ARCHITECTURE WHITEPAPER

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DATA VALUE

In a recent customer survey[1], 94% of respondents stated that managing their data based on the value or priority of that data to their business was “valuable” to them. However, only 32% of respondents are practicing value or priority based data management.

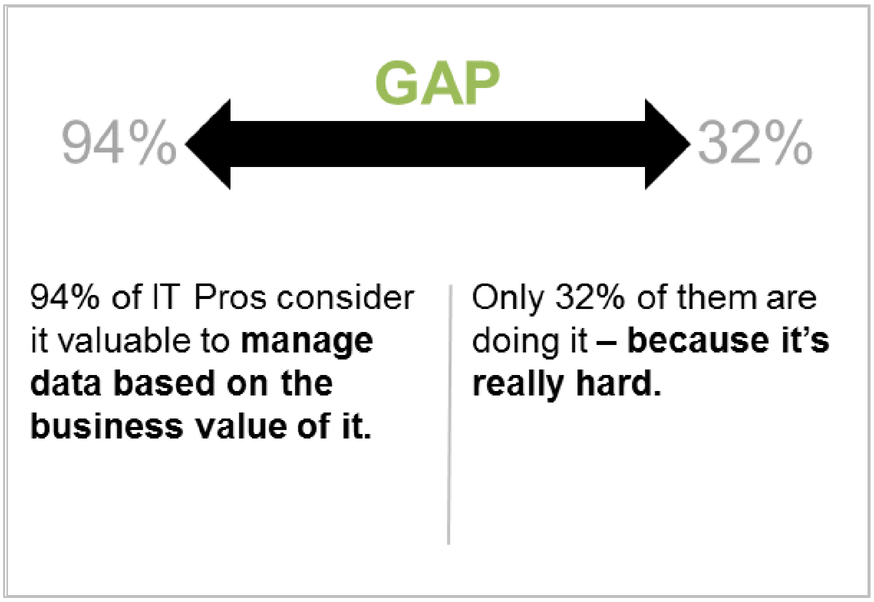

Figure 1: Data Value Management - %-respondents that see value vs. those actively doing it.

So, why is there such a huge gap between what customers desire (managing data via business value/priorities) vs. what is currently in practice? The short answer is that customers lack the systems and tools necessary to address this requirement. Storage systems have never been designed with the end-goal being to help customers prioritize their data based on their own priorities and the value of their data. Solving these challenges was one of the founding principles around the NexGen Hybrid Flash Array architecture that is described in this paper.

1. IDG; December, 2014; “Market Pulse Research: Data Storage Management Strategies, Expectations, and Challenges”

NEXGEN STORAGE ARCHITECTURE

The NexGen architecture was built from the ground up to maximize the business value of data for customers. The NexGen team recognized early-on that with flash in the data-center becoming pervasive, a new storage architecture was required to take full advantage of what it will be able to do for customer applications. Customers have continued to struggle with managing their storage resources and where their data should reside. Painstaking planning is required to prioritize data into specific categories for performance, availability, reliability, backup, etc., and then even more effort is spent designing and implementing storage systems that can meet those goals.

At NexGen Storage, we set out to build storage systems and software that make it simple for customers to assign priorities to their data, and then let the storage system take care of managing the data to meet those prioritizations.

The following table summarizes the NexGen Hybrid Flash Array architectural design elements that will be discussed in the sections that follow:

Quality of Service and Service Levels	Quality of Service (QoS) is an essential data management tool needed to input the relative value of a customer's data to be managed. A comprehensive storage QoS design encompasses all data value management objectives, including Performance, Availability, Data Protection and Security. Service Levels govern how the storage system makes decisions on behalf of the customer once the data value has been prioritized, whether in steady-state or degraded mode.
PCIe Flash	Flash is more like memory than disk. The most effective flash integration is on the PCIe bus, as close to the processors as possible. Putting SSDs behind a RAID controller is a huge bottleneck and drastically reduces the potential of flash in the customer environment.
Dynamic Data Path	Managing where data resides should be a real-time, automatic process of the storage system itself. Multiple storage media types (RAM, Flash, Disk, etc.) can host data. Based on the value of the data, the storage system should locate it in the appropriate location, in real-time, to meet the QoS objectives.

Active-Active High Availability and Performance	Active-Active Storage Processors are required to provide the full benefit of available performance and availability offered by PCIe flash storage. To let a Storage Processor sit idle (Active-Passive) during steady-state operations wastes critical resources.
Simple Management	A powerful storage system is one that requires the least amount of attention and management. Simple, intuitive storage management integrated with applications is now an expectation.
Scalability	Being able to scale performance and capacity independently of each other is required to allow customers the flexibility they need. If they need more performance, install more PCIe flash. If they need more capacity, add more disk storage.

Table 1: NexGen Hybrid Flash Array Architectural Design Elements

Storage Quality of Service and Service Levels

Quality of Service

The NexGen ioControl Operating Environment was designed to deliver storage Quality of Service (QoS), which prioritizes performance to each application based on its assigned performance policy. The QoS policy defines the performance targets for a volume in terms of **IOPS**, **throughput** and **latency**. This eliminates unpredictability and the need to design storage systems for peak workload performance. For example, an organization can assign a business intelligence application 30,000 IOPS, an order database 25,000 IOPS, and a marketing file share 5,000 IOPS. This means that no matter what is happening in the system, each application will get its assigned level of performance. By setting these performance targets, the QoS algorithms function to maintain the priorities of each and every IO in order to meet the performance targets for the volume. Workload spikes from non-critical workloads will not affect business or mission critical applications. This means critical applications like the order database or business intelligence app will never drop to unacceptable performance levels.

The QoS engine operates on three metrics: IOPS, Throughput and Latency. Five performance policies (Table 2) are setup within the system, and are mapped to the three Service Levels. The QoS engine operates on each and every IO based on a QoS-tag assigned to the IO. The QoS policy targets for IOPS and Throughput are treated as target minimums, meaning that the system is designed to be able to meet the minimum target objectives. The QoS policy target for Latency is treated as a maximum target, meaning that volumes in the policy will not exceed the latency target associated to the policy.

The following table summarizes the performance targets of the QoS performance policies:

Performance Policy	IOPS	Throughput (MB/s)	Latency (ms)
Policy-1 Mission Critical	100,000	750	5
Policy-2 Business Critical	50,000	375	10
Policy-3 Business Critical	20,000	150	25
Policy-4 Non-Critical	10,000	75	50
Policy-5 Non-Critical	2,000	37.5	100

Table 2: QoS Performance Policy Targets.

Setting the QoS performance policy of a volume is done at time of its creation, and can be changed anytime in real-time to dynamically adjust the relative priority and performance of the volume. For instance, if a customer wants to allocate more performance to a SQL Reports volume for month-end reporting, they can simply go into one the management interfaces (UI, CLI or vCenter Plugin) and adjust the QoS policy on the volume.

The following screenshot highlights the QoS Performance Policy targets for “Policy-1 Mission Critical”:

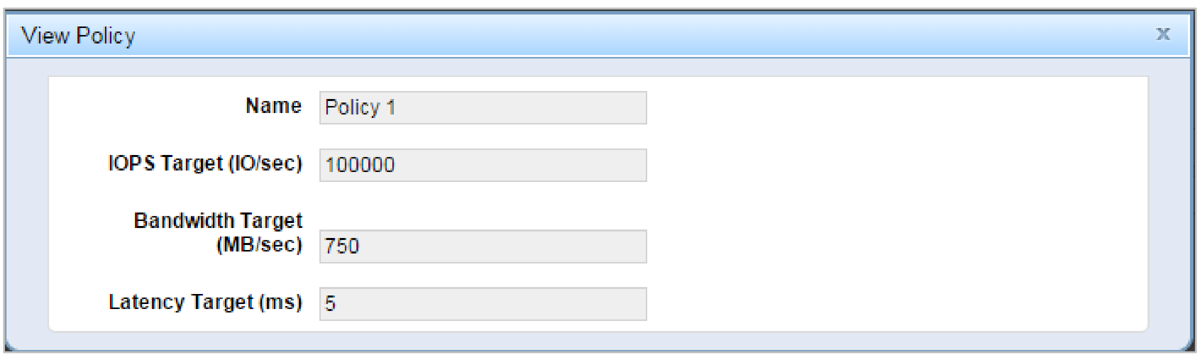

Figure 2: QoS Performance Policy screenshot.

The following screenshot shows how easy it is to change a QoS Policy on a volume on-the-fly:

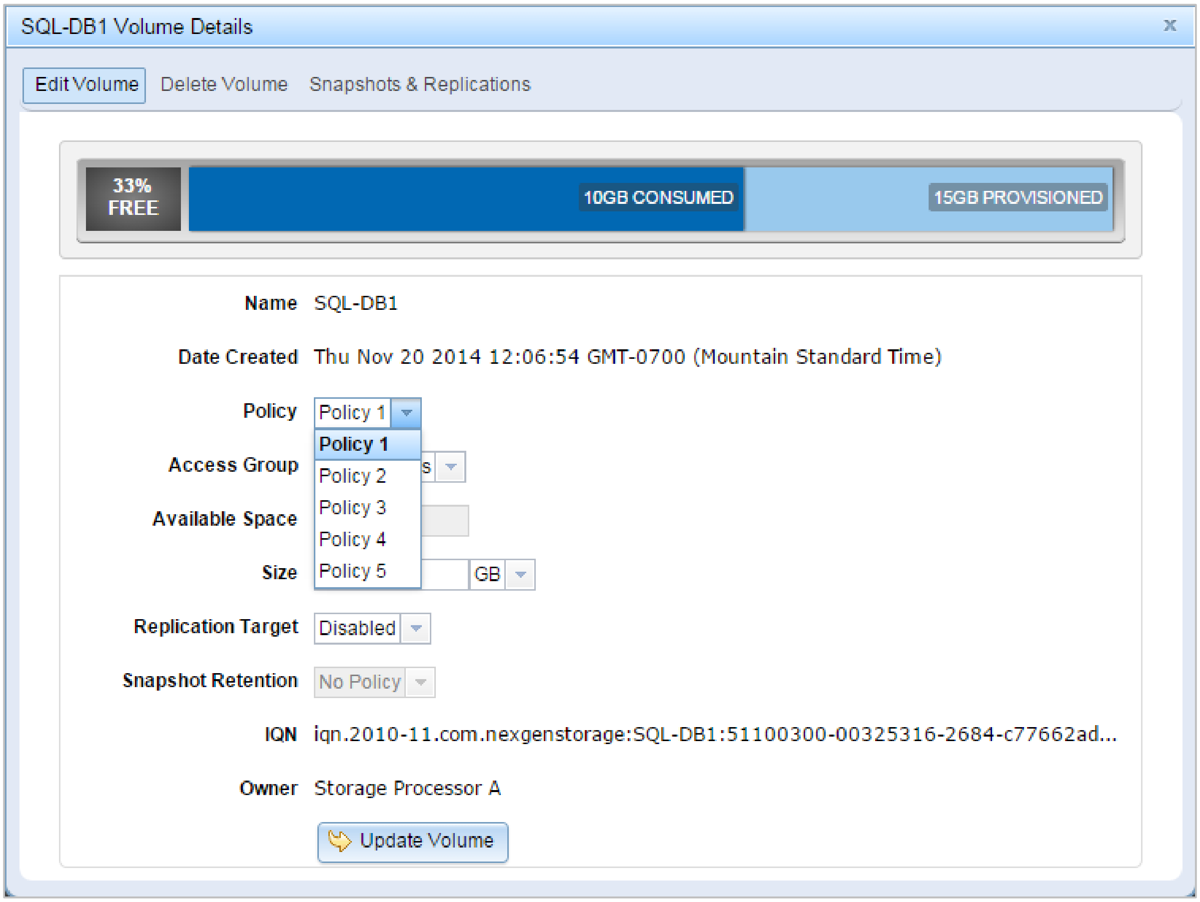

Figure 3: Volume QoS Performance Policy modification screenshot.

Performance monitoring capabilities in the user interface allow performance to be monitored real-time, and viewed up to one year prior. Volume QoS policies can be adjusted to ensure that configurations are always optimized. Storage QoS prioritizes storage performance levels, so you can be confident that your system is as powerful, cost-effective and efficient as possible.

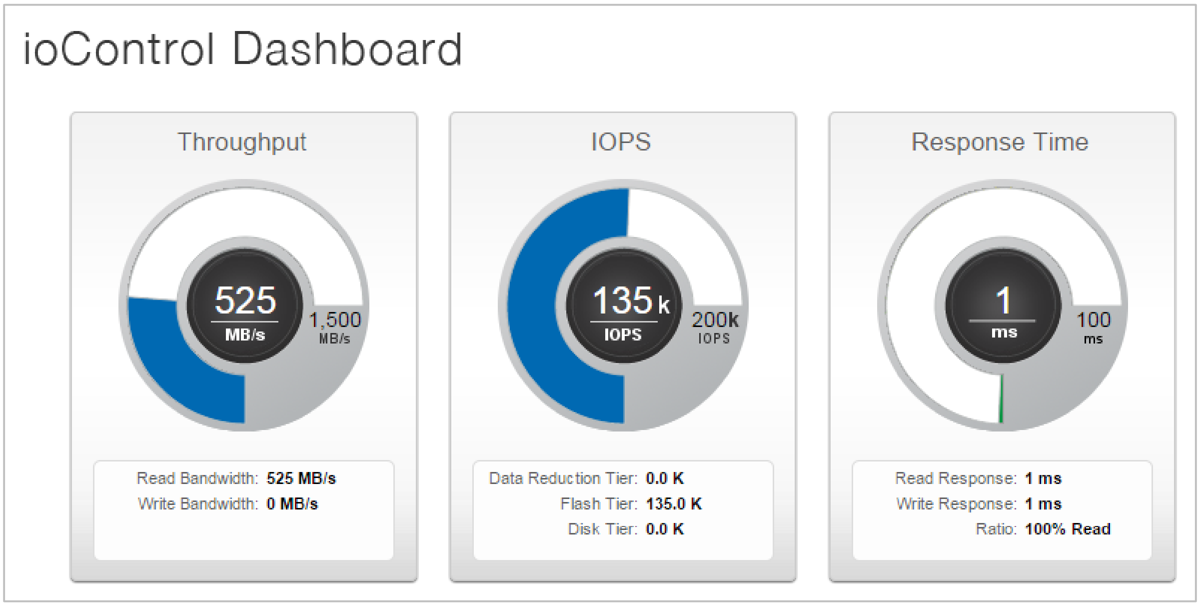

Figure 4: Screenshot of QoS Dashboard.

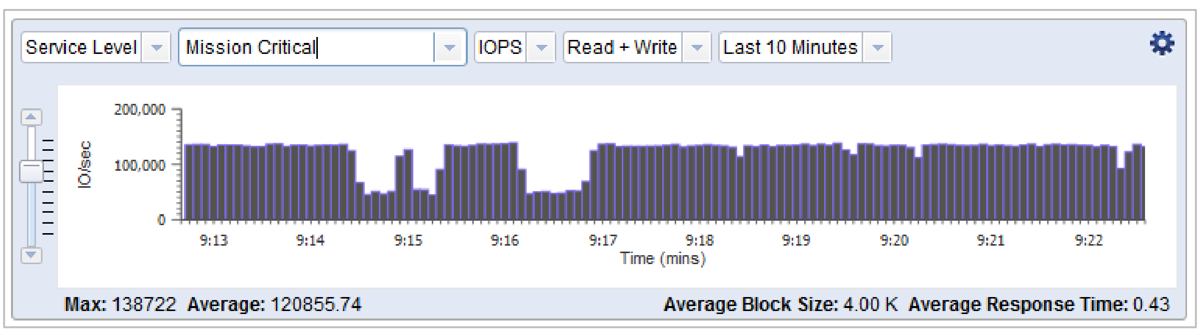

Figure 5: Screenshot of the QoS Metrics for Mission Critical volumes.

Service Levels

Service Levels govern how the NexGen N5 makes decisions about prioritizing IOs based on the QoS performance policies. There are three service levels built into the QoS engine: **Mission-Critical**, **Business-Critical**, and **Non-Critical**. These service levels instruct the system on how important it is to maintain the QoS targets that you've defined for your volumes. The NexGen N5 isolates the performance impact to the Non-Critical applications first, and then minimizes impact to Business-Critical applications. However, it ensures that your Mission-Critical applications are not impacted.

For instance, if the system is under a workload where the Latency target on a Mission Critical volume is not being met, the QoS engine will automatically begin taking performance away from Non-Critical workloads (and Business Critical, if needed) in order the bring the Mission Critical latency target back in-line. Likewise, if the system is in a degraded mode (rebuild, failover, upgrade, etc.) situation, the Service Levels govern how the QoS engine treats the targets in order to maintain Mission Critical performance.

You are able to proactively define the amount of resources a volume will receive during an event. Figure 6 shows the Metrics screen for the three service levels. During a VDI boot storm, Mission Critical performance is maintained while Business Critical performance is impacted to the accepted target levels.

Figure 6: Metrics screenshot during VDI boot storm.

With any other storage system, there is no way to prioritize performance in this manner based on the business value of the data. Not the case with the NexGen N5. Since the volumes associated with the Exchange workload were categorized as Mission-Critical, SQL reports as Business-Critical, and VDI as Non-Critical, the NexGen N5 knows exactly where to allocate resources during an event.

PCIe Flash-first Design

There are a variety of ways to deploy flash into the datacenter. A customer has many choices available to them with respect to the interface, capacity, performance and reliability of flash devices. The following table summarizes popular options available today:

Type	Interfaces	Capacity Points	Performance	Reliability
SSD	SATA or SAS	80GB – 1.6TB	190K iops, 1GB/s	4 – 35 PBW (PB Written)
PCIe Flash	PCIe	200GB – 5.2TB	380K iops, 2.7 GB/s	12 – 64 PBW

Table 3: Flash/Solid-state Choices.

Flash operates more like memory than disk, and treating it like disk by placing flash behind RAID controllers diminishes its performance potential. The most efficient way to connect flash is to place it as close to the CPU as possible. For that reason, when designing the NexGen Storage architecture, PCIe flash was the choice selection for flash/solid-state technology. Most All-Flash Arrays and all Hybrid storage vendors have selected SSD technology with a SAS or SATA interface, which severely limits the performance potential of the system.

Performance is just one factor for choosing PCIe flash over SSD. Other factors are capacity footprint and reliability. The form-factor of PCIe flash is larger than SSD, allowing it to pack in more capacity. And, PCIe flash is more reliable than even the most robust Enterprise SSDs on the market. The following charts summarize the profound differences between PCIe flash and SSD (Enterprise and Economic) for Performance and Reliability:

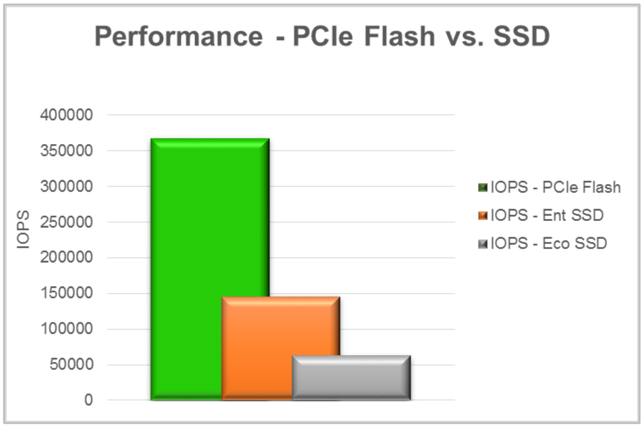

Figure 7: PCIe Flash Performance vs. SSD

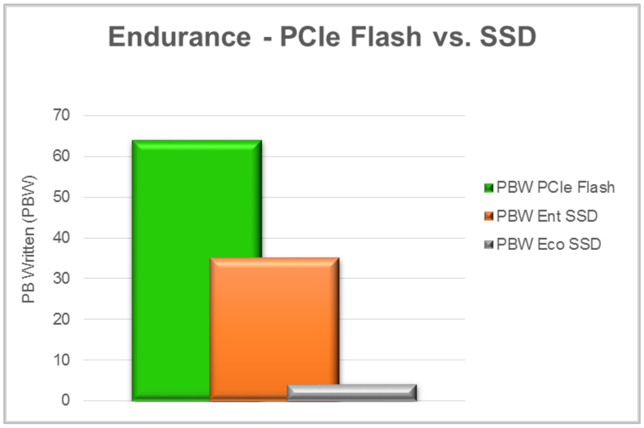

Figure 8: PCIe Flash Reliability vs. SSD

From a data path perspective, PCIe flash is used in the NexGen N5 as an active data tier (Figure 9). When an application sends a write request, it is mirrored between the PCIe flash cards on the two storage processors for high availability and redundancy. Once both copies are stored, the NexGen N5 acknowledges the write completion to the host. However, flash is too expensive to permanently maintain two copies of data. Therefore, once the write is acknowledged, the system will copy the data from PCIe flash to disk (Figure 9). Reads, writes, and modifies of the original copy occur in flash. At this point, the copy on disk is only used in the event that a rebuild on the flash tier is required. Lastly, if the data that is stored in PCIe flash is not being accessed frequently, the NexGen N5 will evict it to make room for more active data based on the QoS priorities and targets. The decision to evict data is made in real time based on access patterns, current performance levels and data-reduction ratios.

The following depicts the PCIe Flash within the NexGen N5 Hybrid Flash Array.

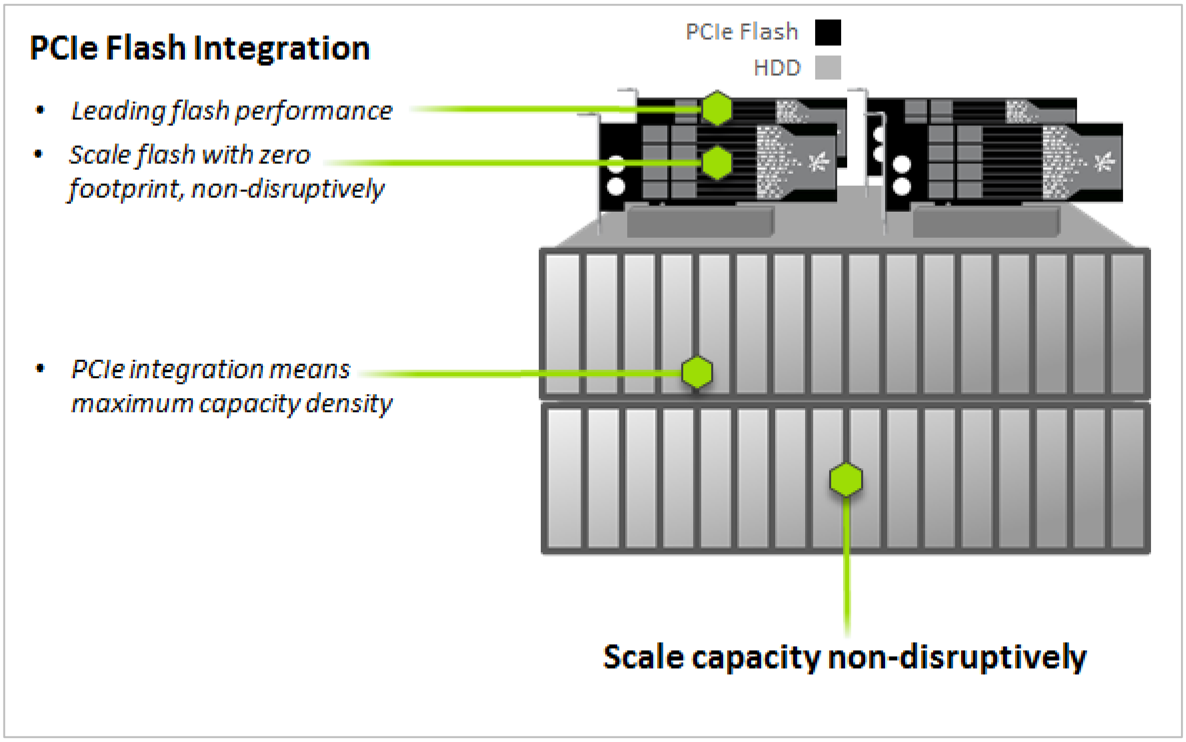

Figure 9: PCIe Flash Integration.

Dynamic Data Path

The NexGen N5 Hybrid Flash Array manages where data is stored in real-time. I/O operations for blocks in the system are used to make a real time decision about where blocks should live. The workload history is stored in memory where it can be quickly accessed without perceivable latency. These heuristics along with quality of service settings are used to decide whether a block of data is being stored on the right storage media (Flash vs. Disk). The data can move between tiers in real time as workloads change, ensuring predictable performance and the most efficient use of system resources.

The NexGen N5 has the following capabilities that set it apart from other storage tiering approaches:

- **Three IO tiers** (RAM, Flash, and Disk) from which application IO requests can be satisfied. The Data Reduction tier is a Pattern Match process that runs in CPU/RAM of the NexGen N5. The flash tier is delivered with two (or four) PCIe flash cards rated for Enterprise reliability and performance. The disk tier is delivered with dual-ported Enterprise MDL-SAS disk for capacity.
- **Quality of Service (QoS)** for predictable performance. The overall goal of the system is to deliver predictable performance for Mission Critical workloads. The QoS operations of the NexGen system have direct influence on how data is moved between the tiers in real-time by Dynamic Data Path.
- **Prioritized Active Cache** based on QoS settings. The Flash Read Caching is directly influenced by the QoS priority settings set for the volume by the administrator. Mission Critical volumes will read cache data into flash more quickly than Business Critical volumes.
- **Real-time data movement** between tiers. Data is moved actively within the system all the time. The Dynamic Data Path algorithms are always running. There is no need to schedule a batch process to move data at night, like with other storage systems.
- **Flash used for both Writes and Reads** for tiering and caching. Because the NexGen N5 uses Enterprise reliable PCIe flash, all writes from the application host land in the PCIe flash cards. High availability is achieved across Storage Processors by mirroring all data writes across both PCIe flash cards before acknowledging (ACK) back to the application server.

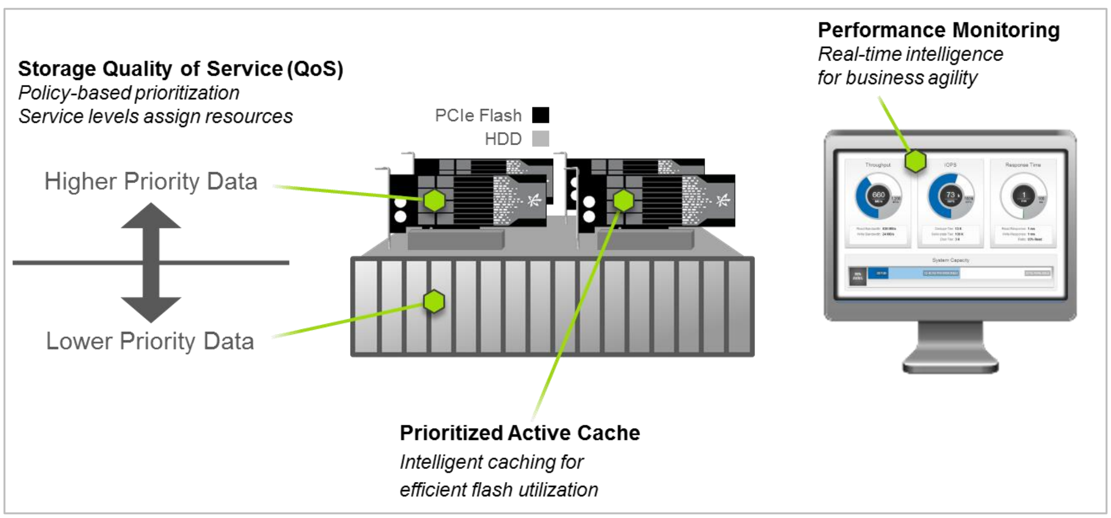

Figure 10: Dynamic Data Path elements.

Data Movement Description

Dynamic Data Path feature operates to keep the “Active” data-set within the flash tier of the system. For most typical customer workloads, no more than 2-10% of their data will be active in at any given time (day). Flash to disk capacity ratio was selected with this in mind. For customers that need more flash in their NexGen N5, they can install a Performance Pack, which increases the flash capacity of the system.

The following table lists the various flash capacity options (Base and Max) of the NexGen N5 models.

Model	Flash Capacity	Read/Write Mirror	Prioritized Active Cache	Usable Data* vs. Flash Capacity	Disk Capacity
N5-200	Base: 2TB Max: 7.2TB	Base: 700GB * 2 Max: 700GB * 2	Base: 600GB Max: 5800GB	Base: 54.5% Max: 87.4%	Base: 32TB Max: 128TB
N5-300	Base: 2.6TB Max: 7.8TB	Base: 800GB * 2 Max: 800GB * 2	Base: 1000GB Max: 6200GB	Base: 60.0% Max: 86.7%	Base: 64TB Max: 256TB
N5-500	Base: 5.2TB Max: 10.4TB	Base: 1600GB * 2 Max: 1600GB * 2	Base: 2000GB Max: 7200GB	Base: 60.0% Max: 80.0%	Base: 64TB Max: 256TB
N5-1000	Base: 10.4TB Max: 15.6TB	Base: 2000GB * 2 Max: 2000GB * 2	Base: 6400GB Max: 11600GB	Base: 75.0% Max: 83.3%	Base: 64TB Max: 256TB

Table 4: Flash Capacity Options by NexGen N5 model.

*Usable Data in Flash is calculated = ((70% evict threshold * RW_Mirror) + PAC) / Flash_Capacity

The Dynamic Data Path algorithms work in conjunction with the Quality of Service (QoS) engine to keep the active data in flash based on meeting the QoS metrics and priorities set on a per volume (LUN) basis. All things being equal, there will be more Mission Critical data held in flash than Business Critical than Non-Critical.

IO Prioritization

All data IO arrives from the application servers into the NexGen N5 array via SCSI commands (encapsulated in a network storage protocol – iSCSI). From the NexGen IO stack perspective, the data IO is first prioritized into the system based on the QoS Performance Policy that the volume (LUN) is part of. It is next handed to the rest of the IO stack for processing. Mission Critical IOs are prioritized higher than Business Critical than Non-Critical. Once an IO is released for processing by the QoS engine, it flows through the rest of the NexGen IO stack. The Dynamic Data Path Engine is a set of software in the NexGen IO stack that manages real-time movement of data between the flash and disk tiers.

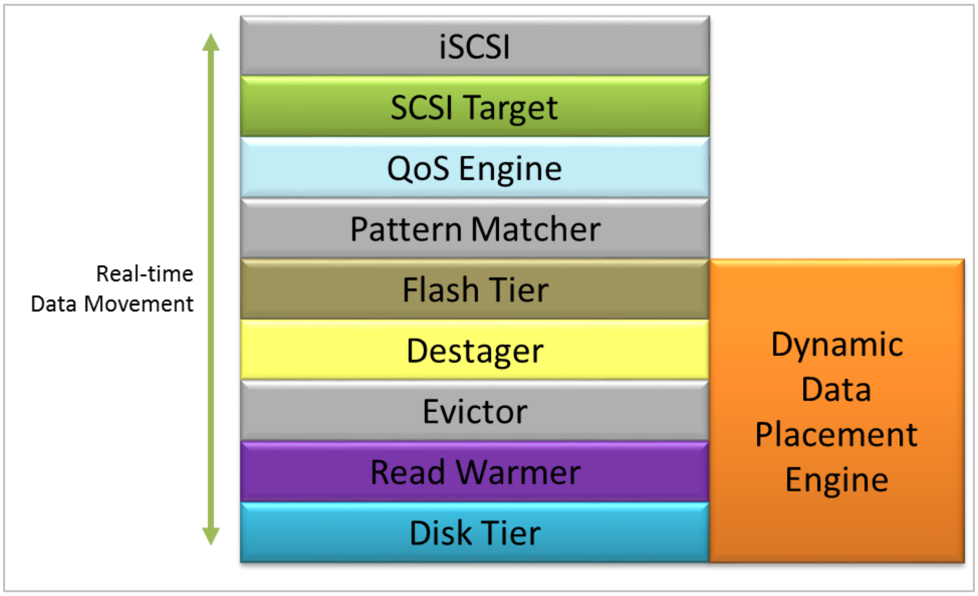

Figure 11: NexGen Storage Stack Diagram with Dynamic Data Path

Dynamic Data Path Components

There are five key components of the Dynamic Data Path Engine: PCIe Flash Tier, De-stager, Evictor, Read-Warmer and Disk Tier. The following table describes the function of each:

Component	Description
PCIe Flash Tier	Data is ingested into the system into the Flash Tier in its native IO format. Meaning that if the application server has handed the NexGen IO stack an 8K IO write, then the 8K IO write is ingested in its native format of 8K into the Flash Tier. The NexGen IO stack is a variable block system, meaning that it can deal with different IO sizes from the hosts ranging from 4K to 1.5MB in size. This capability is important for a variety of reasons, including capacity efficiency, performance, data reduction and tiering granularity. Compared to legacy system with fixed volume page layouts, the variable block nature allows dealing with data in native format without overhead.
De-stager	The De-stager is responsible for copying data from the mirrored portion of the flash down to the disk drives. The De-stager operates on a logical volume level. This means that it will take data out of the Flash Tier logically from the volume (LUN) as the host application server wrote to it and then copy it down to the disk drives. This coalescence effect allows the data to be written physically on the disk drives sequentially as it had arrived from the host application server. This improves overall

	write throughput of the NexGen N5 as well as read performance when data has to be read back from disk. The De-stager operates on data that is relatively aged compared to the rest of the data in the mirrored Flash Tier. The threshold for data to be De-staged is any data past the 30% full threshold on the mirrored Flash Tier.
Evictor	The Evictor is responsible for freeing data from the mirrored Flash Tier. When data reaches a certain relative age compared to rest of the data in the mirrored Flash Tier, it is candidate for removal. The Evictor works to maintain approximately a 30% available space buffer (or 70% full) in the mirrored Flash Tier for new writes to the system.
Read-warmer	Read-warmer is the mechanism that populates data from the Disk Tier back into the Prioritized Active Cache portion of the PCIe flash cards. The data must have been previously copied from flash to disk by the Destager and subsequently removed from mirrored flash by the Evictor. Based on the QoS setting for the volume (LUN), data is copied from disk back into flash at different aggressiveness settings. Mission Critical is most aggressive on read-warming data than Business-Critical, while Non-critical volumes will have no data warmed by a read hit.
Disk Tier	The Disk Tier is the final tier for most of the inactive data on the NexGen N5. The Disk Tier is a virtualized storage pool where volumes are logically stored as a collection of 1.5MB pages. Thru the De-stage process, the De-stager will copy data out of the Flash Tier in 1.5MB logically arranged blocks by volume (LUN) and stripe them down as full stripe writes onto the disks protected by RAID-6. The disks are protected with two 8-disk RAID-6 sets. A 1.5MB page write results in a full-stripe RAID-6 write on 8 disks (256K chunk * (6 data + 2 parity)) of 2MB.

Table 5: Dynamic Data Path Components.

Write IO Path

All write IO first lands in the mirrored Flash Tier. The write IO is mirrored across both PCIe flash cards in Storage Processor A and Storage Processor B for high availability and redundancy. Once a copy of the write IO is in both PCIe flash cards, acknowledgement is sent back to the application server. Once the relative age of the IO block (IOB) ages beyond the 30% mirrored flash "full threshold", the De-stager will begin copying the data from mirrored flash down to the Disk Tier. Finally, after the relative age of the IO block (IOB) ages beyond the 70% mirrored flash full threshold, the Evictor will free up the IO block from the Flash Tier. At this point, there is a single copy of the IO block on the disk drives protected by RAID-6.

De-stager / Evictor Thresholds

Item	Threshold
De-stage data (copy from Flash to Disk)	30% mirrored flash full threshold
Evict data (remove all copies from)	70% flash full threshold

Table 6: Destager / Evictor Thresholds.

Read IO Path

As Read IO is presented to the NexGen IO stack on a Storage Processor, the data will either in flash (flash-hit) or it will be disk (flash-miss). Additionally, there will be some data that will be both in flash and disk, but the NexGen IO stack will always prefer to source the Read from flash. As a general guideline, for a proper performing system, we expect no more than 30% of the Read IOs to result in a flash-miss (where the IO must be satisfied from disk). If more than 30% of Read IO is coming from disk, the customer should evaluate their workloads and whether or not they need more flash in the N5 (add a Performance Pack).

The Read-Warmer function populates the Prioritized Active Cache to ensure that the "active" data-set has a high probability of being sourced from flash within the system even if that data has been through a Destage/Evict cycle. Also, the QoS priority of the volume from which the Read IO is sourced influences how aggressive the Read-Warmer is. Mission Critical data is warmed much faster than Business-Critical than Non-Critical.

The following table summarizes the Read-Warmer function by QoS Performance Policy:

QoS Level	Performance Policy	Read-Warm Setting	Read-Warmer Threshold
Mission-Critical	Policy-1	Most Aggressive	Warms 1MB of data after 1 IO hit per 1MB data region
Business-Critical	Policy-2	High Aggressive	Warms 1MB of data after 4 IO hits per 1MB data region
Business-Critical	Policy-3	Moderate Aggressive	Warms 1MB of data after 16 IO hits per 1MB data region
Non-Critical	Policy-4	None	Data is never warmed
Non-Critical	Policy-5	None	Data is never warmed

Table 7: QoS Read-Warmer Settings.

The Read-Warmer thresholds are tracked on a “hits per data region” for a particular volume. Data is warmed in 1MB chunks even if the IO Read request is much smaller (8K). Most modern applications tend to write data in larger sequentialized patterns to the logical volume. By acting on the hits per 1MB region, the Read-Warmer moves data from disk to flash with a Read-Ahead and Read-Proximity type algorithm effect.

Statistics for every IO are kept by the system. So, if a volume needs more performance, the customer can simply change the performance policy to a higher performance policy and the Dynamic Data Path algorithms will automatically take effect. For instance, if a volume is moved from Policy-3 to Policy-1, the Read-Warmer will automatically begin warming data that has exceeded the warming threshold for Policy-1, even though it was not candidate for warming under Policy-3.

Active-Active High Availability and Performance

The NexGen N5 Hybrid Flash Array utilizes an "Active-Active" (aka Dual-Active) Storage Processor design for high availability. During normal operations, both Storage Processors satisfy IO requests for volumes. All volumes are presented for IO out of all data ports on the NexGen N5 on both storage processors. By using an Active-Active storage architecture, all CPU, RAM and PCIe flash are always being utilized for performance, while remaining highly available. Storage solutions that employ an Active-Passive configuration are only leveraging half of their performance resources at all times, thus largely diminishing the steady-state performance potential of the system.

The following diagram illustrates the various platform and software HA components of the NexGen N5 Hybrid Flash Array described in the sections below.

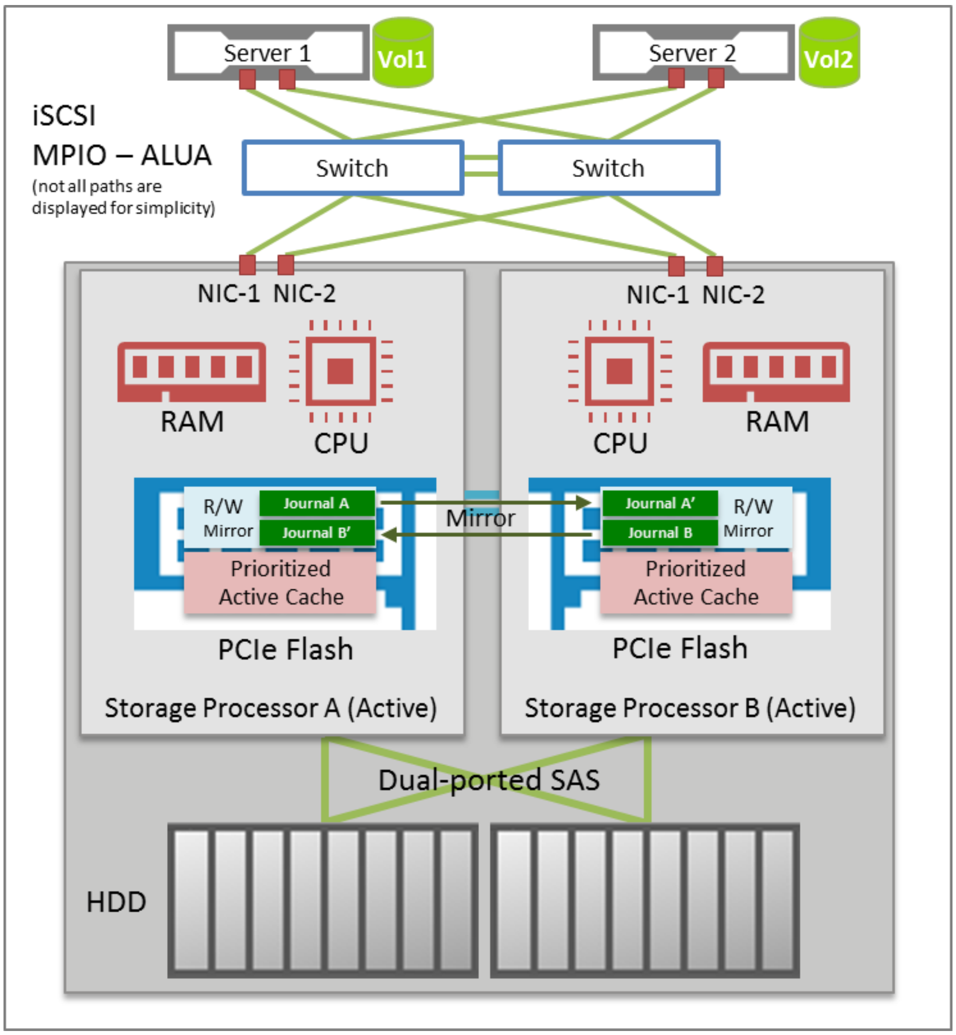

Figure 12: NexGen N5 Active-Active PCIe flash Architecture Diagram.

Several design elements factor into the HA architecture of the NexGen Storage System:

Item	HA Implementation	Description
Active-Active Storage Processors (SPs)	Dual-Redundant hot-swappable SPs per NexGen N5	An SP can be offline for any reason (maintenance, upgrade, failure, etc.) and the entire system operates on remaining SP. The Active-Active SP design if leveraged for a variety of failover/failback use-cases (maintenance, upgrade, failure, etc.), and is managed seamlessly via the NexGen Storage user interfaces.
PCIe Flash	Writes are mirrored across PCIe Flash cards	Data ingested into PCIe flash is mirrored for high availability and redundancy. Acknowledgement returned to host once both mirror copies are written.
SAS HDDs	Dual-ported Enterprise SAS hard drives	Each SAS hard drive is connected to both SPs for high availability. In the event of a failover, the surviving SP is able to read/write to all drives.
MPIO	MPIO ALUA with Round-Robin pathing policy	Utilizing the native host operating system MPIO stacks, multiple paths are connected to each volume for redundancy and performance. MPIO ALUA allows the NexGen N5 storage to instruct the host which paths are “optimized” for IO and which are “non-optimized”.
Data Ports	Redundant Data Port NICs	MPIO paths are constructed from the host NICs to the Data Port NICs on the NexGen N5. Typically, on a host with 2-port iSCSI NIC and the 4x 10Gb NIC ports on the NexGen N5, there will be 8x MPIO paths to a volume. Four paths will be ALUA “optimized” and four paths will be ALUA “non-optimized”.
Power Supplies	Dual-Redundant Hot-plug Power Supplies	The NexGen N5 chassis comes with two independent power supplies. The entire chassis can be powered via a single power supply. In the event a power supply fails, the chassis operates on the single remaining power supply until the faulty one is replaced.
Fans	12 Redundant Variable-Speed Fans (6 per SP)	Each storage processor has 6x variable-speed fans installed. In the event a fan fails, the system automatically increases the RPMs of the remaining fans until the failed fan can be replaced.

Table 8: High Availability components of the NexGen N5.

The HA function of the NexGen N5 product is always-on. Normal operational mode of the NexGen N5 is in the "Active-Active" state where both SPs are servicing IO for volumes. Typically, volumes are load-balanced across both Storage Processors to provide for optimal performance and capacity layout. In the event that an SP is offline, the surviving SP will take on IO operations for all volumes.

From a host perspective, a volume is "owned" by one storage processor at a time. Hosts connect to the volumes with MPIO ALUA (Asymmetric Logical Unit Assignment) in order for the NexGen N5 to instruct the operating system on which paths to prefer for IO ("optimized" paths. The recommended MPIO policy for connecting to volumes on the NexGen N5 is the "Round-Robin" policy. Most modern operating systems today have native MPIO stacks that support MPIO ALUA and Round-Robin MPIO Policies.

The following screenshot shows a volume connected to an ESX host with MPIO ALUA (VMW_SATP_ALUA) and the "Round Robin (VMware)" path selection policy.

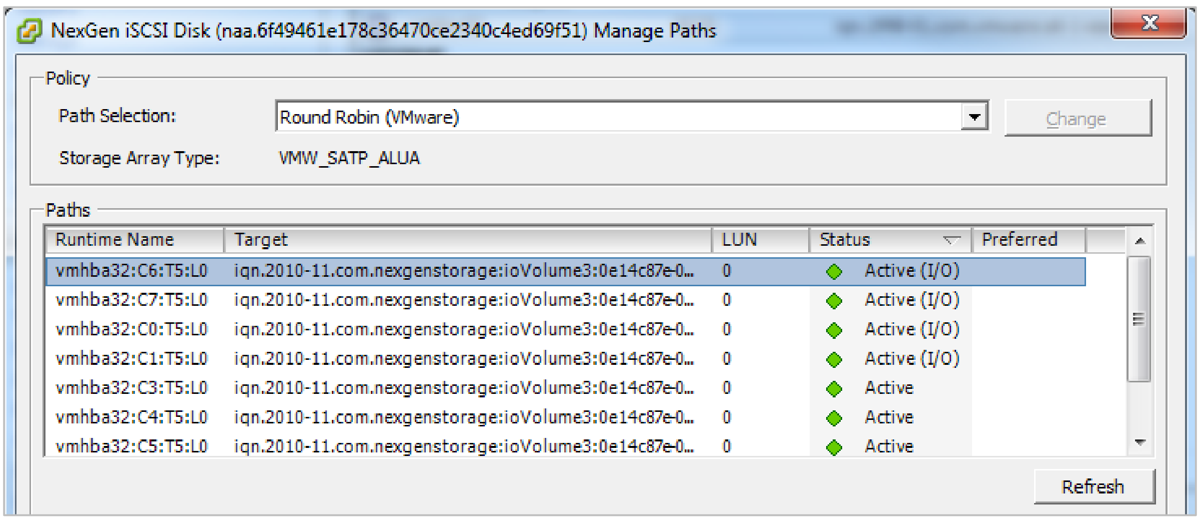

Figure 13: MPIO ALUA setup on ESX host.

Management

Management of a storage system should be simple, straight-forward and flexible. Let's face it, most IT administrators are stretched thin and can't dedicate time for managing their storage systems on a day-to-day basis. With that in mind, the NexGen Storage management architecture is one that is built on the latest technologies so that customers can manage their storage simply while in the context of their applications.

The NexGen Storage management architecture is based on a secure RESTful API transport with JSON payloads. Based on this management architecture, there are three customer-facing management interfaces that can be used to manage the NexGen N5:

- A **web-interface** is instantiated on the NexGen N5 itself and can be accessed via your favorite web-browser (including mobile).
- A **CLI** client is available for Windows and Linux hosts.
- A **vCenter plug-in** is available for integrated vSphere management.

Accessing the web-UI is as simple as pointing your web-browser to one of the management ports of the NexGen N5.

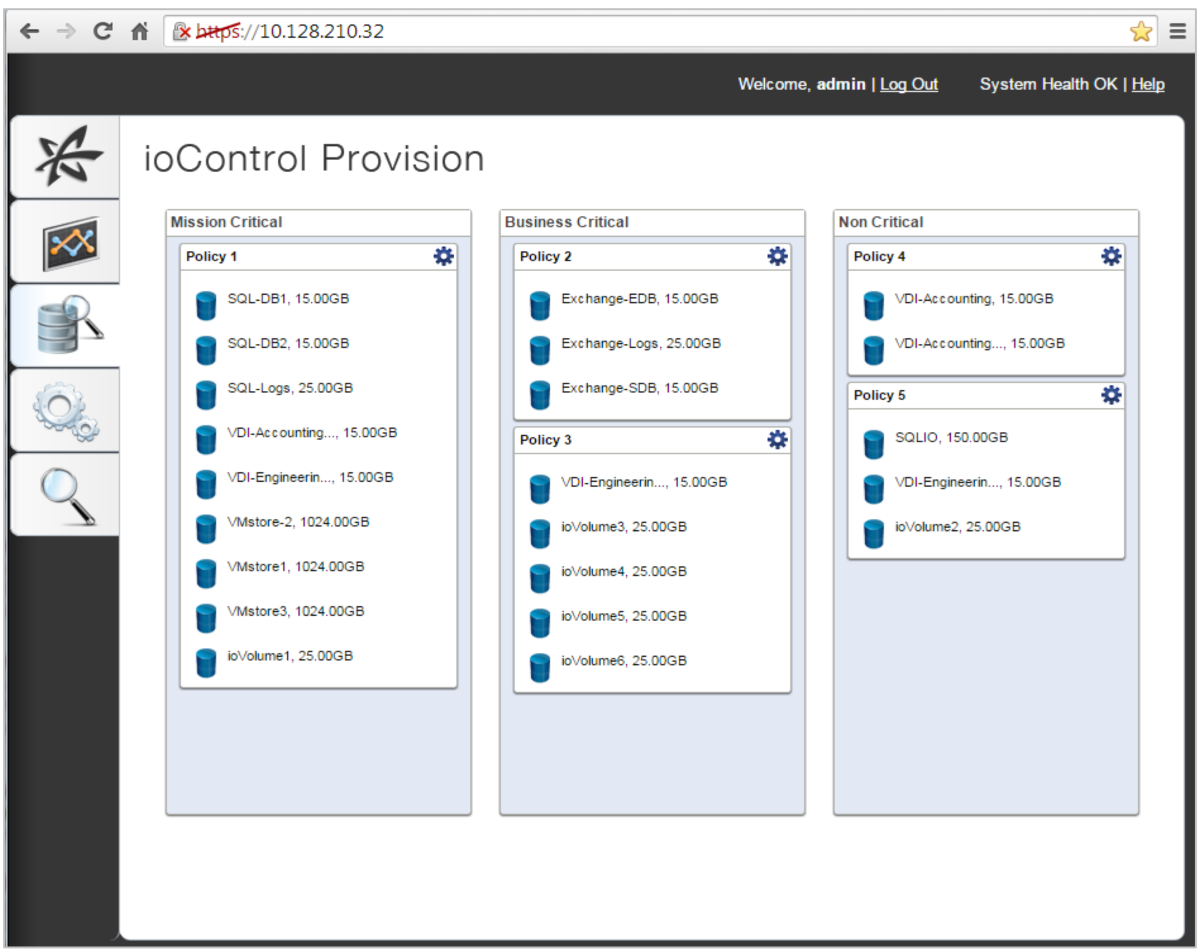

Figure 14: NexGen Storage Web Interface.

The CLI is a powerful tool used for automation and scripting of common storage management tasks.

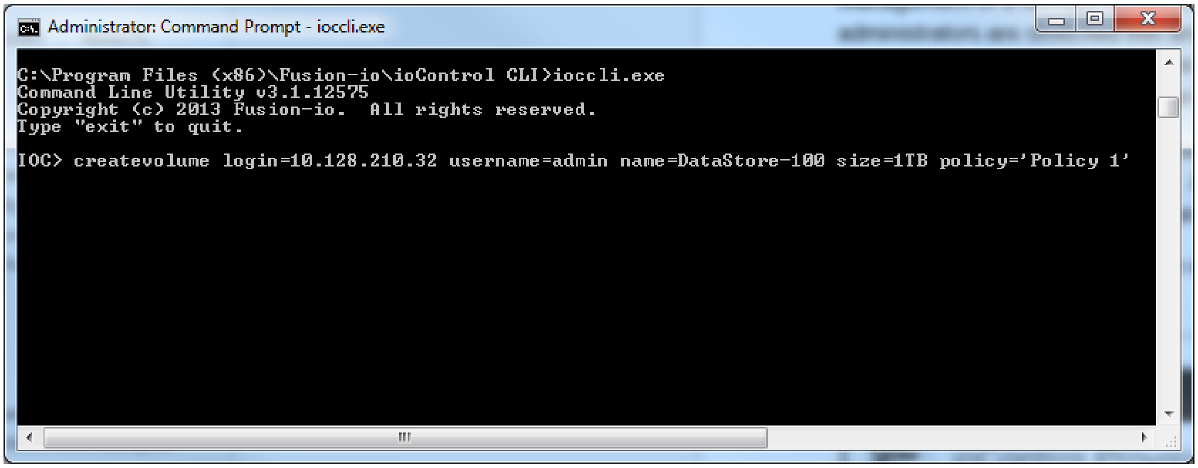

Figure 15: NexGen Command Line Interface.

The vCenter Plug-in allows the administrator to perform common ESX storage tasks from directly within the vSphere management console. Provisioning Datastores, Setting/Modifying QoS policies, Growing Datastores and monitoring storage performance and capacity are all common management tasks performance within the vCenter Plug-in.

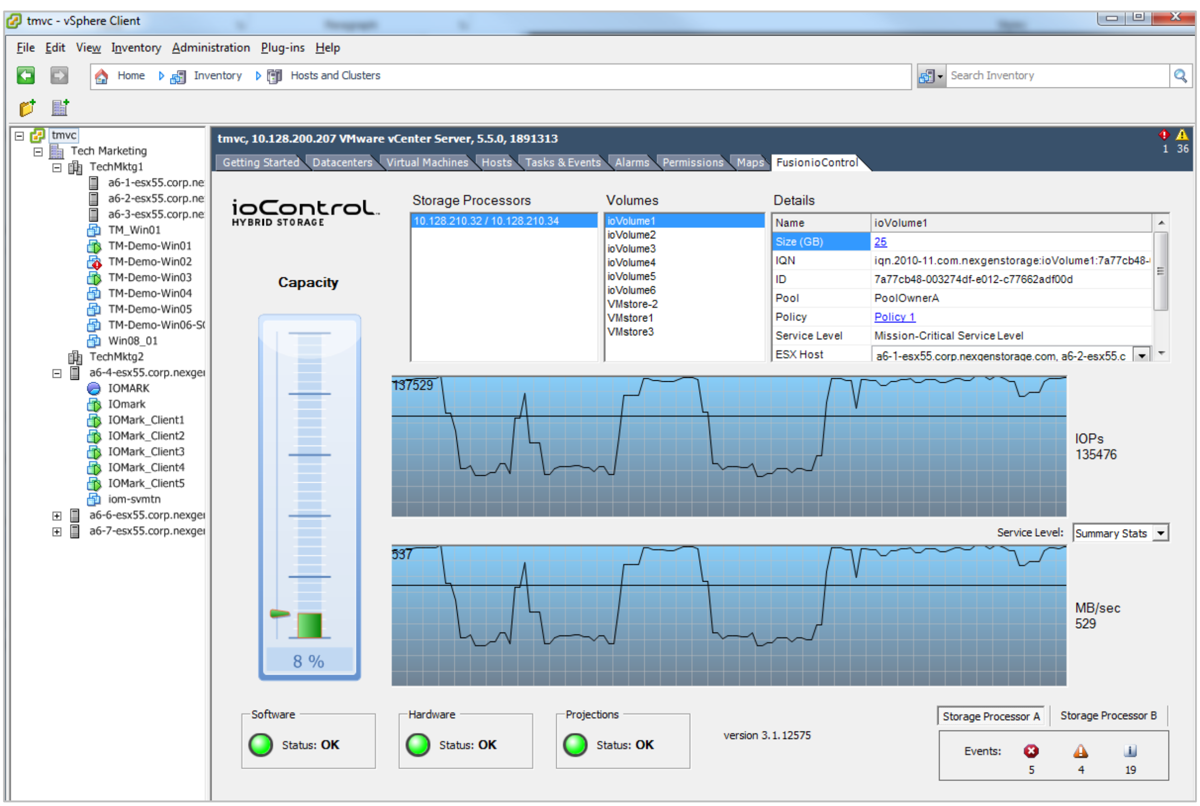

Figure 16: NexGen Storage vCenter Plug-in.

Scalability

For most storage systems available today, the scalability of the system is largely dictated by how many spindles are required for either Performance or Capacity. The answer to the question, “How to scale?” is always to add more disks. The same holds true for both HDDs and SSDs. If you need more Performance = more disks. If you need more Capacity = more disks. Each disk consumes a hard disk drive carrier that consumes footprint in the rack. More Performance = more footprint. More Capacity = more footprint.

At NexGen Storage, we believe that the scaling of Performance or Capacity should be mutually exclusive of each other. If a customer wants to grow Performance, simply add more PCIe flash in the form of a Performance Pack to each Storage Processor. If more Capacity is required, add more disk shelves to the NexGen N5 in the form of a Capacity Pack. Scaling Performance and/or Capacity can be done independent of each other, and can be performed online. Moreover, there is no additional footprint required when adding more PCIe flash, as we are simply adding cards into dedicated PCIe slots in the Storage Processors.

The following diagrams illustrate how the NexGen N5 can scale performance and/or capacity.

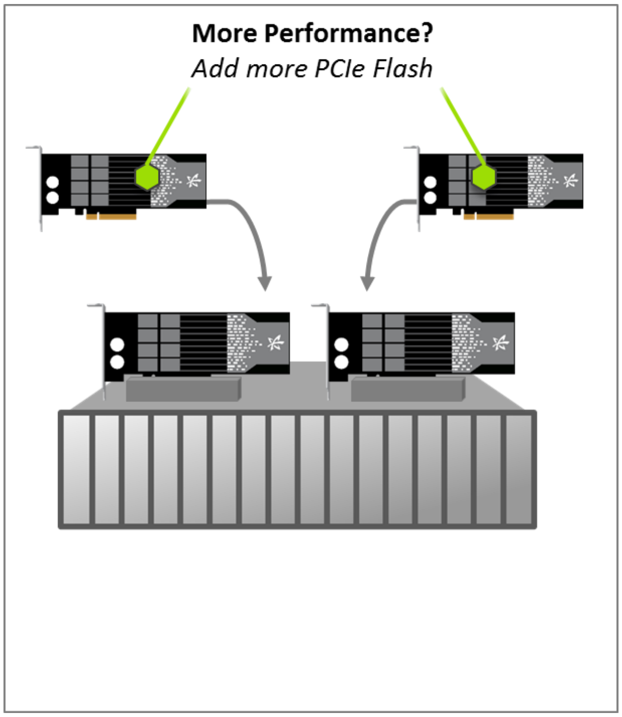

Figure 17: PCIe Flash Scalability

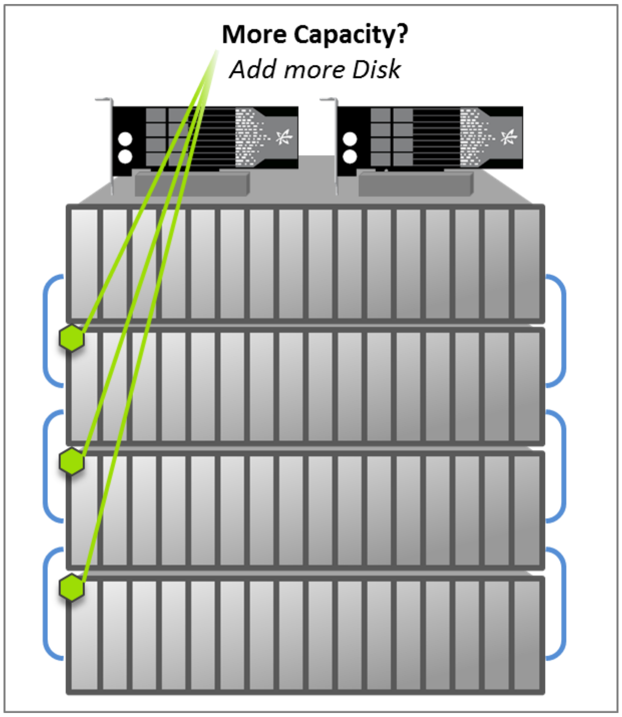

Figure 18: Storage Capacity Scalability

Adding Performance Packs to the system is an **online event**. Installing the Performance Pack involves adding additional PCIe flash cards to each Storage Processor. In order to do this we leverage the Active-Active HA function of the product to take each SP offline independently. For instance, SPA is taking offline to install the PCIe flash card and the system fails over to SPB and continues to service all volumes for IO. The same is done for SPB to install the PCIe flash card.

Adding Capacity Packs to the system is also an **online event**. Installing the Capacity Pack involves connecting additional disk shelves to the NexGen N5 chassis via SAS cables. Once connected, the additional capacity is added to the existing storage pools online with no interruption to volume availability.

The following table summarizes the Performance and Capacity scalability of each NexGen N5 model.

Model	Flash Scalability	Flash Upgrade	Disk Capacity Scalability	Disk Upgrade
N5-200	Base: 2TB Max: 7.2TB	Online (PCIe Flash Add)	Base: 32TB Max: 128TB	Online (Pool Expansion)
N5-300	Base: 2.6TB Max: 7.8TB	Online (PCIe Flash Add)	Base: 64TB Max: 256TB	Online (Pool Expansion)
N5-500	Base: 5.2TB Max: 10.4TB	Online (PCIe Flash Add)	Base: 64TB Max: 256TB	Online (Pool Expansion)
N5-1000	Base: 10.4TB Max: 15.6TB	Online (PCIe Flash Add)	Base: 64TB Max: 256TB	Online (Pool Expansion)

Table 9: Performance and Capacity Scalability options.

Conclusion

The NexGen Storage architecture is designed to help customers achieve their desire to manage data based on business value and priorities of the data. By implementing a storage architecture designed specifically around PCIe flash and storage QoS and Service Levels, NexGen allows customers to instruct the storage system about the value of their data. The NexGen N5 Hybrid Flash Array automatically manages the IO prioritization based on the customer inputs.

The Dynamic Data Path manages the data in real-time making decisions based on QoS performance policies to ensure the data resides in the appropriate location (flash vs. disk), at the appropriate time. The Prioritized Active Cache is populated with the most valuable data based on QoS priorities in order to fulfill the performance targets for the volumes.

The Active-Active PCIe flash architecture is optimized for High Availability and Performance. Simple and flexible management allows a customer to manage the NexGen N5 Hybrid Flash Array easily and with a minimal learning curve. Finally, being able to scale Performance and Capacity independently of each other provides the best value to the customer.