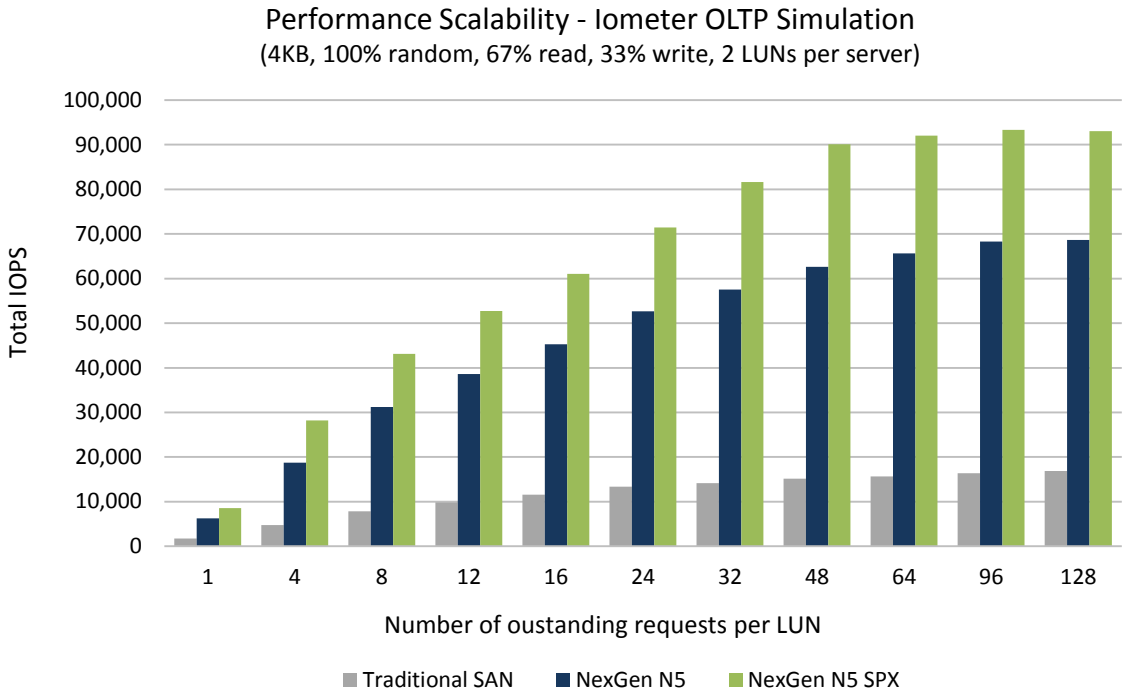


Table 1. Performance Analysis – IOPS

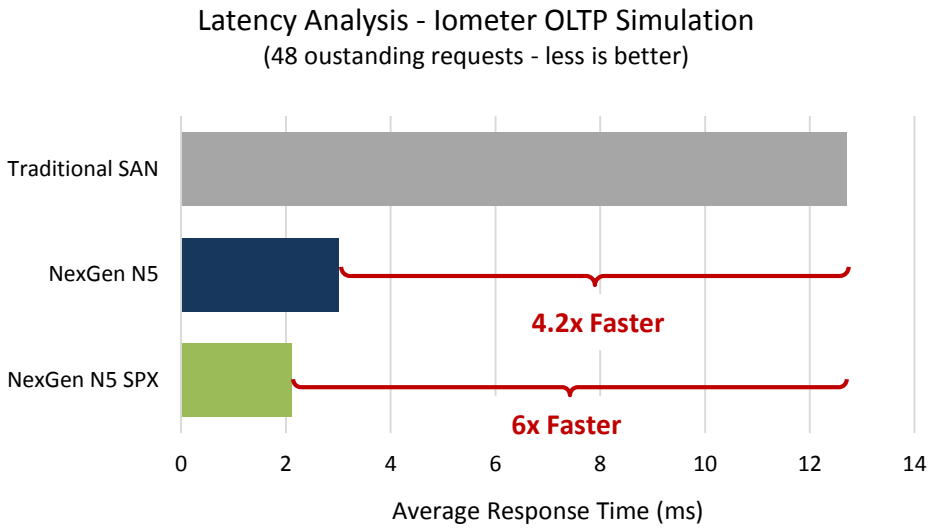
Number of Outstanding Requests	Total Number of IOPS		
	Traditional SAN	NexGen N5	NexGen N5 SPX
1	1,765	6,241	8,530
4	4,727	18,725	28,230
8	7,842	31,208	43,150
12	9,877	38,591	52,748
16	11,560	45,290	61,080
24	13,358	52,696	71,441
32	14,170	57,543	81,619
48	15,145	62,602	90,093
64	15,687	65,652	92,007
96	16,371	68,323	93,349
128	16,905	68,687	93,038

What the Numbers Mean

- Three storage scenarios were tested using Iometer and an OLTP simulation was measured as the number of outstanding requests increased from one to 128.
- The traditional SAN architecture peaked at 16,905 IOPS, while NexGen N5 and NexGen N5 SPX peaked at 68,687 and 93,349 respectively.
- While the number of outstanding requests increased, NexGen averaged a 3x performance improvement over the traditional architecture.
- While both NexGen solutions yielded high levels of performance with flash, NexGen N5 SPX with server-side ioMemory PCIe flash increased performance by 40% on average compared to NexGen N5.

NexGen N5 not only increased the maximum database performance potential of the solution (IOPS), is also delivered a significant boost in response times. As shown in Figure 8, at the peak stress level of 48 outstanding IO requests, NexGen N5 SPX response times were six times faster than the traditional disk-based SAN array.

Figure 8. Performance Analysis – Latency



For the next phase of performance testing, ESG Lab used an OLTP workload to simulate the activity of thousands of Microsoft SQL Server users. The goal was to demonstrate the performance and scalability of a clustered SQL environment that leverages a NexGen storage solution compared with a traditional architecture with no flash. On each of the two physical servers, two volumes were created: a 200GB database volume and a 200GB log volume.

The workload emulated the database activity of users in a typical online brokerage firm as they generated trades, performed account inquiries, and did market research. The workload was composed of ten transaction types with a defined ratio of execution. Four of the transactions performed database updates, and the rest were read only. The workload generated a high level of I/O activity with small access sizes and spent a lot of execution time at the operating system kernel level. Two 15,000-customer databases were configured within each physical server and the number of transactions/sec was monitored as the number of concurrent users increased. The results are summarized in Figure 9 and Table 2.

Figure 9. Performance Analysis – Transactions/sec

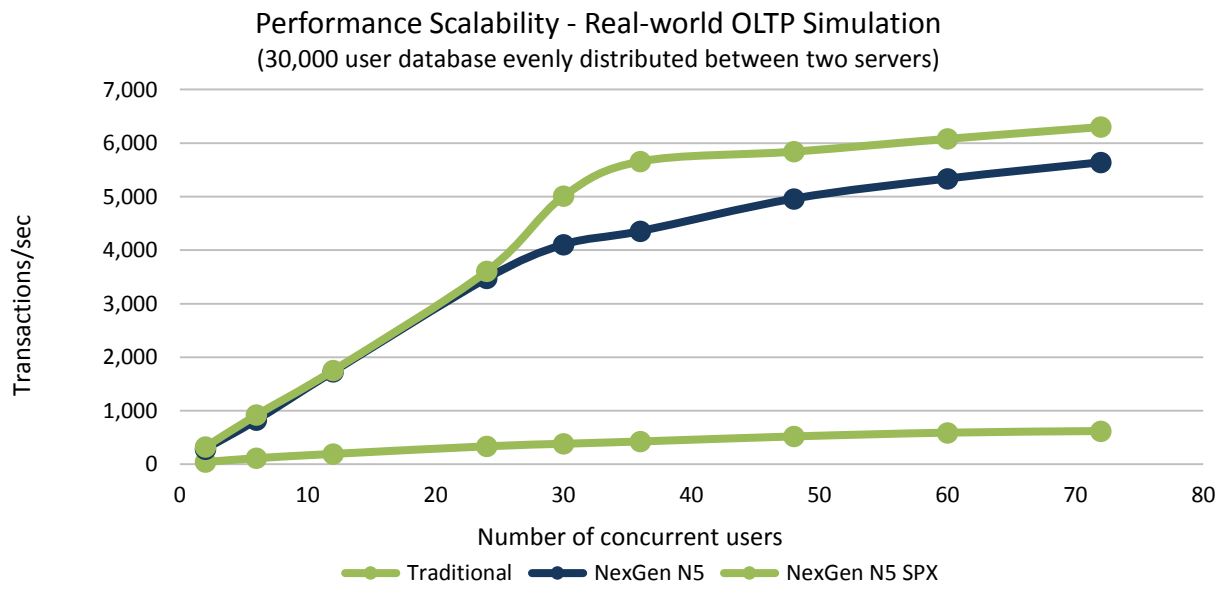


Table 2. Performance Analysis – Transactions/sec

Number of Concurrent Users	Total Number of Transactions/sec		
	Traditional SAN	NexGen N5	NexGen N5 SPX
2	43	285	324
6	115	826	921
12	195	1,729	1,756
24	336	3,473	3,607
30	383	4,103	5,010
36	426	4,354	5,660
48	520	4,961	5,843
60	590	5,335	6,082
72	620	5,640	6,303

What the Numbers Mean

- When compared to a traditional SAN, NexGen N5 SPX supports 10X the number of transactions/sec and NexGen N5 9X the number of transactions/sec.
- Three storage scenarios were tested using a real-world OLTP simulation that utilized a clustered SQL Server environment and the number of transactions/sec was measured as the number of concurrent users increased from two to 72.
- As the concurrent user count scaled to 24 concurrent users, similar performance and linear scalability was witnessed for both NexGen N5 solutions.
- NexGen N5 SPX continued to scale linearly past 24 concurrent users and yielded as much as a 30% performance boost over NexGen N5.

Why This Matters

The performance of a storage infrastructure is critical, particularly one that houses tier-1 application workloads with strict performance requirements. With important business applications like mission-critical transactional databases being a lifeline to the business, more performance is required to satisfy customer needs. Faster, scalable performance means not only improved productivity for those directly impacted, but also improved customer satisfaction and increased revenue.

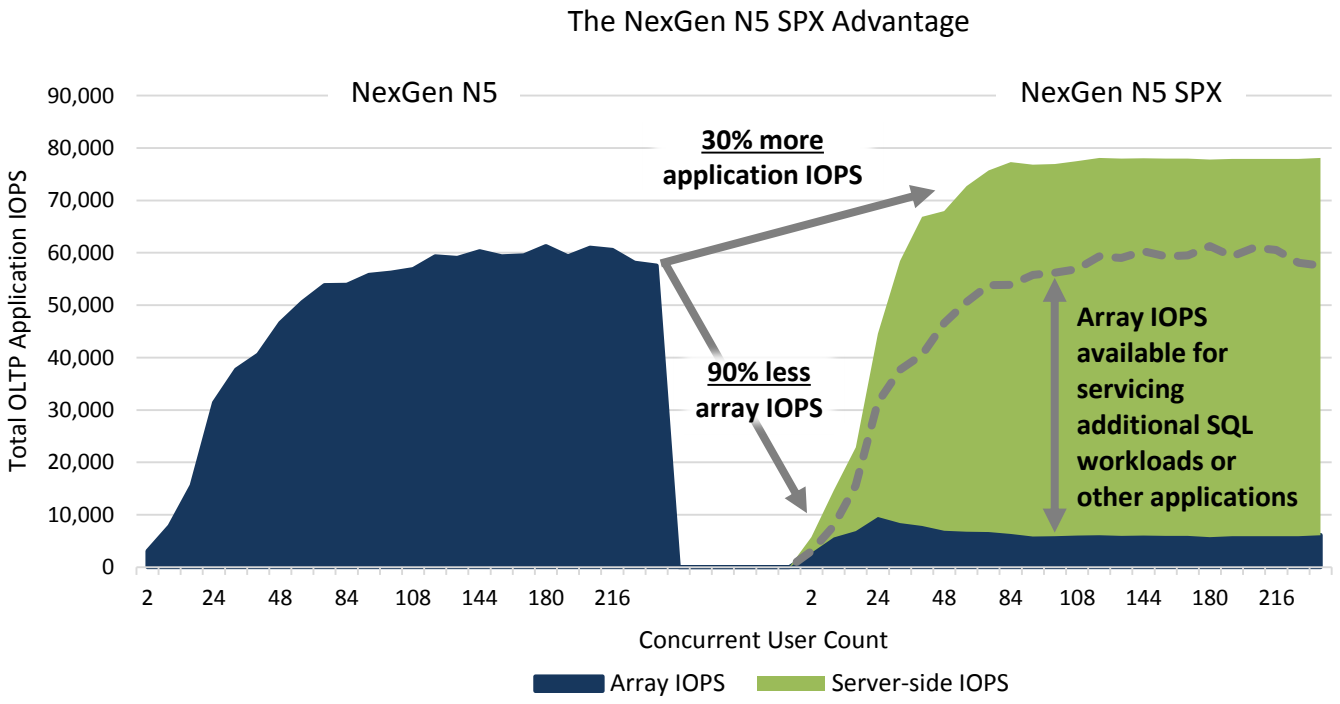
ESG Lab validated that the cost effective efficiency of NexGen's end-to-end flash hybrid approach with PCIe flash at both the server and the storage array provides a dramatic performance boost for a SQL Server workloads compared to traditional disk-based SAN array. Simulated OLTP performance with Iometer showed just less than a 6x performance gain for both IOPS and response times. Also, as a result of localized server caching along with optimization of array-flash to server-flash read/writes, performance increased by more than 12x during higher level OLTP application testing on a Microsoft SQL Server 2012 cluster.

Advantages of NexGen N5 SPX

Both NexGen N5 and NexGen N5 SPX leverage PCIe flash to help accelerate storage performance for mission-critical applications. NexGen N5 has ioMemory flash at the storage array level to serve as a flash buffer for everything connected, while NexGen N5 SPX adds server-based PCIe flash cache. By moving flash closer to where the application resides, the IOPS from that specific application can get an even greater performance boost, while offloading IOPS from the storage array. This frees up the storage array and its own PCIe flash to service other applications, while not impacting a mission-critical application like SQL Server.

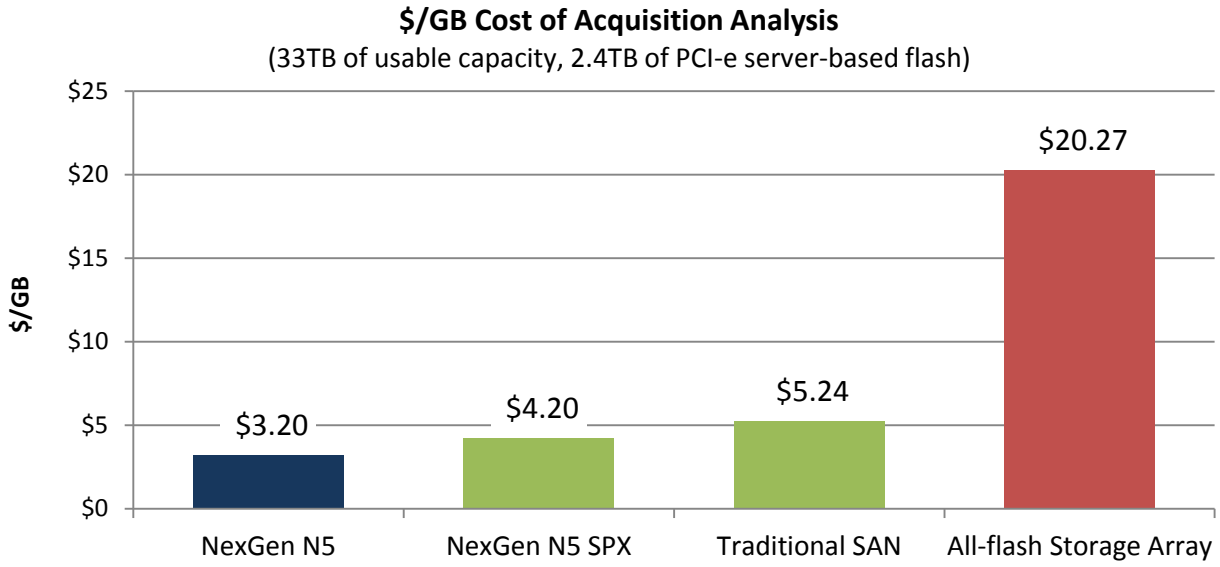
ESG Lab leveraged the performance results from the earlier real-world OLTP testing and analyzed the advantages that could be gained from utilizing the NexGen N5 SPX end-to-end flash solution. The total application IOPS were measured and by using NexGen software, ESG Lab could measure which IOPS occurred on the storage array flash and which occurred on the server-based flash. The goal was to not only understand the overall application IOPS performance improvement with server-based flash cache, but to also understand the number of IOPS that get offloaded from the storage array, helping free up storage array resources to service other applications. The analysis is shown in Figure 10. By utilizing server-based PCIe flash to service a clustered mission-critical SQL Server OLTP application workload, 30% more application level IOPS were delivered with 90% less array IOPS.

Figure 10. NexGen N5 SPX End-to-End Flash Performance Advantage



After witnessing the performance advantages that NexGen N5 SPX can offer an organization, ESG Lab next analyzed the cost difference between a traditional SAN, the two NexGen storage solutions, and an all-flash storage array. ESG Lab broke down the total acquisition cost into a commonly viewed metric of $/GB. This was done by converting the capacity of TBs to GBs and dividing the total cost of acquisition by the GB value. The usable capacity in both NexGen N5 and NexGen N5 SPX for this test was set at 33TB, with 2.4TB of flash in the NexGen hybrid appliance and an additional 1.65TB of server-side flash in NexGen N5 SPX. For the traditional SAN, ESG Lab compared three industry-leading vendor storage solutions and averaged the estimated cost of acquisition. SSDs were not included in the traditional storage pricing. It's important to note that the flash capacity in the NexGen N5 SPX option is not included in the usable capacity because the server-based PCIe flash is used strictly as cache. The results are shown in Figure 11.

Figure 11. NexGen N5 SPX Cost Advantage



The first big takeaway from this cost of acquisition analysis is the traditional SAN $/GB compared to both NexGen options, where NexGen is $1-2/GB less. This cost savings, combined with the performance benefits of both NexGen options shows what organizations could gain from leveraging a NexGen N5 hybrid flash appliance or SPX hybrid end-to-end flash solution. The second takeaway focuses more on meeting the same performance requirements with various flash technology approaches. Some organizations are leveraging all-flash storage arrays to meet the performance demands of mission-critical applications, but this approach, from a $/GB standpoint, can be significantly more expensive. With NexGen N5 and NexGen N5 SPX, the performance benefits offered by flash can still be achieved, but at almost five times less the cost than an all-flash storage solution.

Why This Matters

With growing businesses comes more data, and with more data comes performance challenges, in particular more pressure to make that data available quickly and efficiently. Organizations think that simply throwing more storage at an application to meet the higher performance requirements is the solution, but this approach adds unnecessary management complexity. At a storage array level, flash has gained momentum, but over provisioning and using flash inefficiently can become very costly. By strategically utilizing flash not only at a storage array level, but also at a server level, organizations can realize significant performance benefits, increase storage efficiency, and reduce the storage array footprint, which helps to lower overall costs and obtain a quicker ROI.

ESG Lab validated that by utilizing NexGen N5 SPX end-to-end flash solution to service a simulated real-world database workload, storage array IOPS were reduced by up to 90%, while total application IOPS increased by up to 30%. The benefit of this end-to-end flash solution is not only the ability to improve application performance, but also to increase application density. By freeing up the storage array to service other applications without sacrificing the performance of mission-critical applications like SQL Server, higher ROI and lower TCO can be realized. NexGen N5 and NexGen N5 SPX provide organizations with the benefits of flash mixed with traditional disk in a cost-effective, end-to-end hybrid solution at a price point that is hard to beat.

ESG Lab Validation Highlights

- ☑ Provisioning storage for performance was quick and easy. In just a few mouse clicks, ESG Lab had created a SQL Clustered volume to house an OLTP database and assigned a predefined service level to guarantee mission-critical performance.
- ☑ Using the industry-standard Iometer tool, an OLTP simulation showed performance scalability as the number of outstanding requests increased. ESG Lab witnessed more than a 5x performance improvement from an IOPS standpoint and 6x faster average response times when comparing NexGen's storage solution with a traditional SAN.
- ☑ When simulating a real-world OLTP workload with a SQL cluster, ESG Lab witnessed linear performance scalability and an impressive number of transactions/sec as the number of concurrent users increased.
- ☑ When specifically comparing NexGen N5 with NexGen N5 SPX, ESG Lab witnessed how server-based PCIe flash cache can help accelerate performance, improve application density, and improve the overall efficiency of the storage infrastructure. NexGen N5 SPX yielded up to 30% more application performance, while reducing storage array IOPS by 90%, enabling more consolidation within the storage infrastructure.
- ☑ Based on current pricing, ESG Lab calculated the cost per GB an organization could expect based on cost of acquisition, and found that NexGen N5 and NexGen N5 SPX can cost-effectively meet organization's mission-critical performance requirements while not breaking the bank.

Issues to Consider

- ☑ Default server BIOS, operating systems, and application settings were used during ESG Lab testing. As expected, after any testing of this magnitude, analysis of the results indicates that tuning would most likely yield slightly higher absolute results. Given that the goal of this report was not to generate a hero number, ESG Lab is confident that the results presented in this report meet the objective of demonstrating the achievable performance levels of a SQL Clustered OLTP environment.
- ☑ The test results presented in this report are based on benchmarks deployed in a controlled environment. Due to the many variables in each production data center environment, capacity planning and testing in your own environment is recommended.
- ☑ For the real-world OLTP simulation, ESG Lab did not push the NexGen storage system to its limit. A bottleneck occurred at the application and server level. ESG Lab is confident that with more powerful servers and the ability to push more application concurrency, even higher levels of performance could be achieved.

The Bigger Truth

A key objective for any IT administrator is improving application performance to give business users the best possible application experience. This is especially important for mission-critical database applications. Advancements in server and network resources occur regularly, which definitely helps, but as more workloads are added to the infrastructure and leverage the same underlying storage infrastructure, I/O bottlenecks can quickly become a concern. This is due in part to not only the increase in I/O traffic, but also the randomness of I/O. Over purchasing and over provisioning storage is an easy answer to the problem, but doing this with a strict IT budget is becoming impossible.

For handling mission-critical performance requirements, such as for an OLTP database application like SQL Server, organizations have started using SSDs, whether as a tier of cache in the external storage system or as a full storage array. These options are expensive, regardless of whether or not flash technology is coming down in price. NexGen has introduced an end-to-end flash solution that addresses the performance problem in two locations. The first way is at the storage array level. Instead of using SSDs, which can become bottlenecked by RAID controller limitations, NexGen N5 uses PCIe flash technology in the array. This creates an architectural leap that can deliver performance that runs at CPU and RAM speeds. The second way NexGen addresses performance problems is by leveraging PCIe flash as a cache on a server where a mission-critical application runs. This not only creates a significant boost to the particular application, but also alleviates potential bottlenecks that could occur on the storage array. By placing PCIe flash in the right place at the right time, mission-critical applications can cost-effectively deliver significant performance improvements while increasing the overall efficiency of the storage infrastructure. The result is a more efficient hybrid shared storage array that will support the performance and capacity needs of other applications.

ESG Lab has confirmed that NexGen N5 and NexGen N5 SPX use PCIe flash technology to its maximum effectiveness at both a storage array and server cache level. By being able to easily provision storage performance that can utilize array QoS and predefined service levels, performance was guaranteed even in the event of competing application IOPS or a component failure. Application performance was optimized by combining the fast response times of localized server cache with fast, active-active storage array IOPS. For a real-world clustered SQL Server OLTP environment, ESG Lab witnessed significant performance acceleration of up to 12x when compared with a traditional storage architecture. Even further, when utilizing NexGen N5 SPX server-based PCIe flash compared with NexGen N5, array IOPS were reduced by up to 90% while overall application performance increased by 30%. The cost-effectiveness of NexGen's hybrid storage solutions were validated by calculating the $/GB, costing less than a traditional SAN and significantly less than an all-flash storage array

Organizations are turning to server-based cache solutions for database application workloads that demand high performance. NexGen has leveraged its already strong PCIe flash knowledge and architecture at a storage system level and expand it to incorporate servers, too, creating an end-to-end hybrid flash solution that cost effectively improves application density and increases overall storage infrastructure efficiency. If your organization is looking to cost effectively meet the strict performance requirements imposed by business critical application workloads like Microsoft SQL Server, ESG Lab suggests taking a look at NexGen N5 SPX — end-to-end hybrid flash storage from NexGen Storage.

Appendix

Table 3. ESG Lab Test Bed

Software	
Clustered Servers	Windows Server 2012
Database	Microsoft SQL Server 2012
Hardware	
Server	HP ProLiant DL380 G8 Dual E5-2690 processors 128GB 1333MHz RAM
Traditional SAN	Two 9-Disk RAID5 Aggregates Two 200GB LUNs per aggregate 15K RPM SAS drives
NexGen N5 SPX	N5-150 Hybrid Flash Array 8-Disk RAID6 Set per Controller Two 200GB LUN's per Controller 7.2K RPM SAS drives – 3TB each

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