

Introduction to the EMC VNX2 Series

VNX5200, VNX5400, VNX5600, VNX5800, VNX7600, & VNX8000
A Detailed Review

Abstract

This white paper introduces the EMC® VNX™2 series platform. It discusses the different models, new and improved features, and key benefits.

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Executive summary

Power, efficiency, protection, and simplicity are four traits that must characterize an array in today's high demand storage environment. Storage systems are required to provide powerful and efficient storage technologies, keep data protected, and be simple to use and manage.

The VNX multicore initiative, MCx™, is an architecture project that redesigns the core Block OE stack within the new VNX series (VNX2). Developed with many goals, the MCx platform's most significant mission is CPU Scaling. This mission is very simple: take advantage of the many CPU cores that the Intel microarchitecture offers and create a solution for further technological growth.

The VNX2 platform is a union of increased hardware performance and the extensive code changes required to support it. The optimization focuses on ensuring that cache management and back-end RAID management processes take full advantage of multicore CPUs, allowing cache and back-end processing software to scale in a linear fashion. In this way, EMC fully leverages the power of Intel's latest multicore CPUs. The VNX2 series has a scaling factor of 97 percent, so future scaling using additional cores is guaranteed. This not only allows EMC to deliver cost efficient performance, but also to scale while delivering advanced efficiency and protection.

The VNX2 series is designed for a wide range of environments from mid-tier to enterprise. Each VNX2 model is offered in file only, block only, and unified (block and file) implementations. The VNX2 series is still managed through a simple and intuitive user interface called Unisphere®; this single pane of glass completes the unified experience.

This white paper discusses the VNX2 series models (VNX5200™, VNX5400™, VNX5600™, VNX5800™, VNX7600™, and VNX8000™), their hardware and software, limits, I/O modules, and more. This paper also describes the software, serviceability, and availability features of the VNX2 platform, such as MCx, Block Deduplication, FAST™, Data-At-Rest Encryption, Windows 8.1/Server 2012 R2 support, One Button Shutdown, and Unisphere Service Manager.

For details on the VNX5100/VNX5300/VNX5500/VNX5700/VNX7500 models, refer to the white paper titled *Introduction to the EMC VNX Series – VNX5100, VNX5300, VNX5500, VNX5700, & VNX7500: A Detailed Review*, available on EMC Online Support.

Audience

This white paper is intended for IT architects, administrators, and others who are interested in the VNX2 series arrays. It assumes familiarity with storage array concepts, general hardware, and the software services provided by the arrays.

Terminology

Automatic Volume Management (AVM)—Feature of VNX File Operating Environment (OE) that creates and manages volumes automatically without manual volume management by an administrator. AVM organizes volumes into storage pools that can be allocated to file systems.

Converged Network Adapter (CNA)—Host adapter that allows a host to process Fibre Channel and Ethernet traffic through a single type of card and connection, decreasing infrastructure costs over time.

Disk Array Enclosure (DAE)—Shelf in a VNX2 that includes: an enclosure; either 15, 25, 60, or 120 disk modules; two SAS link control cards (LCCs) or InterConnect Modules (ICMs); and two power supplies. It does not contain storage processors (SPs).

Disk Processor Enclosure (DPE)—Shelf in the VNX2 that includes: an enclosure; disk modules; storage processors (SPs); two base modules; two battery backup units (BBUs); two power supplies; up to ten I/O modules; and four fan packs. A DPE supports DAEs in addition to its own disk modules. This 3U form factor is used in the VNX5200TM, VNX5400TM, VNX5600TM, VNX5800TM, and VNX7600TM. It supports a maximum of 125, 250, 500, 750, and 1,000 drives, respectively.

Base Module—Part of the VNX2 DPE, a single base module contains two Serial-attached SCSI (SAS) back-end ports, one power supply, and one battery backup unit (BBU).

Fibre Channel (FC)—Gigabit-speed data transfer interface technology. Data can be transmitted and received simultaneously. Common transport protocols, such as Internet Protocol (IP) and Small Computer Systems Interface (SCSI), run over Fibre Channel. Consequently, a single connectivity technology can support high-speed I/O and networking.

Fibre Channel over Ethernet (FCoE)—Allows Fibre Channel frames to be encapsulated via Ethernet. With Converged Network Adapter cards, a host may use one type of adapter and cable for Ethernet and Fibre Channel traffic.

Flash drive—Flash drives provide extremely high performance and consume very little power. These drives enable a VNX2 to provide an *Extreme Performance* level of storage for critical workloads. Flash drives can also extend the array's cache using FAST Cache technology. The VNX2 series supports both FAST Cache Optimized drives and FAST VP optimized drives.

Fully Automated Storage Tiering for Virtual Pools (FAST VP)—Advanced data service that relocates data of pool-based LUNs at a sub-LUN level to optimal locations within a storage pool.

Logical Unit Number (LUN)—Identifying number of a SCSI or iSCSI object that processes SCSI commands. The LUN is the last part of the SCSI address for a SCSI object. The LUN is an ID for the logical unit, but the term often refers to the logical unit itself.

MCx—Multicore initiative (Multicore Cache, Multicore FAST Cache, Multicore RAID) and re-architecture project that redesigns the Block OE stack within the VNX2 series. MCx

delivers core functionality improvements making the VNX Block OE more robust, reliable, predictable, and easier to use than ever before.

Multicore Cache—VNX array cache (sometimes referred to as DRAM Cache) is an MCx software component that increases host write and read performance by using the VNX2 Storage Processor's DRAM.

Multicore FAST Cache—Large capacity secondary cache that uses enterprise Flash drives.

Multicore RAID—MCx component that defines, manages, creates, and maintains VNX2 RAID protection.

Near-Line Serial Attached SCSI (NL-SAS) drives—Enterprise SATA drives with a SAS interface head, media, and rotational speed of Enterprise SATA drives with a fully capable SAS interface. These drives provide similar performance and capacity to SATA drives, utilizing a SAS interface for I/O.

Serial-attached SCSI (SAS)—Communication protocol used to move data to and from computer storage devices. SAS is a point-to-point serial protocol that replaces parallel SCSI bus technology. Expanders facilitate the connection of multiple SAS end devices to a single initiator port.

I/O Module—A hardware component that provides front-end and back-end connectivity between the storage processors disk-array enclosures, and hosts.

Storage Processor Enclosure (SPE)—Shelf in the VNX2 that includes: an enclosure; storage processors (SPs); up to twenty-two I/O modules; four power supplies; and ten fan assemblies. This 4U form factor is used for the high-end VNX8000™ and supports a maximum of 1,500 drives.

Storage Pool—Single repository of homogeneous or heterogeneous physical disks from which LUNs may be created. This concept enables ease of use and technologies such as FAST VP.

VNX family overview

The VNX family includes the *VNXe*[®], *VNX*, and *VNX2* series arrays. The VNXe series is designed for small-to-midsize storage environments, while the VNX series is designed for midtier-to-enterprise storage environments.

The VNX2 series is EMC's next generation of midrange-to-enterprise products. The VNX2 series utilizes EMC's VNX Operating Environment for Block & File that you can manage with Unisphere, a simple, easy to use management framework. This VNX2 software environment offers significant advancements in efficiency, simplicity, and performance.

The VNX2 series includes six models that are available in block, file, and unified configurations:

- VNX5200
- VNX5400
- VNX5600
- VNX5800
- VNX7600
- VNX8000

There are two existing Gateway models:

- VNX VG2
- VNX VG8

There are two VMAX[®] Gateway models:

- VNX VG10
- VNX VG50

The VNX2 series offers:

- State-of-the-art hardware:
 - PCI-E Gen 3 I/O modules
 - 6 Gb/s x 4 lanes SAS back-end infrastructure
 - Up to x 8 wide (6 Gb/s x 8 lanes) high-bandwidth connection to 60 drive DAE with new 6 Gb SAS I/O module
 - Increased memory and core optimization with MCx
 - Intel's latest Xeon E5 multicore processors
 - Expanded UltraFlex I/O, delivered with denser packaging
 - NEBS (Network Equipment-Building System) certified DC-powered arrays (VNX5200, VNX5400, & VNX5600)

- Block functionality that supports the FC, iSCSI, and FCoE protocols
- File functionality that supports the NFS, CIFS, and pNFS protocols
- Support for up to 1,500 drives
- Ultra-dense 120-drive DAE
- Automated tiering with Fully Automated Storage Tiering for Virtual Pools (FAST VP) for block and file data
- Controller based, drive level, Data-At-Rest Encryption
- Updated unified management with Unisphere delivers a cohesive, unified user experience

VNX hardware components

VNX2 storage systems include these hardware components:

- **Storage Processors (SPs)** support block data with UltraFlex I/O technology that supports Fibre Channel, iSCSI, and FCoE protocols. The SPs provide access for all external hosts and the file components of the VNX array.
- The **Storage Processor Enclosure (SPE)** is 4U in size and houses dual storage processors. This form factor is used for the high-end VNX8000™ model. It does not contain any onboard drive slots and requires the use of DAEs, supporting a maximum of 1,500 drives.
- The **Disk Processor Enclosure (DPE)** is 3U in size and houses dual storage processors and the first tray of disks. Mid-to-high-end VNX2 models (VNX5200, VNX5400, VNX5600, VNX5800, and VNX7600) use this form factor. It contains 25 x 2.5" onboard drive slots and supports a maximum of 125, 250, 500, 750, and 1000 drives, respectively.
- **Blade** (or *Data Mover*) accesses data from the back end and provides host access using the same UltraFlex I/O technology that supports the NFS, CIFS, and pNFS protocols. The blades in each array are scalable and provide redundancy.
- The **Data Mover Enclosure (DME)** is 2U in size and houses the Data Movers (Blades). All file and unified VNX models use at least one DME.
- **Li-Ion Standby Power Supplies (SPSs)** are 2U in size and used only in the VNX8000. There are two SPSs in a VNX8000 array. Each SPS has two batteries. One SPS provides backup power to the SPE, and the second to the first DAE. These SPSs provide enough power to each storage processor and first DAE to ensure that any data in flight is de-staged to the vault area in the event of a power failure, guaranteeing no writes are lost. When the array is restarted, the pending writes are reconciled and persisted.
- **Battery Backup Units (BBUs)** are used in the VNX5200, VNX5400, VNX5600, VNX5800, and VNX7600. There are a total of two BBUs per array (one per SP) and they

are installed in the base module of each SP. BBUs provide enough power to ensure that any data in flight is de-staged to the vault area in the event of a power failure.

- **Control Stations** are 1U in size and provide management functions to the file blades. The Control Station is responsible for controlling blade failover. The Control Station may optionally be configured with a matching secondary Control Station to ensure redundancy on the VNX2 array.
- **Disk Array Enclosures (DAE)** house the drives used in the array. They enable the expansion of each array's drive count to provide the storage needed for expanding needs over time of each implementation. The 15-drive DAE is 3U in size, the 25-drive is 2U in size, the 60-drive DAE is 4U in size, and the 120-drive DAE is 3U in size.
- The SPE/DPE and DME use **dual power supplies** that are integrated into the chassis, and provide back-up electricity if a single power supply fails.
- For NAS services (i.e., Data Mover Blade I/O options):
 - 4-port 1 GbaseT Ethernet copper module
 - 2-port 10 Gb Ethernet optical/twin-ax module
 - 2-port 10 GBaseT Ethernet copper module
- For Block Services to host (i.e., Storage Processor I/O options):
 - 4-port 8 Gb optical Fibre Channel UltraFlex I/O module
 - 4-port 1 GBaseT Ethernet iSCSI/TOE module
 - 2-port 10 Gb Ethernet optical/twin-ax iSCSI/TOE module
 - 2-port 10 GBaseT Ethernet copper iSCSI/TOE module
 - 2-port FCoE optical/twin-ax module

Configurations

The hardware components of a VNX2 depend on the overall configuration and options ordered. The three basic configurations are:

- Block—Supports block data
- File—Supports file data
- Unified—Supports block and file data

Block configuration – supports block data (shown in [Figure 1](#))

This configuration supports the FC, iSCSI, and FCoE protocols and consists of:

- 3U DPE (disk-processor enclosure) for VNX5200, VNX5400, VNX5600, VNX5800, and VNX7600, or 4U SPE (storage-processor enclosure) for VNX8000 + at least one DAE for Vault Drives.
- [optional] 2U 25-drive DAE, or 3U 15-drive DAE, or 4U 60-drive DAE (in deep rack), or 3U 120-drive DAE (in deep rack) up to the system maximum

- Dual 2U Li-Ion SPSs for VNX8000

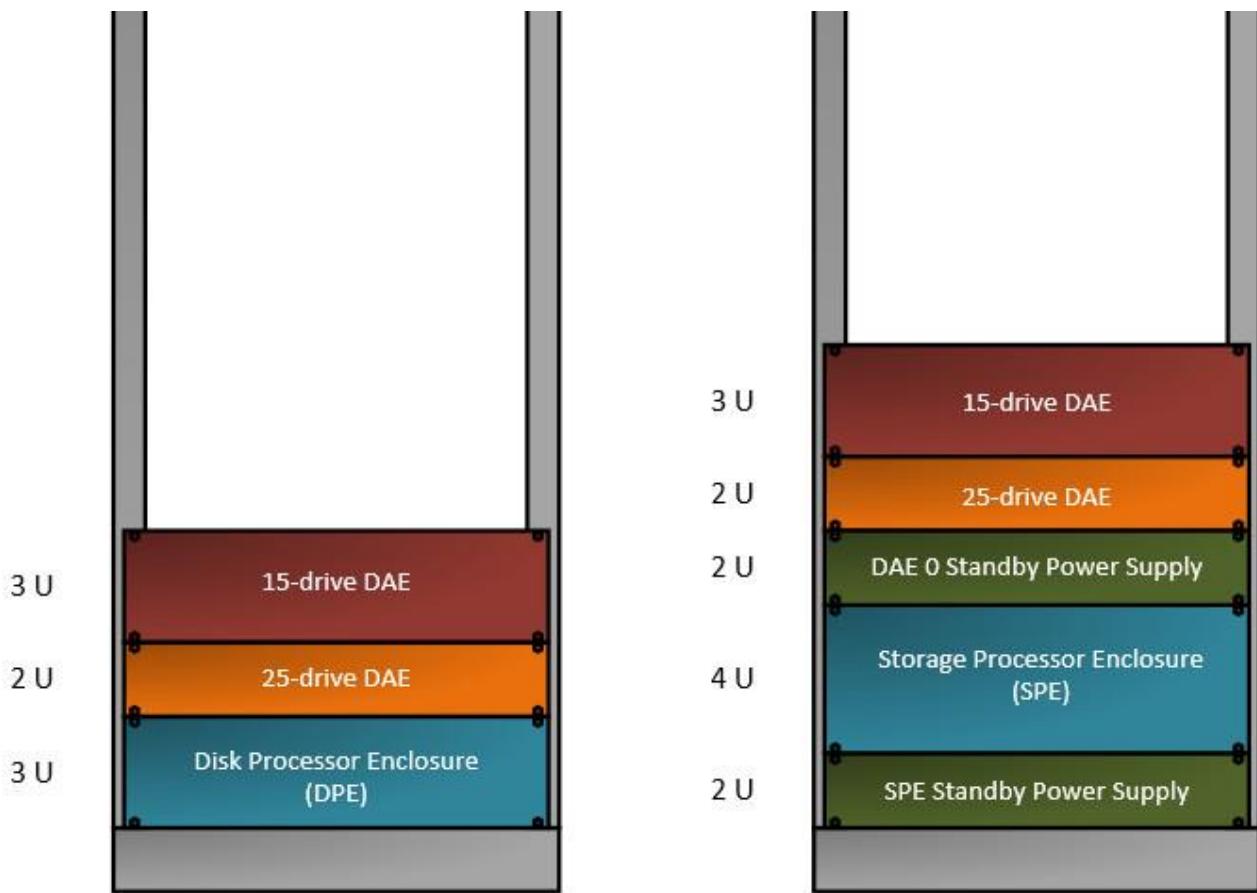


Figure 1: Block configurations for VNX5600 (left) and VNX8000 (right)

File configuration – supports file data (shown in [Figure 2](#))

This configuration supports the NFS, CIFS, and pNFS protocols and consists of:

- 3U DPE (disk-processor enclosure) for VNX5200, VNX5400, VNX5600, VNX5800, and VNX7600 *or* 4U SPE (storage-processor enclosure) for VNX8000 + at least one DAE for Vault Drives
- [optional] 2U 25-drive DAE (disk-array enclosure), or 3U 15-drive DAE, or 4U 60-drive DAE (in deep rack), or 3U 120-drive DAE (in deep rack) up to the system maximum
- At least one 2U Blade (or Data Mover) enclosure
- One *or* two 1U Control Stations
- Dual 2U Li-Ion SPSs for VNX8000

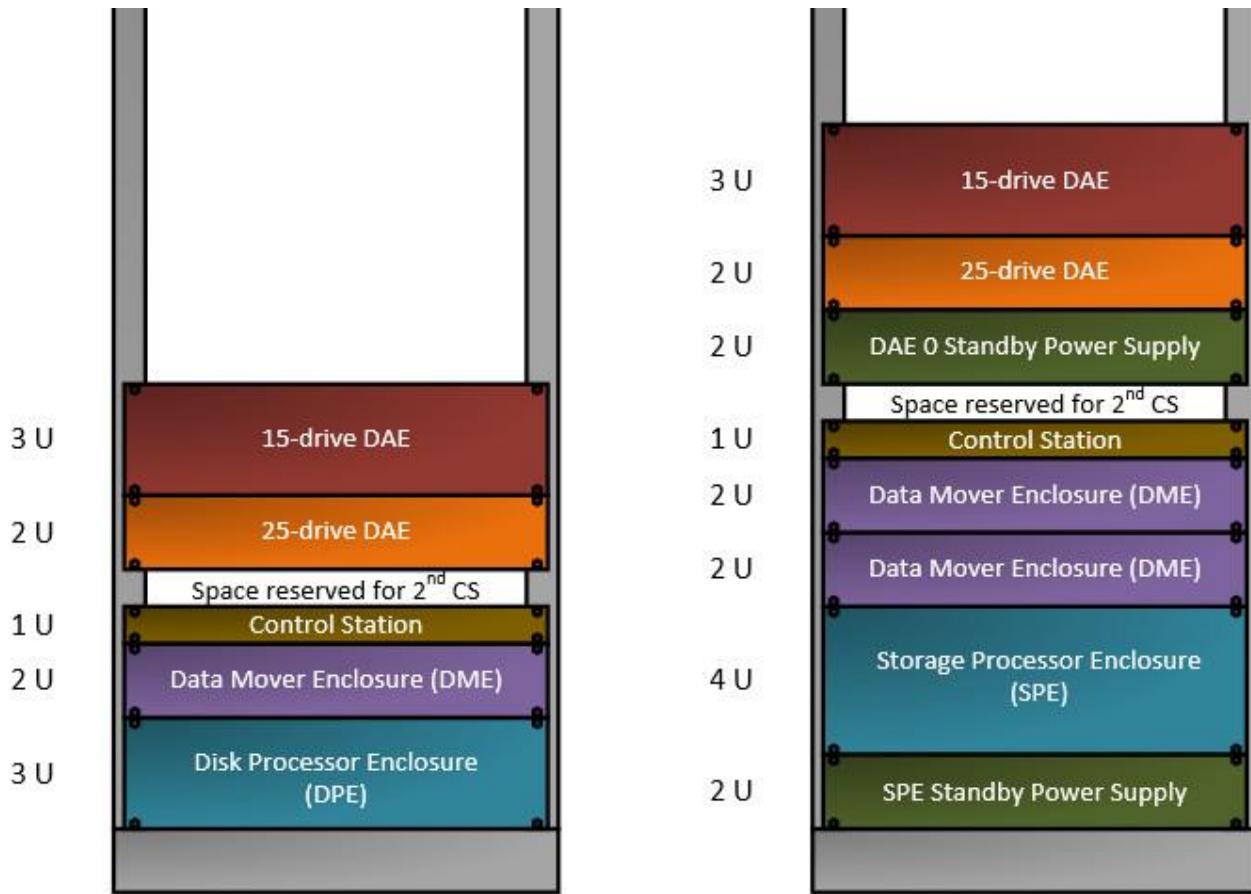


Figure 2. File configurations for VNX5600 (left) and VNX8000 (right)

Unified configuration – supports file and block data (shown in [Figure 3](#))

The unified configuration supports the FC, iSCSI, and FCoE protocols for block data and the NFS, CIFS, and pNFS protocols for file data. A unified configuration has the same components as a file configuration.

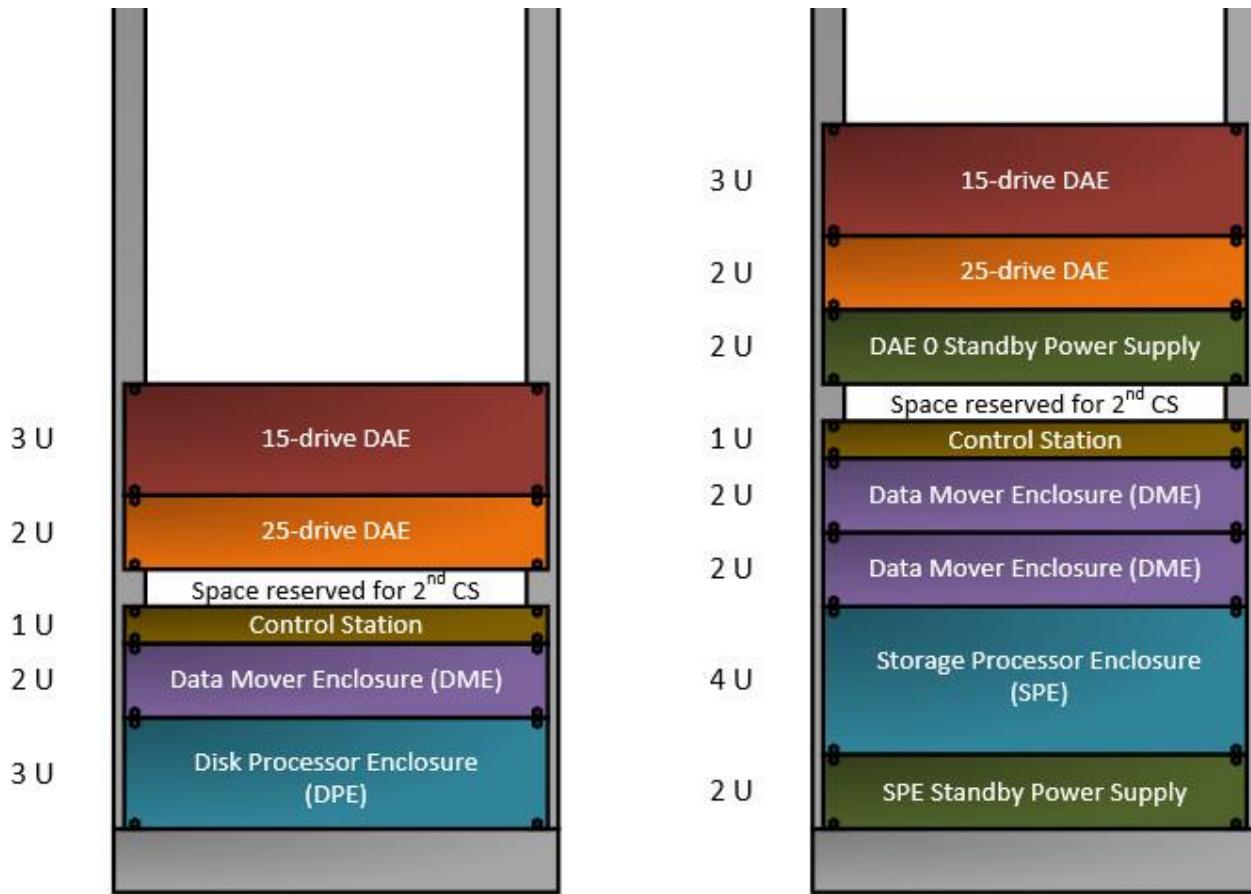


Figure 3. Unified configurations for VNX5600 (left) and VNX8000 (right)

Components and features in the VNX2

The VNX2 series arrays are comprised of advanced components that have these features:

- Intel Xeon E5 processor makes the VNX2 faster and greener
- Dual Li-Ion SPSs with removable battery backs and upgradeable firmware on VNX8000
- Dual BBUs located inside of the DPE of VNX7600, VNX5800, VNX5600, VNX5400, and VNX5200
 - BBUs replace traditional SPSs and support firmware upgrades
- New Control Station with faster CPU and increased memory
- High- capacity and small form factor drives
 - New FAST VP optimized drives
- Increased density from new DAEs, DPEs, and drives
- 6 Gb/s x 4 lanes SAS back-end improves performance and availability
 - x 8 SAS back-end connection introduced with back-end SAS I/O module and both the 60-drive and 120-drive DAEs
- Expanded UltraFlex I/O using PCI-E Gen 3 increases bandwidth

Xeon E5 processor

The VNX2 series uses Intel's Xeon E5 processor. This new 32 nm processor architecture provides multicore capability that translates into significant scalability for all VNX2 models. The processor speeds range from 1.80 GHz to 2.7 GHz and have four to eight cores per socket. As a result, these processors pack more processing power in a smaller footprint, consume less power, and keep systems cooler.

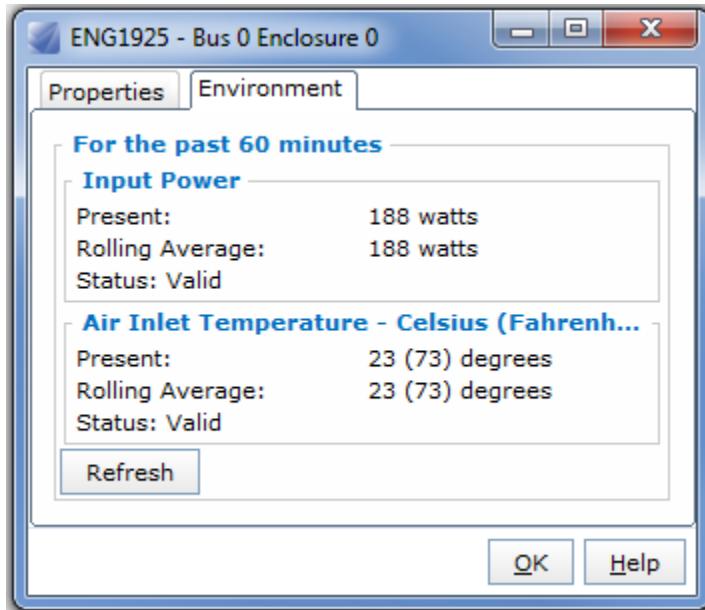
Li-Ion SPS, BBUs, and power

The VNX8000 utilizes Li-Ion SPSs with removable battery trays, and all other models utilize new BBUs.

Power supplies provide the information necessary for Unisphere to monitor and display the ambient temperature and power consumption. The power supplies:

- Use a lead-free construction
- Meet the EPA Gold Standard for efficiency targets (90 percent)
- Provide adaptive cooling, in which an array adjusts the power supply fan speeds to spin only as fast as needed to ensure sufficient cooling. This optimizes blower speeds and energy consumption. The power supplies have an onboard sensor that provides energy information reporting. The reports include input power and air inlet temperature for each enclosure on the array, as well as input power reporting at an

overall array level. The values are based on a rolling average for each hour that is reported in the Unisphere GUI, as shown in [Figure 4](#).



[Figure 4. Energy information provided in the Unisphere Environment tab](#)

High-capacity and small form factor drives

The VNX2 series supports high-capacity 4 TB drives, along with small form factor 2.5" Flash, SAS, and NL-SAS drives.

New Control Station

The VNX2 series introduces a new Control Station that offers improved administration performance (due to a quad-core Intel Xeon Processor) and increased memory.

DAEs, DPEs, and drives provide increased density

The VNX2 series uses updated components and new drive options that make it significantly denser than earlier models:

- **25-drive DAEs and DPEs paired with 2.5" SAS drives**—Increased performance and spindle density are provided by 25-drive DAEs and DPEs paired with 2.5" SAS drives, available in both 10K and 15K rpm speeds.
- **15-drive DAEs paired with 3.5" 4 TB 7.2K rpm NL-SAS drives**—In terms of drive capacity, maximum density is achieved by using 15-drive DAEs paired with 3.5" 4 TB 7.2K rpm NL-SAS drives. This combination allows more spindles and storage capacity per square foot than in any other previous array using the 15-drive enclosures.
- **60-drive high-capacity DAE paired with 3.5" 7.2 K rpm NL-SAS drives and 2.5" 15 K rpm drives using a 3.5"-carrier**—This dense enclosure utilizes a top load design, using 4U of rack space, providing the VNX2 with 15 drives per U. In terms of drive capacity,

maximum density is achieved by using 3.5" 4TB 7.2K rpm NL-SAS drives. Increased performance may be achieved by using 2.5" and 3.5" Flash and 10-15 K rpm drives with the use of a 3.5"-carrier. The 60-drive DAE requires a deep rack for housing.

- **120-drive high capacity DAE paired with 2.5" SAS and Flash drives**—This ultra-dense enclosure utilizes a top load design, using only 3U of rack space, providing the VNX2 with 40 drives per U. Performance and spindle density are achieved by 120-drive DAEs paired with 2.5" SAS drives, available in both 10K and 15K rpm speeds, as well as 2.5" Flash drives. The 120-drive DAE requires a deep rack for housing.

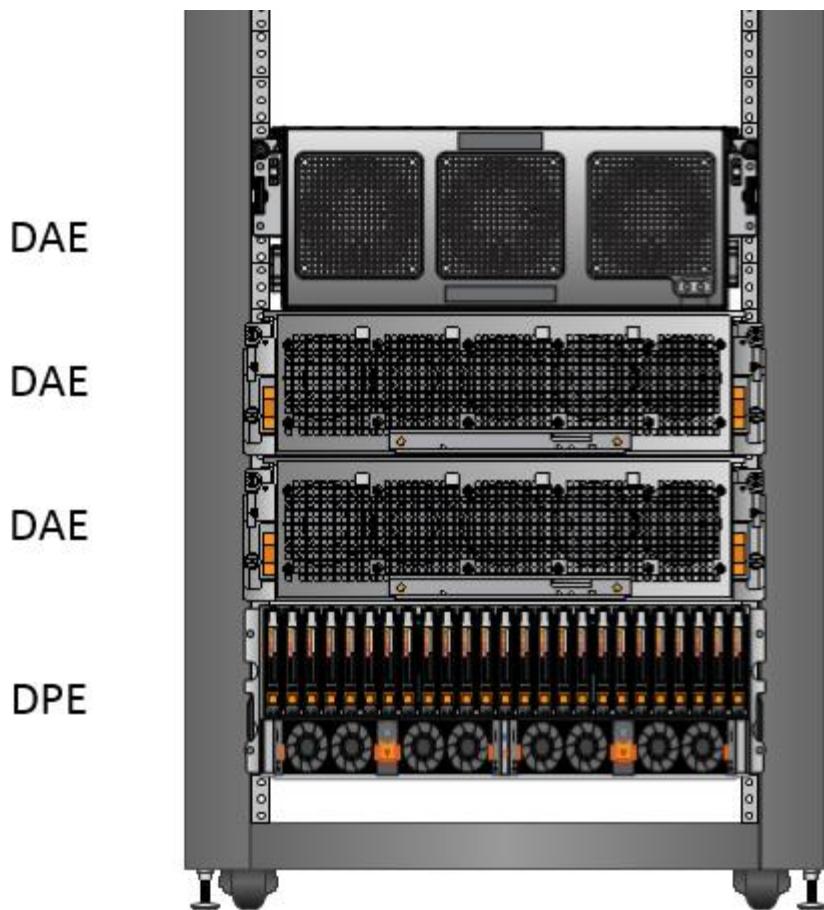


Figure 5. Block dense configuration example

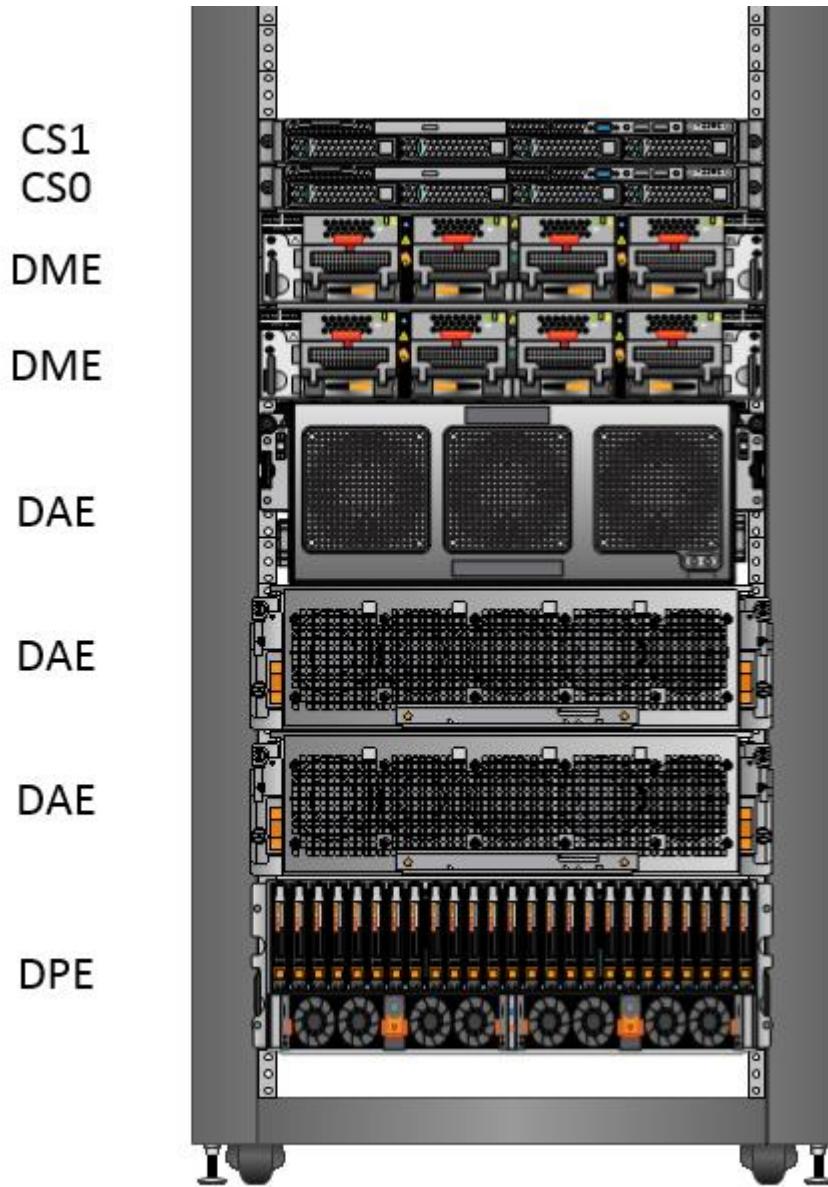
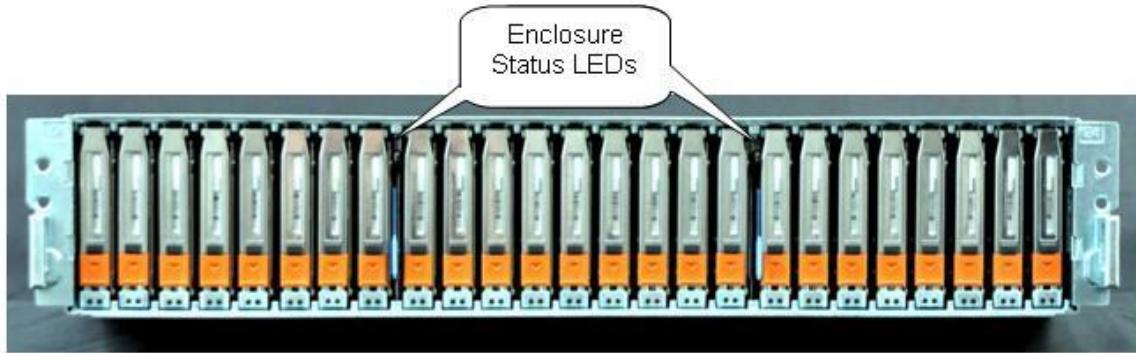


Figure 6. Unified dense configuration example

The 25-drive 2.5" DAE and DPE supports 2.5" SAS, 2.5" NL-SAS, and 2.5" Flash drives

The 25-drive DAE and DPE can be populated with any combination of 2.5" Flash, SAS, and NL-SAS drives. These options enable you to configure your system for optimal efficiency and performance. Unisphere identifies this DAE as "DAE5S".

[Figure 7](#) and [Figure 8](#) show the front and back of the 25-drive DAE that is housing 2.5" SAS drives.



[Figure 7. Front of the 25-drive DAE housing 2.5" drives](#)



[Figure 8. Back of the 25-drive DAE housing 2.5" drives](#)

[Figure 9](#) shows the back of the 25-drive DAE. In this figure, you can see the primary/extension SAS ports; SPS ports; and the LEDs for power, fault, SAS lane status, bus number, and enclosure number.

These 25-drive DAEs are compatible across the entire VNX series, as the DAEs use SAS as the back-end bus architecture. VNX series arrays do not accept previous-generation (CX series) DAEs.

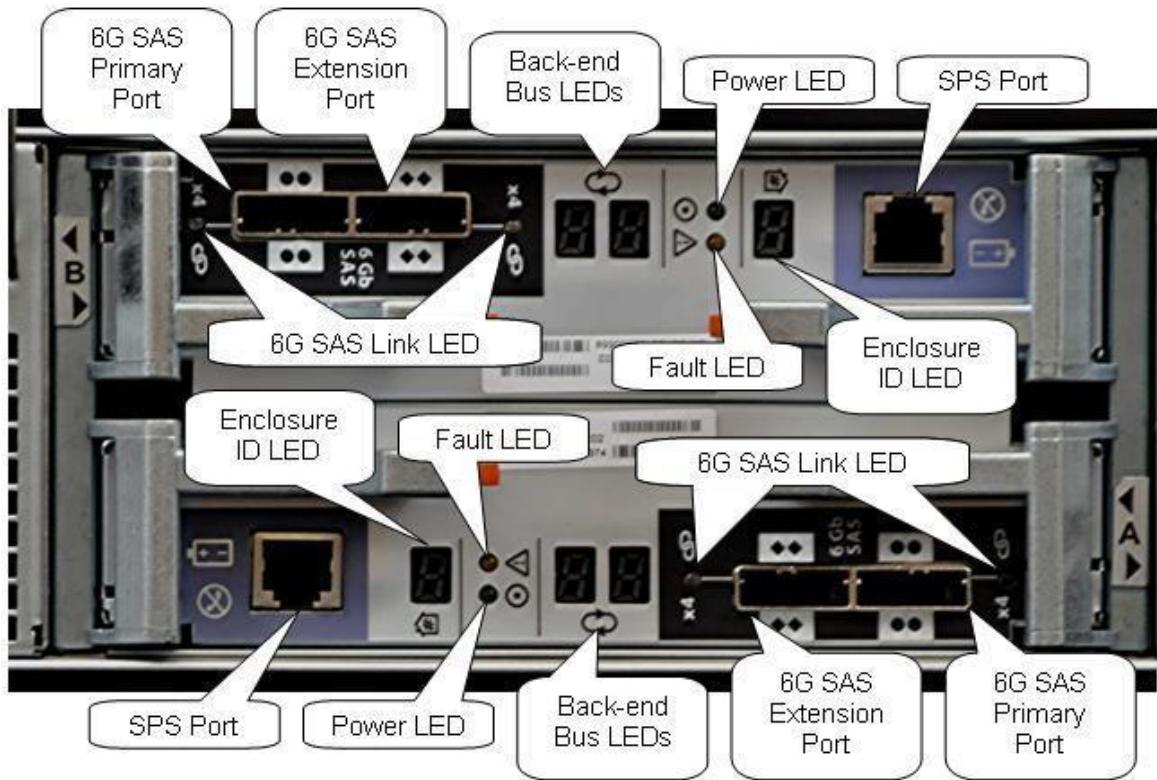


Figure 9. Close-up of the back of the 25-drive DAE

The 15-drive DAE supports 2.5" SAS, 3.5" NL-SAS, and 3.5" Flash drives

The 15-drive DAE, shown in [Figure 10](#) and [Figure 11](#), can be populated with 2.5" drives in 3.5" carriers. The 15-drive DAE may also be populated with any combination of 3.5" Flash, SAS, and NL-SAS drives. Unisphere identifies this DAE as "DAE6S".

These options enable you to configure your system for optimal efficiency and performance. The Flash drives provide extreme performance, the mid-tier SAS drives provide a good balance of price and performance (reaching speeds of up to 15k rpm), and the cost-effective NL-SAS drives have a capacity of up to 4 TB.

These 15-drive DAEs are compatible across the entire VNX series, as the DAEs use SAS as the back-end bus architecture. VNX series arrays do not accept previous-generation (CX series) DAEs.



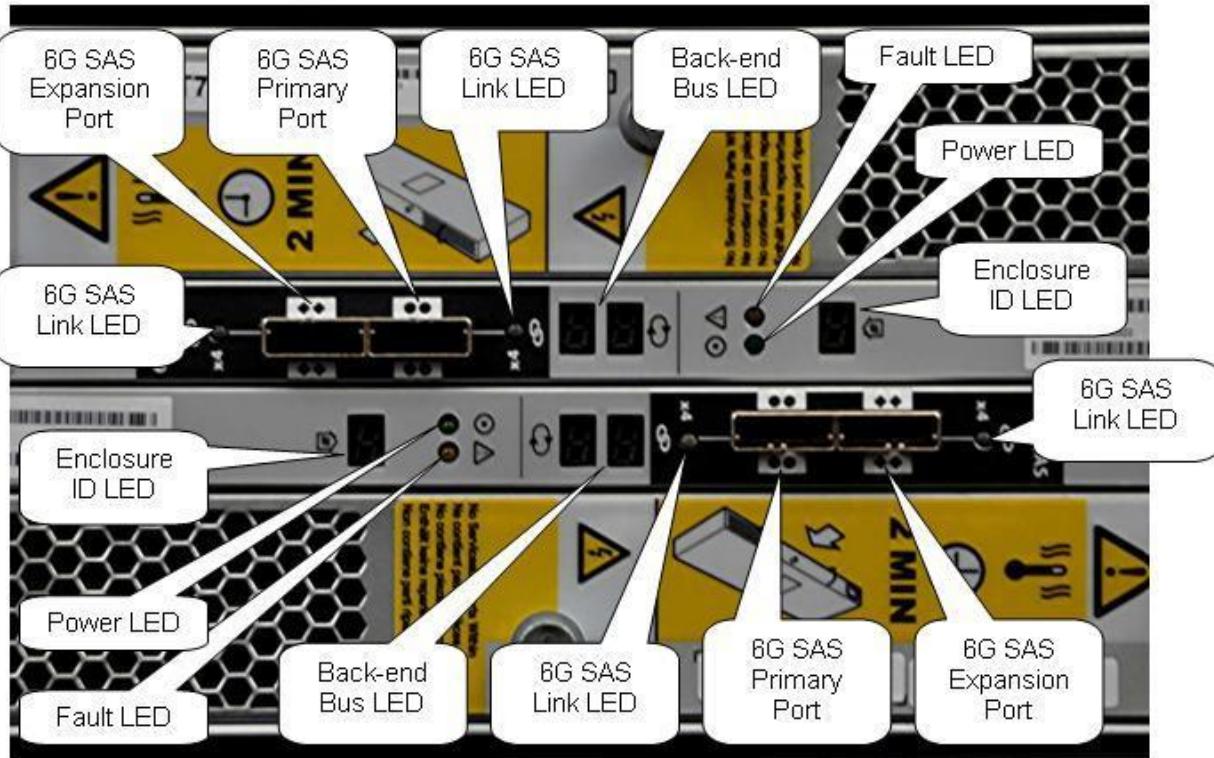
Figure 10. Front of the 15-drive DAE



Figure 11. Back of the 15-drive DAE

As Figure 11 shows, there is no bus-reset button on the back of the DAE; it is unnecessary because VNX uses SAS technology for the back-end.

[Figure 12](#) shows the back of the 15-drive DAE. In this figure, you can see the primary/expansion SAS ports; and the LEDs for power, fault, SAS lane status, bus number, and enclosure number.



[Figure 12. A close-up of the back of a 15-drive DAE](#)

The 60-drive high-capacity DAE supports 2.5" SAS, 3.5" NL-SAS, and 3.5" Flash drives

The 60-drive DAE can be populated with 2.5" SAS drives using a 3.5" carrier. The 60-drive DAE holds up to 60 rotating or SSD-type drives in 3.5" (SSD, 7.2K rpm and 10K rpm) and 2.5" (SSD, 10K rpm, 15K rpm) form factors. For the 3.5" drive types, 15K rpm drives are not supported in this enclosure. Unisphere identifies this DAE as "DAE7S".

These options allow you to configure your system for optimal efficiency and performance. The Flash drives provide extreme performance in SFF (small form factor), 2.5" and LFF (large form factor), 3.5" sizes. The mid-tier SAS drives provide a balance of price and performance (reaching speeds of up to 15K rpm), and the cost-effective NL-SAS drives have a capacity of up to 4 TB.

The enclosure employs a slide-out drawer with access to the drives from the top. The drive matrix consists of 5 rows (banks A-E) of 12 disks (slots 0-11). These disks are addressed and notated using a combination of letters and numbers, such as A1 and B4, to uniquely identify a single drive in the enclosure. The enclosure is labeled clearly to ensure proper drive identification.

The dimensions of the 60-drive high-capacity enclosure are 7" (height) (4U) x 35" (depth, chassis only) with a maximum weight of 225 pounds. Because the design of this enclosure provides more density per square foot of rack space than many other

enclosures, a special dimensionally enhanced rack (44" deep) is required for this enclosure. The deep rack provides three power zones (A, B, and C), each with its own power drops to power each zone. The two power supplies are FRUs. These power supplies can be removed without detaching the bus cable by using the cable management arm (CMA), which quickly disconnects.

The 60-drive DAE contains four hot-swappable LCCs:

- Two ICM LCCs are located at the rear of the enclosure. They house the SAS ports and provide connectivity to the storage processors.
- Two internal LCCs are centrally located and provide connectivity to all of the disks in the enclosure.

All LCCs on this enclosure are field replaceable units (FRUs). There are also three cooling modules located on the front of the enclosure that are FRUs.

[Figure 13](#) shows the front of the 60-drive DAE.



[Figure 13](#). Front of the 60-drive DAE

Figure 14 shows the top of the 60-drive DAE extended with the top panel open, which reveals the drives and cooling modules.

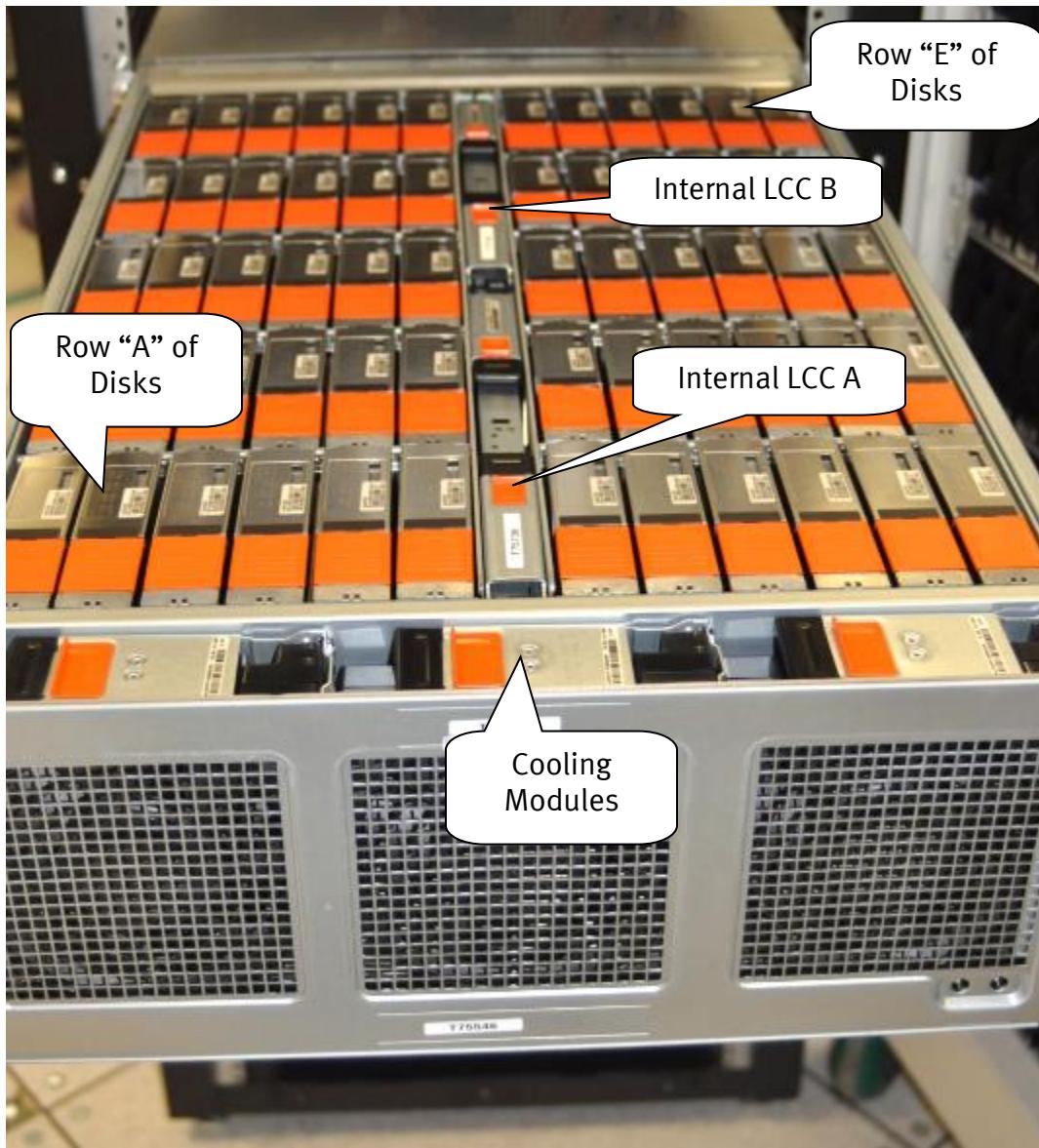
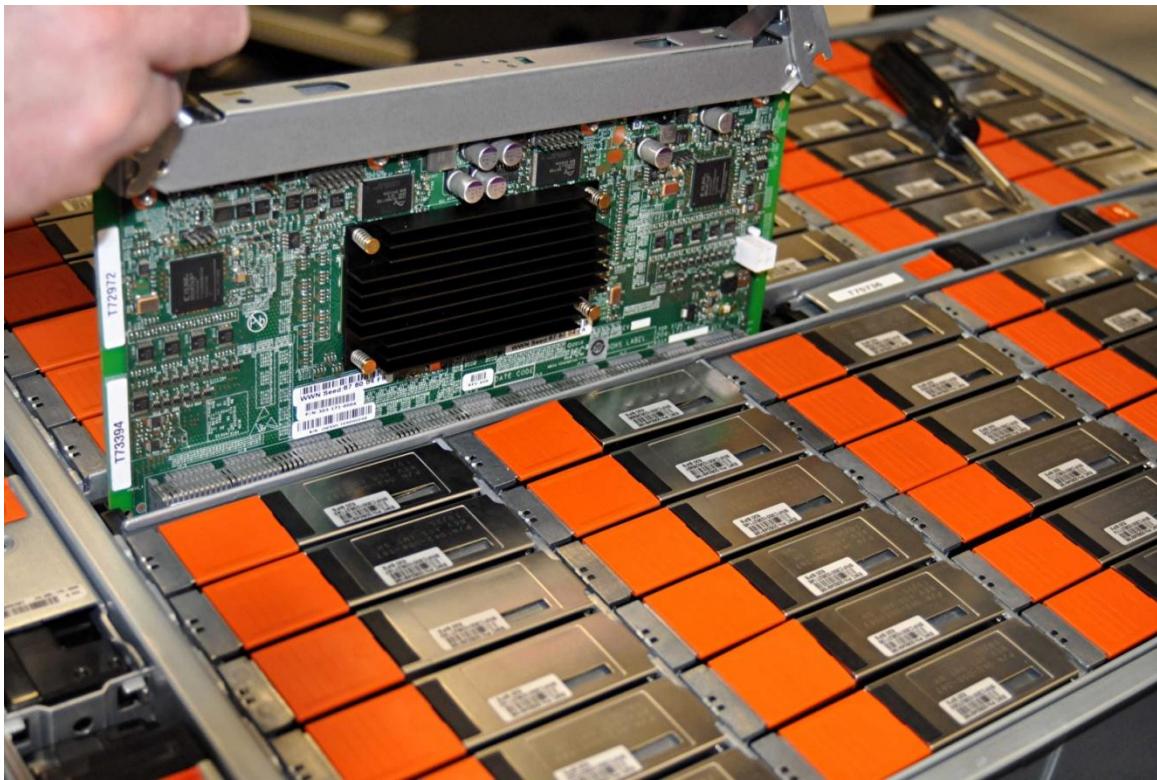


Figure 14. Top of the 60-drive DAE

[Figure 15](#) shows the internal LCC cards that are located in the middle of the 60-drive DAE from the top of the DAE.



[Figure 15. The internal LCC cards](#)

Figure 16 shows one of the three cooling modules removed from the 60-drive DAE.

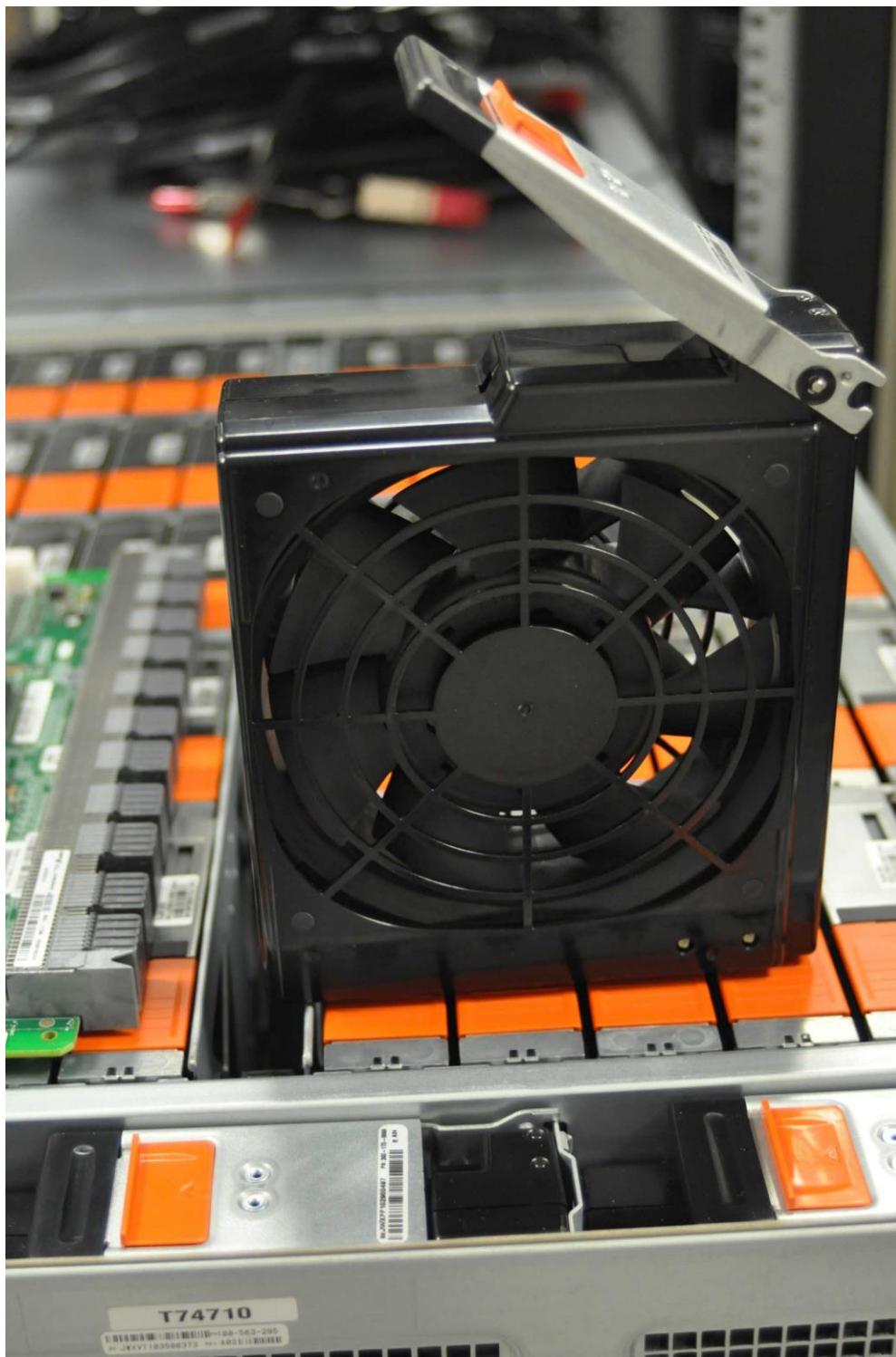


Figure 16. Cooling module in the 60-drive DAE

Figure 17 shows the cable management arms at the rear of the 60-drive DAE.

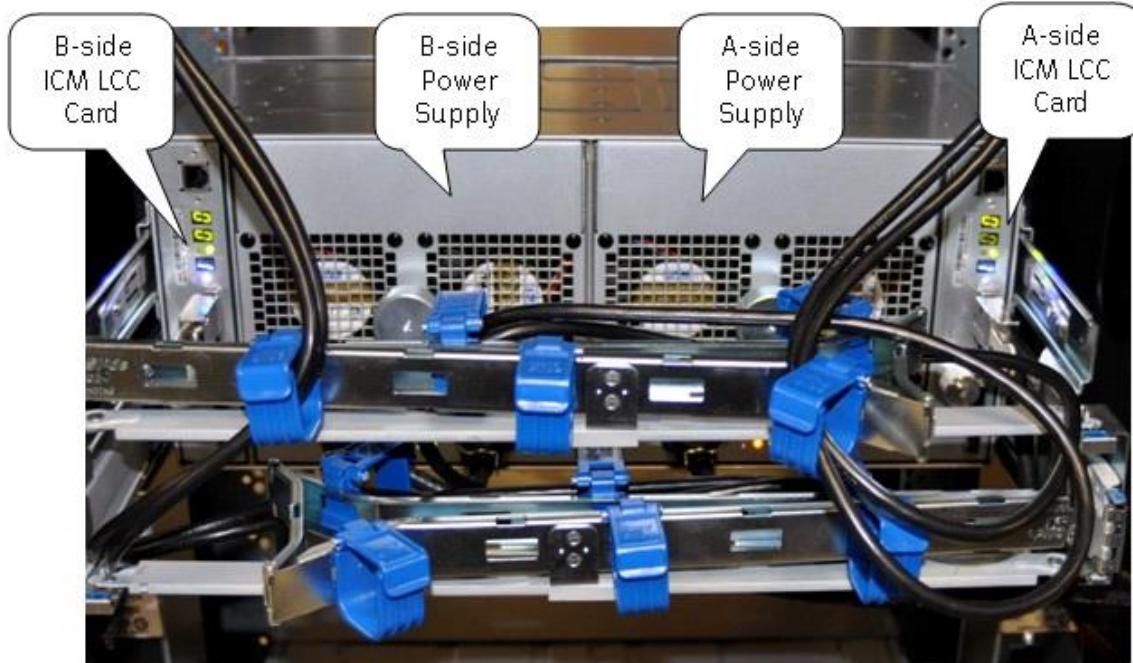


Figure 17. Cable management arms in the rear of the 60-drive DAE

Figure 18 shows a power supply at the rear of the 60-drive DAE, the ICM LCC (containing the bus and enclosure LEDs), and SAS expander ports.

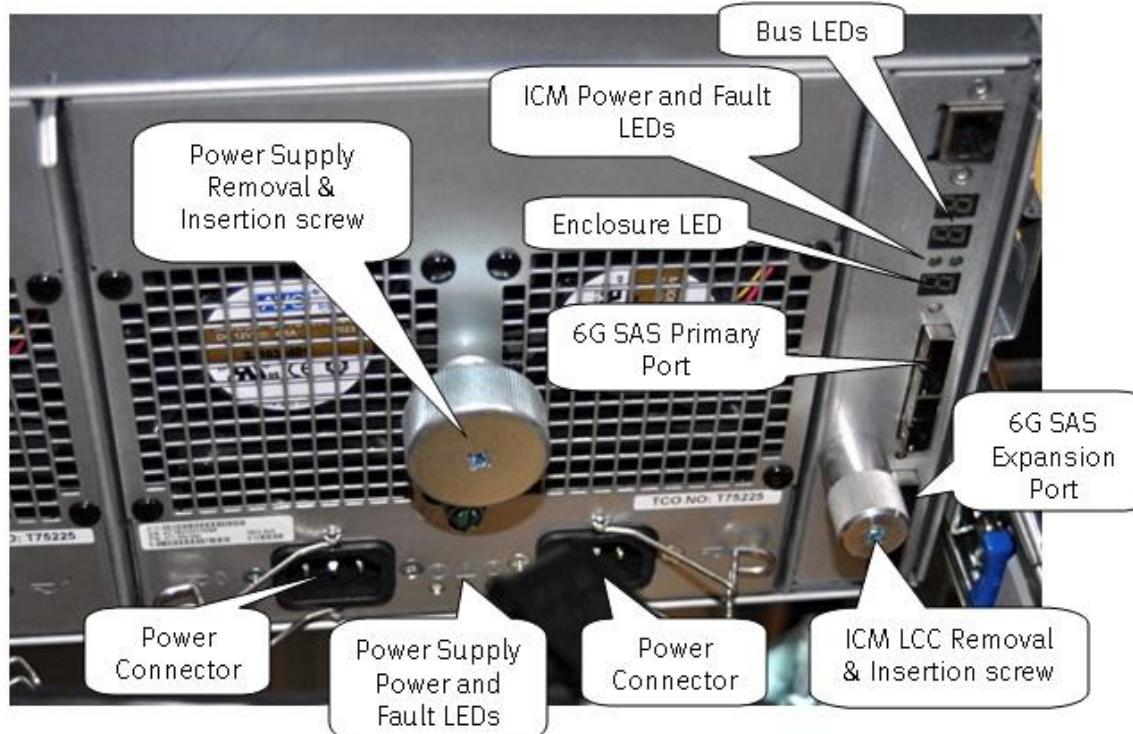


Figure 18. Power supply, ICM LCC, and SAS expander ports

The 120-drive high-capacity 2.5" DAE

The 120-drive DAE can be populated with 2.5" SAS and Flash drives. The 120-drive DAE holds up to 120 rotating or SSD-type drives in 2.5" (SSD, 10K rpm and 15K rpm) form factors. Unisphere identifies this DAE as "DAE8S".

These options allow you to configure your system for optimal efficiency and performance. The Flash drives provide extreme performance in Small Form Factor (SFF), 2.5" sizes. The mid-tier SAS drives provide a balance of price and performance (reaching speeds of up to 15K rpm), with capacity up to 1.2 TB.

The enclosure employs a slide-out drawer with access to the drives from the top. The drive matrix consists of 6 rows (banks A-F) of 20 disks (slots 0-19). These disks are addressed and notated using a combination of letters and numbers, such as A1 and B4, to uniquely identify a single drive in the enclosure. The enclosure is labeled clearly to ensure proper drive identification.

The dimensions of the 120-drive high-capacity enclosure are 5.25" (height) (3U) x 35" (depth, chassis only) with a maximum weight of 165 pounds. Because the design of this enclosure provides more density per square foot of rack space than many other enclosures, a special dimensionally enhanced rack (44" deep) is required for this enclosure. The deep rack provides three power zones (A, B, and C), each with its own power drops to power each zone. The four power supplies are FRUs. These power supplies can be removed without detaching the bus cable by using the cable management arm (CMA), which quickly disconnects.

The 120-drive high-capacity enclosure can be the first DAE and contain the vault drives (row A, positions 0-3) for the VNX8000 model.

The 120-drive DAE contains two hot-swappable LCCs and a System Status Card (SSC):

- Two ICM LCCs are located at the rear of the enclosure. They house the SAS ports and provide connectivity to the storage processors.
- The SSC is located at the front of the enclosure. It contains LEDs that display system power and fault status.

The LCCs and SSC on this enclosure are field replaceable units (FRUs).

There are also a total of ten fans (five across the front, five across the rear) located inside of the enclosure. These fans are all CRUs.

Figure 19 shows the front of the 120-drive DAE.

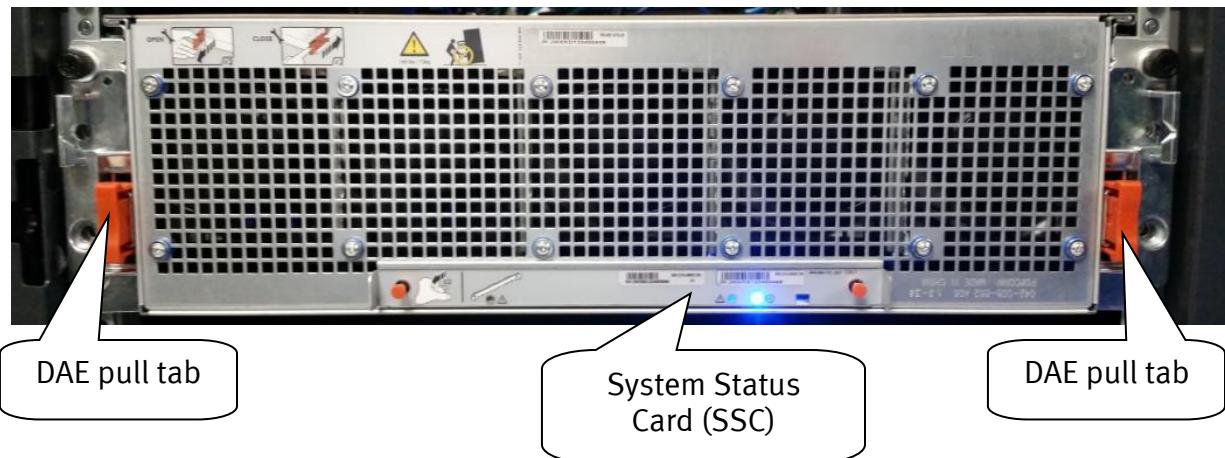


Figure 19. Front of the 120-drive DAE

Figure 20 shows the top of the 120-drive DAE tray extended and open, which reveals the drives and fans.

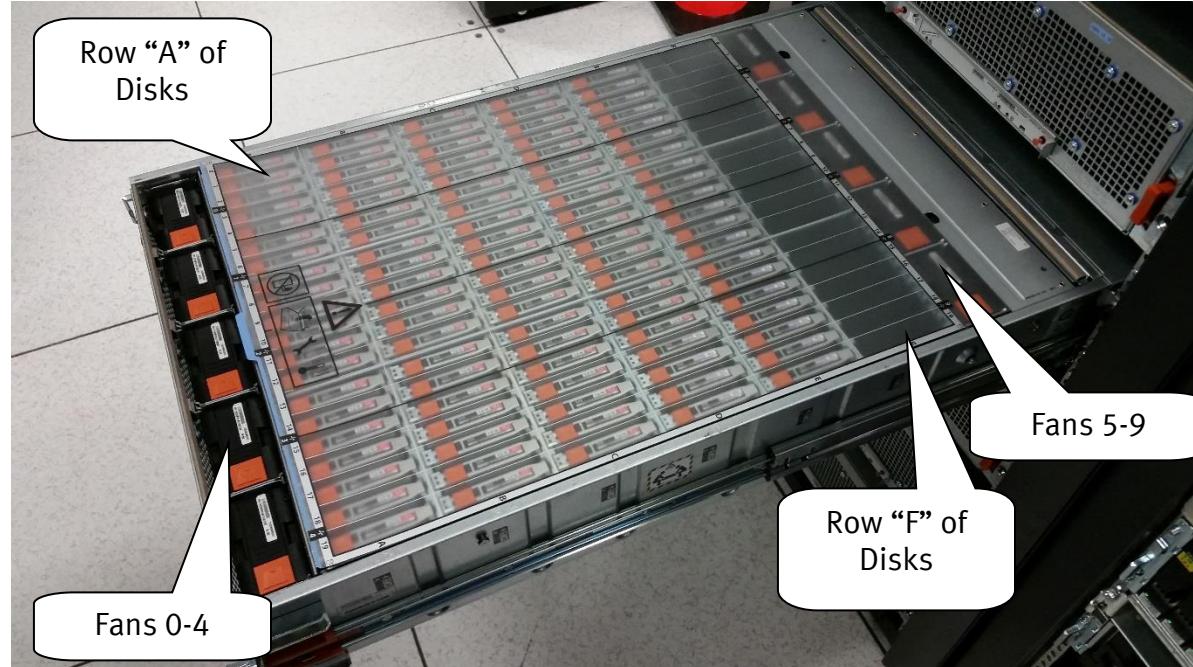


Figure 20. Top of the 120-drive DAE

[Figure 21](#) shows one of the ten fans removed from the 120-drive DAE.



[Figure 21. Fan in the 120-drive DAE](#)

Figure 22 shows the cable management arms and power supplies in the rear of the 120-drive DAE

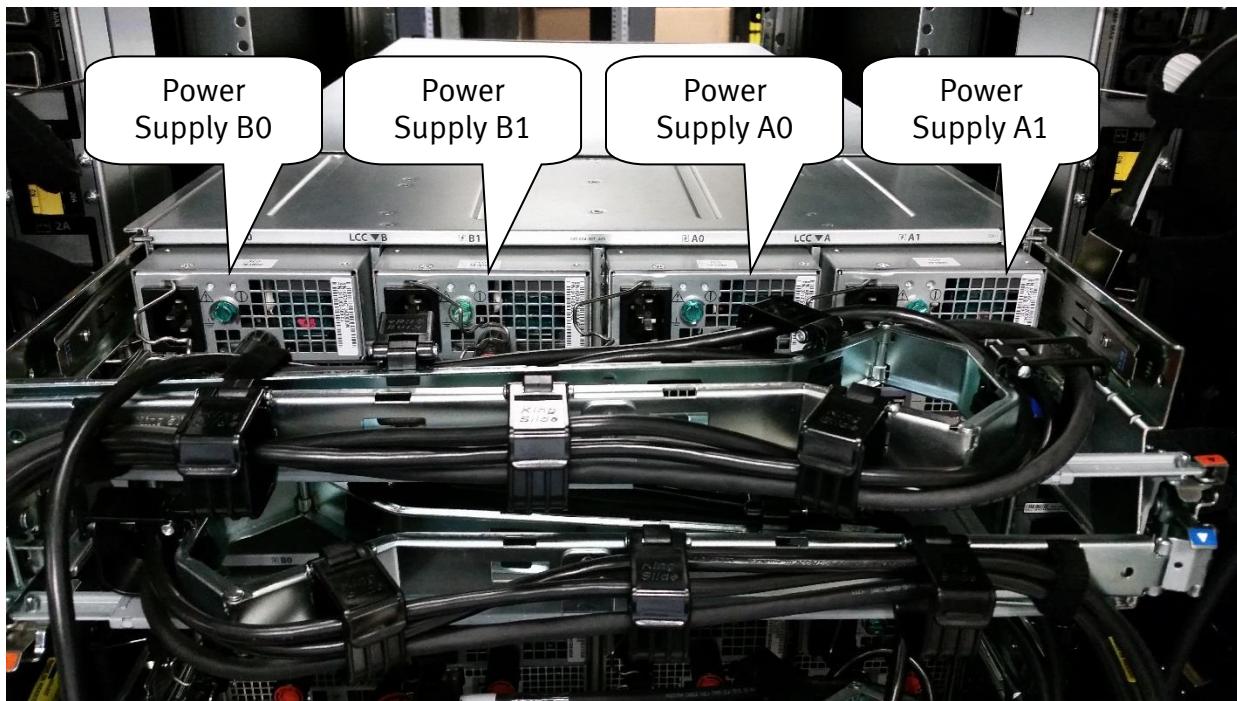


Figure 22. Cable management arms and power supplies in the rear of the 120-drive DAE

Figure 23 shows the LCCs and power supplies in the rear of the 120-drive DAE, with the cable management arms removed.

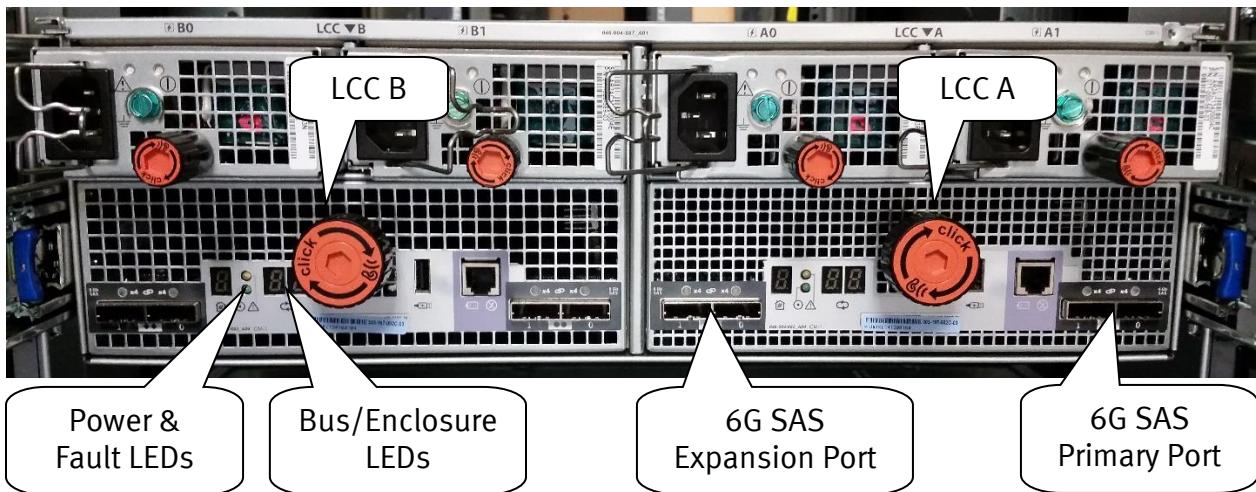


Figure 23. LCCs and power supplies

6 Gb/s x 4 lane and 6 Gb/s x 8 lane SAS back-end

The back-end of the VNX series uses an architecture that dramatically improves performance and availability.

The 6 Gb/s x 4 lanes SAS back-end provides speeds of up to 3 GB/s. SAS is a significant improvement over previous-generation FC back-ends that provide speeds of 0.25 GB/s (4Gbps). This point-to-point architecture, in which all drives connect directly to an expanding switching matrix, allows direct communication from the controller to the drive. The data frames do not have to travel throughout the entire bus accessing each of the drives, as was the case in earlier models that used a Fibre Channel arbitrated loop as the back-end architecture. This provides much higher bandwidth across the VNX line than prior models. In addition, because SAS uses acknowledgements (ACK/NAK), an immediate response is received in the event of a failure--unlike Fibre Channel, which requires waiting for a time-out.

The SAS back-end increases availability by offering improved back-end fault isolation, and VNX series systems benefit from this dramatic improvement. Because data frames no longer traverse the entire bus and do not pass through every drive, a corrupt frame is much easier to isolate to a specific drive or SAS cable. This advancement is key, especially compared to Fibre Channel, where locating the exact drive or cable that corrupted a frame requires significant time and resources.

When connected to the new back-end SAS I/O module on the VNX2 using a SASHD “Y” cable, the 60-drive and 120-drive DAEs support an x 8 wide connection (6 Gb/s x 8 lanes). This connection uses 2 SAS ports on the I/O module and 2 SAS ports on the DAE LCC, and is designed for high bandwidth workloads. This x 8 wide connection is not supported with other DAEs.

Expanded UltraFlex I/O using PCI-E Gen 3 increases bandwidth

The VNX2 series expands the UltraFlex I/O technology of previous-generation midrange storage arrays. The UltraFlex I/O uses PCI-E Gen 3, which is even faster than the PCI-E Gen 2 architecture used in previous-generation models. This increase in bandwidth is an important factor in the enhanced performance of the VNX2 series.

VNX2 models

Comprised of 5000, 7000, and 8000 class systems, the available models of the VNX2 series are VNX5200, VNX5400, VNX5600, VNX5800, VNX7600, and VNX8000. The hardware and connectivity options scale with each model, providing more power and options throughout the model range.



Figure 24. VNX2 series storage systems

All VNX2 models support 2.5" and 3.5" SAS drives using either the 15-drive DAE, 25-drive DAE, 60-drive DAE, or 120-drive DAE. They also and utilize the 6 Gb/s SAS backend. SAS drives, NL-SAS rotational drives, and Flash drives are supported.

The following table compares each model of the VNX2 series. The sections after the table give more detailed information about each model.

Table 1. Model comparison chart

| Model | VNX5200 | VNX5400 | VNX5600 | VNX5800 | VNX7600 | VNX8000 |
|----------------------------------|--------------------|--------------------|--------------------|--------------------|------------------------|--------------------------|
| Industry position | Entry | Midrange/ Entry | Midrange/ Midtier | Midrange/ Midtier | High-end/ Mid-capacity | High-end/ Large-capacity |
| Management software | Unisphere | Unisphere | Unisphere | Unisphere | Unisphere | Unisphere |
| Drive count | 125 | 250 | 500 | 750 | 1000 | 1500 |
| Drive types | Flash, SAS, NL-SAS | Flash, SAS, NL-SAS |
| Block: Protocols | FC, iSCSI, FCoE | FC, iSCSI, FCoE |
| Standby power supplies | N/A | N/A | N/A | N/A | N/A | 4 |
| Battery backup units | 2 | 2 | 2 | 2 | 2 | N/A |
| File: Protocols | NFS, CIFS, pNFS | NFS, CIFS, pNFS |
| File: number of Blades | 1-3 | 1-4 | 1-4 | 2-6 | 2-8 | 2-8 |
| Array enclosure/ SP count | DPE/2 SP | SPE/2 SP |
| CS count | 1-2 | 1-2 | 1-2 | 1-2 | 1-2 | 1-2 |

VNX5200

The VNX5200 is designed for the entry space. This model supports block, file, and unified configurations, and utilizes a DPE (disk processor enclosure) chassis.

The SPs in this model use a 1.2 GHz, four-core Xeon E5 processor with 16 GB of RAM, supporting a maximum of 125 drives with the following host connectivity options: FC, iSCSI, and FCoE.

This model uses a DPE that is available in a 25 x 2.5" drive form factor. The VNX Operating Environment boots from the first four drives on the DPE, known as Vault drives.

The VNX5200 DPE uses UltraFlex I/O slots for all connectivity. The first slot houses the internal network management switch, which includes a mini-serial port and service LAN port. EMC service personnel use these ports to connect to the SPs.

There is a LAN connection on each SP for array management. Each SP has five I/O module slots, and the VNX5200 supports a maximum of three I/O modules. Any slots without I/O modules populate with blanks (to ensure proper airflow).

The DPE includes two base modules, one per SP. Each base module contains a power supply, a BBU, and a SAS module containing two 6 Gb/s SAS ports for back-end connectivity to DAEs.

[Figure 25](#) shows the back of the DPE. In this figure, you can see the various components including I/O modules and SAS modules. [Figure 26](#) provides a close-up view of the back of the DPE.



[Figure 25. Back view of the DPE with SP A \(on the right\) and SP B \(on the left\)](#)

The System Information tag (not pictured) is located on the back of the DPE, in between each SP. This tag contains serial number and part number information and should be handled carefully when racking the system.

[Figure 26](#), [Figure 27](#), and [Figure 28](#) show the back of the DPE-based storage processor.

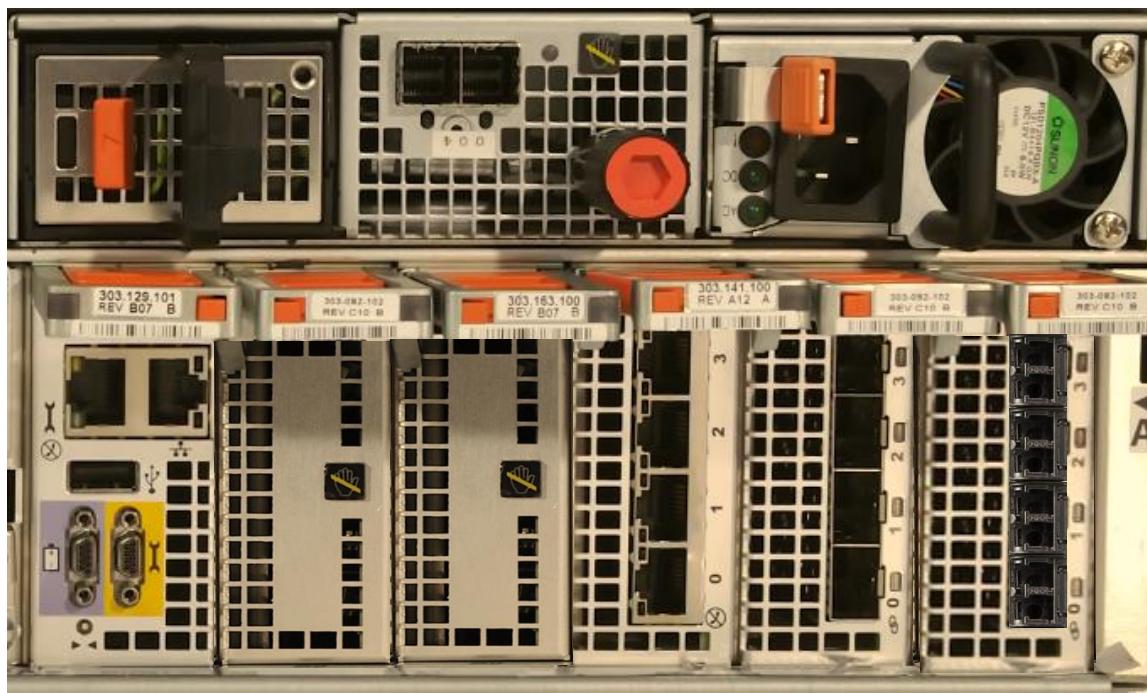


Figure 26. A close-up of the back of the DPE-based storage processor

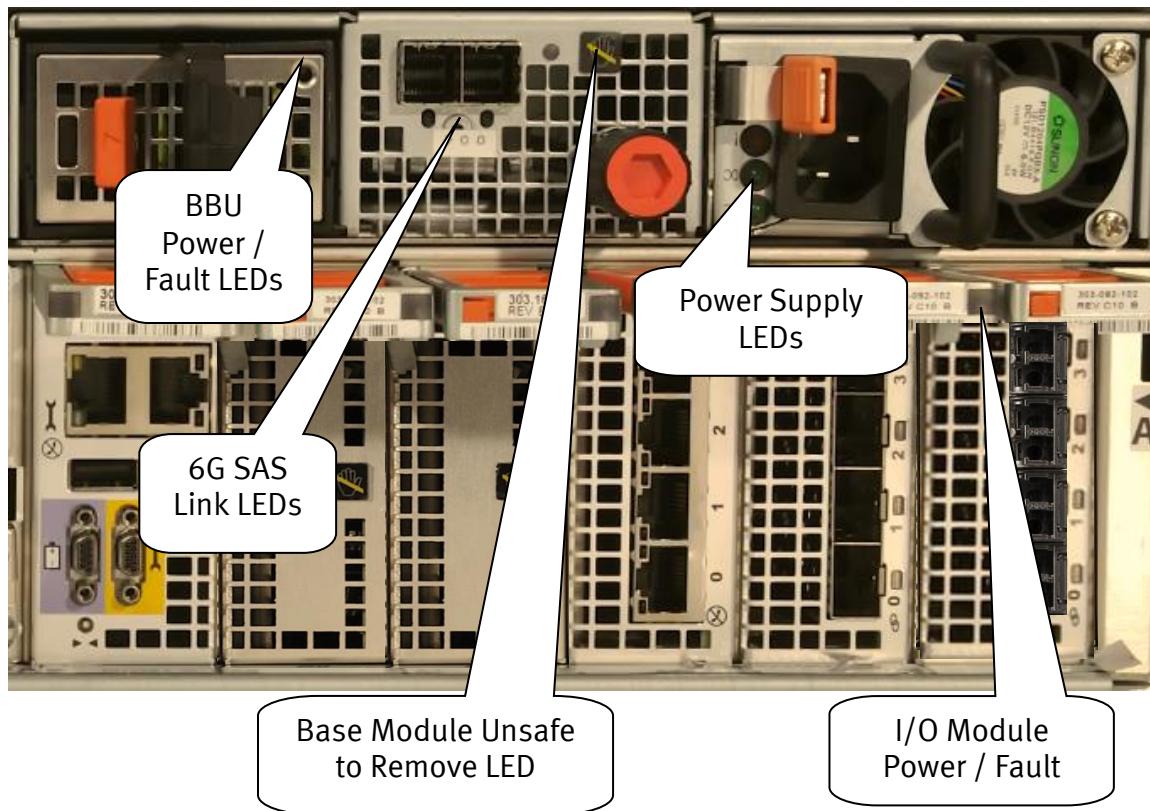


Figure 27. Power, fault, activity, link, and status LED

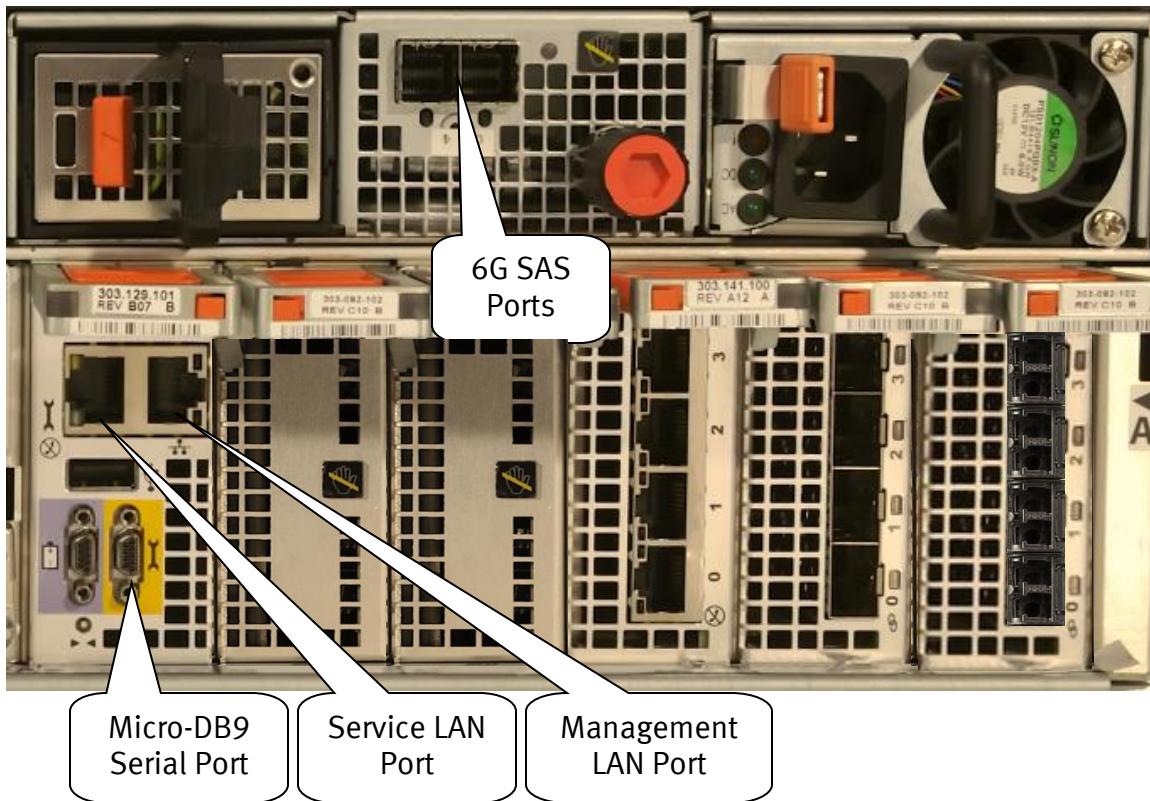


Figure 28. Storage processor management and base module ports

The front of the DPE houses the first bus of 25 x 2.5" drives and four fan packs, two per SP. In the middle of the enclosure, between the SPs, there is the enclosure power LED (blue) and fault LED (amber if there is a fault). Each SP has its own power LED (green), unsafe to remove LED (white hand), and fault LED (bi-color blue/amber for SP boot or fault). The drives have a power/activity LED (blue) and fault LED (amber if there is a fault), and the fan packs have an amber LED that only lights in the case of a fault. This is shown in Figure 29.

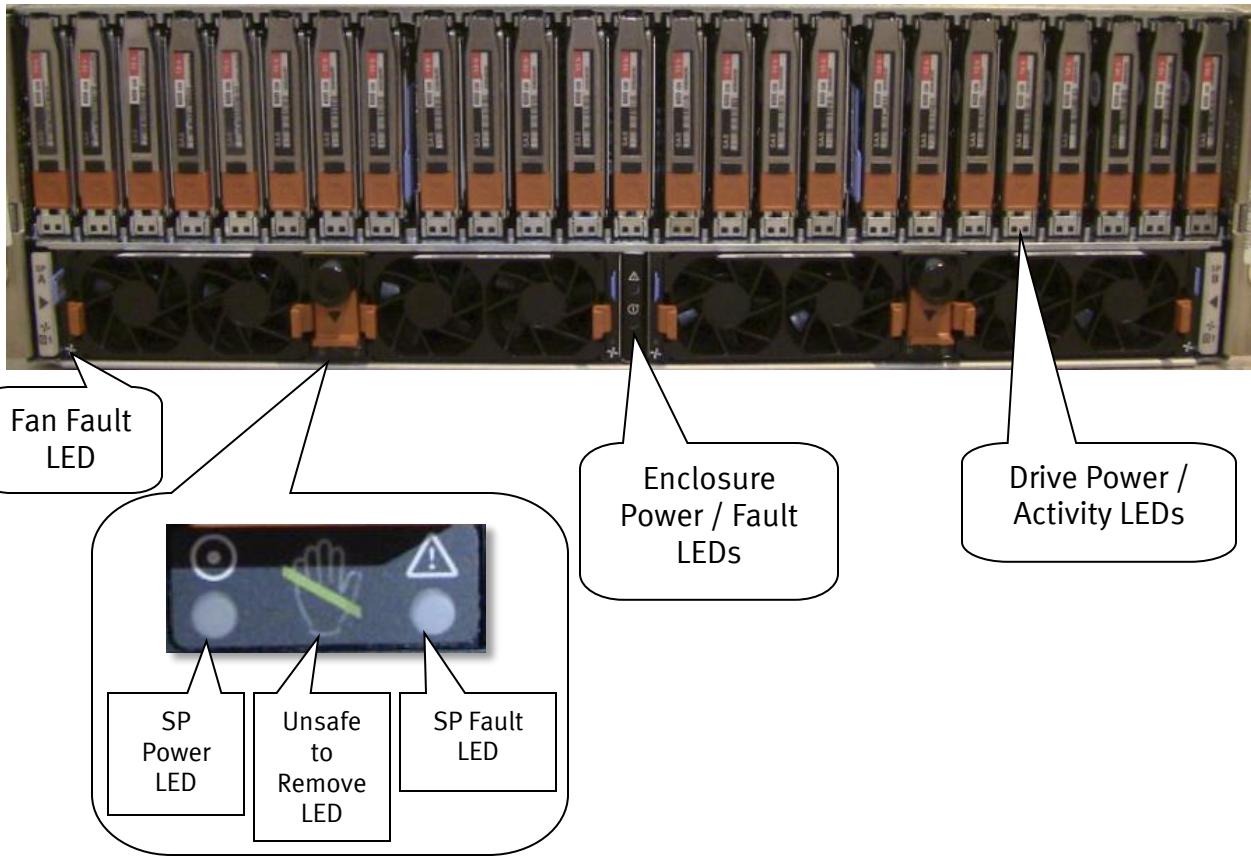


Figure 29. Front of a 25-drive DPE with 2.5" drives

File and unified configurations use a Data Mover Enclosure (DME) with blades containing 2.13 GHz, four-core Xeon 5600 processors with 6 GB RAM per blade, with a maximum storage capacity of 256 TB per blade. The model can have one, two, or three blades, and each blade has redundant power supplies located in the front of the blade. The file and unified configurations support the following NAS protocol options: NFS, CIFS, and pNFS. The CPU module is also accessible via the front of each blade after removing the power supplies. The rear of each blade houses the slots used for internal/external network connectivity, back-end fibre connectivity, and front-end connectivity options. The DME can house two blades per 2U enclosure, and each blade can accept a maximum of two I/O modules for front-end connectivity. [Figure 30](#), [Figure 31](#), and [Figure 32](#) provide pictures of the DME.



Figure 30. Front of a DME



Figure 31. Back of a DME

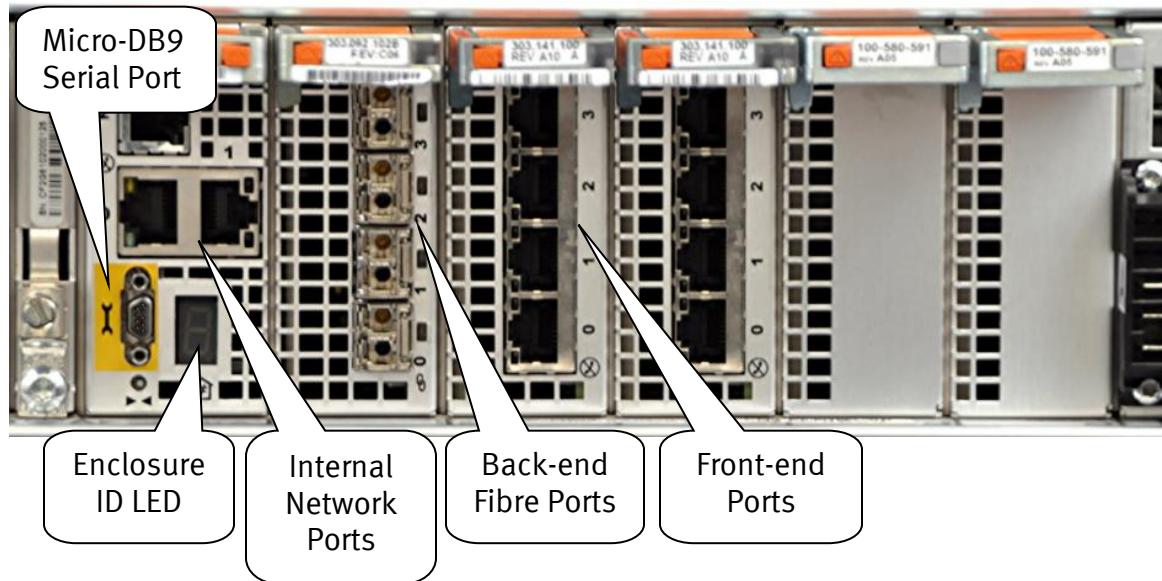


Figure 32. Close-up of the back of a DME

VNX5400

The VNX5400 is designed for the entry-to-mid-tier space. This model supports block, file, and unified configurations, and utilizes a DPE chassis.

The SPs in this model use a 1.8 GHz, four-core Xeon E5 processor with 16 GB of RAM, supporting a maximum of 250 drives with the following host connectivity options: FC, iSCSI, and FCoE.

This model uses a DPE available in a 25 x 2.5" drive form factor. The VNX Operating Environment boots from the first four drives on the DPE known as Vault drives.

The VNX5400 DPE uses UltraFlex I/O slots for all connectivity. The first slot houses the internal network management switch, which includes a mini-serial port and service LAN port. EMC service personnel use these ports to connect to the SPs.

There is a LAN connection on each SP for array management. Each SP has five I/O module slots, and the VNX5400 supports a maximum of four I/O modules. Any slots without I/O modules populate with blanks (to ensure proper airflow).

The DPE includes two base modules, one per SP. Each base module contains a power supply, a BBU, and a SAS module containing two 6 Gb/s SAS ports for back-end connectivity to DAEs.

The front of the DPE houses the first bus of 25 x 2.5" drives and four fan packs, two per SP. In the middle of the enclosure, between the SPs, there is the enclosure power LED (blue) and fault LED (amber if there is a fault). Each SP has its own power LED (green), unsafe to remove LED (white hand), and fault LED (bi-color blue/amber for SP boot or fault). The drives have a power/activity LED (blue) and fault LED (amber if there is a fault), and the fan packs have an amber LED that only lights in the case of a fault.

In file and unified configurations, this model uses a Data Mover Enclosure (DME) with blades containing 2.13 GHz, four-core Xeon 5600 processors with 6 GB RAM per blade, with a maximum storage capacity of 256 TB per blade. The model can have between one and four blades, and each blade has redundant power supplies located at its front. The file and unified configurations support the following NAS protocol options: NFS, CIFS, and pNFS. The CPU module is also accessible via the front of each blade after removing the power supplies. The rear of each blade houses the slots used for internal/external network connectivity, back-end fibre connectivity, and front-end connectivity options.

The DME can house two blades per 2U enclosure, and each blade can accept a maximum of two I/O modules for front-end connectivity.

VNX5600

The VNX5600 is designed for the mid-tier space. This model supports block, file, and unified configurations, and utilizes a DPE chassis.

The SPs in this model use a 2.4 GHz, four-core Xeon E5 processor with 24 GB of RAM, supporting a maximum of 500 drives with the following host connectivity options: FC, iSCSI, and FCoE.

This model uses a DPE available in a 25 x 2.5" drive form factor. The VNX Operating Environment boots from the first four drives on the DPE, known as Vault drives.

The VNX5600 DPE uses UltraFlex I/O slots for all connectivity. The first slot houses the internal network management switch, which includes a mini-serial port and service LAN port. EMC service personnel use these ports to connect to the SPs.

There is a LAN connection on each SP for array management. Each SP has five I/O module slots, and the VNX5600 supports the use of all five. Any slots without I/O modules populate with blanks (to ensure proper airflow).

The DPE includes two base modules, one per SP. Each base module contains a power supply, a BBU, and a SAS module containing two 6 Gb/s SAS ports for back-end connectivity to DAEs.

The front of the DPE houses the first bus of 25 x 2.5" drives and four fan packs, two per SP. In the middle of the enclosure, between the SPs, there is the enclosure power LED (blue) and fault LED (amber if there is a fault). Each SP has its own power LED (green), unsafe to remove LED (white hand), and fault LED (bi-color blue/amber for SP boot or fault). The drives have a power/activity LED (blue) and fault LED (amber if there is a fault), and the fan packs have an amber LED that only lights in the case of a fault.

In file and unified configurations, this model uses a Data Mover Enclosure (DME) with blades containing 2.13 GHz, four-core Xeon 5600 processors with 12 GB RAM per blade, with a maximum storage capacity of 256 TB per blade. The model can have between one and four blades, and each blade has redundant power supplies located in the front of the blade. The file and unified configurations support the following NAS protocol options: NFS, CIFS, and pNFS. The CPU module is also accessible via the front of each blade after removing the power supplies. The rear of each blade houses the slots used for internal/external network connectivity, back-end fibre connectivity, and front-end connectivity options.

The DME can house two blades per 2U enclosure, and each blade can accept a maximum of two I/O modules for front-end connectivity.

VNX5800

The VNX5800 is designed for the mid-tier space. This model supports block, file, and unified configurations, and utilizes a DPE chassis.

The SPs in this model use a 2.0 GHz, six-core Xeon E5 processor with 32 GB of RAM, supporting a maximum of 750 drives with the following host connectivity options: FC, iSCSI, and FCoE.

This model uses a DPE available in a 25 x 2.5" drive form factor. The VNX Operating Environment boots from the first four drives on the DPE known as Vault drives.

The VNX5800 has a DPE that uses UltraFlex I/O slots for all connectivity. The first slot houses the internal network management switch, which includes a mini-serial port and service LAN port. EMC service personnel use these ports to connect to the SPs.

There is a LAN connection on each SP for array management. Each SP has five I/O module slots, and the VNX5800 supports the use of all five. Any slots without I/O modules populate with blanks (to ensure proper airflow).

The DPE includes two base modules, one per SP. Each base module contains a power supply, a BBU, and a SAS module containing two 6 Gb/s SAS ports for back-end connectivity to DAEs.

The front of the DPE houses the first bus of 25 x 2.5" drives and four fan packs, two per SP. In the middle of the enclosure, between the SPs, there is the enclosure power LED (blue) and fault LED (amber if there is a fault). Each SP has its own power LED (green), unsafe to remove LED (white hand), and fault LED (bi-color blue/amber for SP boot or fault). The drives have a power/activity LED (blue) and fault LED (amber if there is a fault), and the fan packs have an amber LED that only lights in the case of a fault.

In file and unified configurations, this model uses Data Mover Enclosures (DMEs) with blades containing 2.4 GHz, four-core Xeon 5600 processors with 12 GB RAM per blade, with a maximum storage capacity of 256 TB per blade. Starting with the 8.1.2.51 release, the model can have between two and six blades. Each blade has redundant power supplies located in the front of the blade; VNX5800 systems previously ordered with 1 DM will continue to be supported. The file and unified configurations support the following NAS protocol options: NFS, CIFS, and pNFS. The CPU module is also accessible via the front of each blade after removing the power supplies. The rear of each blade houses the slots used for internal/external network connectivity, back-end fibre connectivity, and front-end connectivity options.

The DMEs can house two blades per 2U enclosure, and each blade can accept a maximum of three I/O modules for front-end connectivity.

VNX7600

The VNX7600 is designed for the high-end, mid-capacity space. This model supports block, file, and unified configurations, and utilizes a DPE chassis.

The SPs in this model use a 2.2 GHz, eight-core Xeon E5 processor with 64 GB of RAM, supporting a maximum of 1000 drives with the following host connectivity options: FC, iSCSI, and FCoE.

This model uses a DPE available in a 25 x 2.5" drive form factor. The VNX Operating Environment boots from the first four drives on the DPE, known as Vault drives.

The VNX7600 has a DPE that uses UltraFlex I/O slots for all connectivity. The first slot houses the internal network management switch, which includes a mini-serial port and service LAN port. EMC service personnel use these ports to connect to the SPs.

There is a LAN connection on each SP for array management. Each SP has five I/O module slots, and the VNX7600 supports the use of all five (within ports limits). Any slots without I/O modules populate with blanks (to ensure proper airflow).

The DPE includes two base modules, one per SP. Each base module contains a power supply, a BBU, and a SAS module containing two 6 Gb/s SAS ports for back-end connectivity to DAEs.

The front of the DPE houses the first bus of 25 x 2.5" drives and four fan packs, two per SP. In the middle of the enclosure, between the SPs, there is the enclosure power LED (blue) and fault LED (amber if there is a fault). Each SP has its own power LED (green), unsafe to remove LED (white hand), and fault LED (bi-color blue/amber for SP boot or fault). The drives have a power/activity LED (blue) and fault LED (amber if there is a fault), and the fan packs have an amber LED that only lights in the case of a fault.

In file and unified configurations, this model uses Data Mover Enclosures (DMEs) with blades containing 2.8 GHz, six-core Xeon 5600 processors with 24 GB RAM per blade, with a maximum storage capacity of 512 TB per blade. The model can have between two and eight blades, and each blade has redundant power supplies located in the front of the blade. The file and unified configurations support the following NAS protocol options: NFS, CIFS, and pNFS. The CPU module is also accessible via the front of each blade after removing the power supplies. The rear of each blade houses slots used for internal/external network connectivity, back-end fibre connectivity, and front-end connectivity options.

The DMEs can house two blades per 2U enclosure, and each blade can accept a maximum of three I/O modules for front-end connectivity.

VNX8000

The VNX8000 is designed for the enterprise space. This model supports block, file, and unified configurations, and utilizes a storage processor enclosure (SPE) chassis.

The SPs in this model use dual socket, 2.7 GHz, eight-core Xeon E5 processors with 128 GB of RAM, supporting a maximum of 1500 drives with the following host connectivity options: FC, iSCSI, and FCoE.

Since this model uses an SPE (and contains no drives), the VNX Operating Environment boots from the first four drives (Vault drives) on the first DAE (bus 0 enclosure 0).

The VNX8000' SPE's uses UltraFlex I/O slots for all connectivity. The first slot houses the internal network management switch, which includes a mini-serial port and service LAN port. EMC service personnel use these ports to connect to the SPs.

There is a LAN connection on each SP for array management. Each SP has eleven I/O module slots, and the VNX8000 supports the use of all eleven (within ports limits). Any slots without I/O modules populate with blanks (to ensure proper airflow).

The SPE base configuration includes four SAS I/O modules, two per SP (slot 5 and slot 10) for back-end connectivity to DAEs.

[Figure 33](#) displays the back of the SPE and the various components, including I/O modules and SAS modules.



Figure 33. Back view of the SPE with SPA (on the bottom) and SPB (on the top)

Note: To achieve optimal performance, the load should be distributed to all the CPU resources in the array. To accomplish this, front end I/O modules installed should be balanced between slots 0-5 and slots 6-10, and load should be applied to ports on I/O modules in both sets of slots. If you notice that front-end I/O modules are not installed in a balanced manner in slots 0-5 and also in slots 6-10, do not remove the I/O modules. Please contact EMC support.

The System Information tag (not pictured) is located on the back of the SPE, to the right of SPB. This tag contains serial number and part number information and should be handled carefully when racking the system.

Figure 34 shows the first few I/O module slots on the back of the SPE-based storage processor.

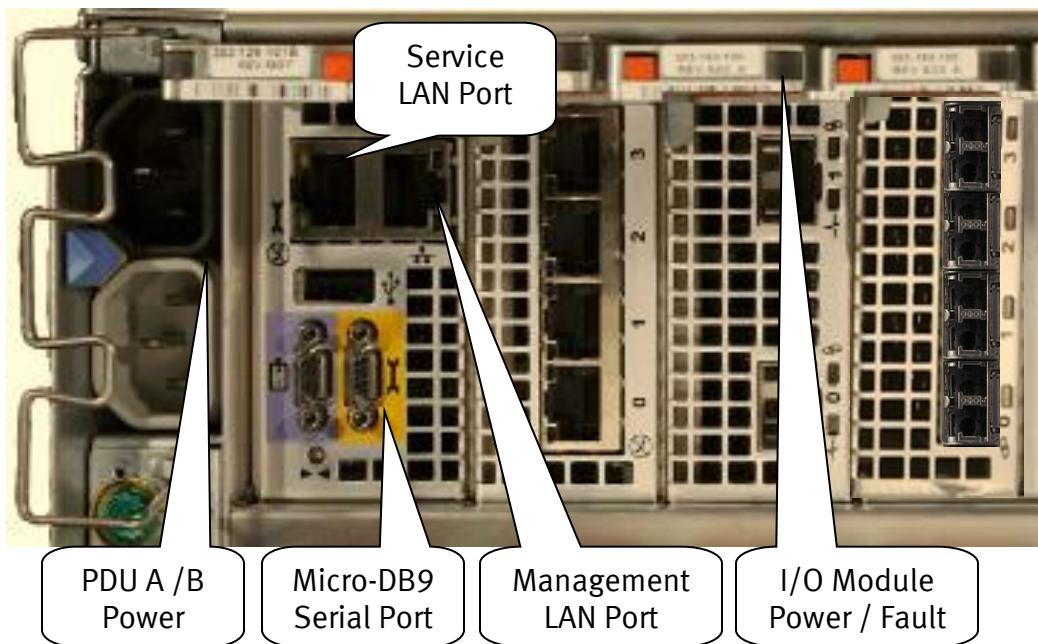
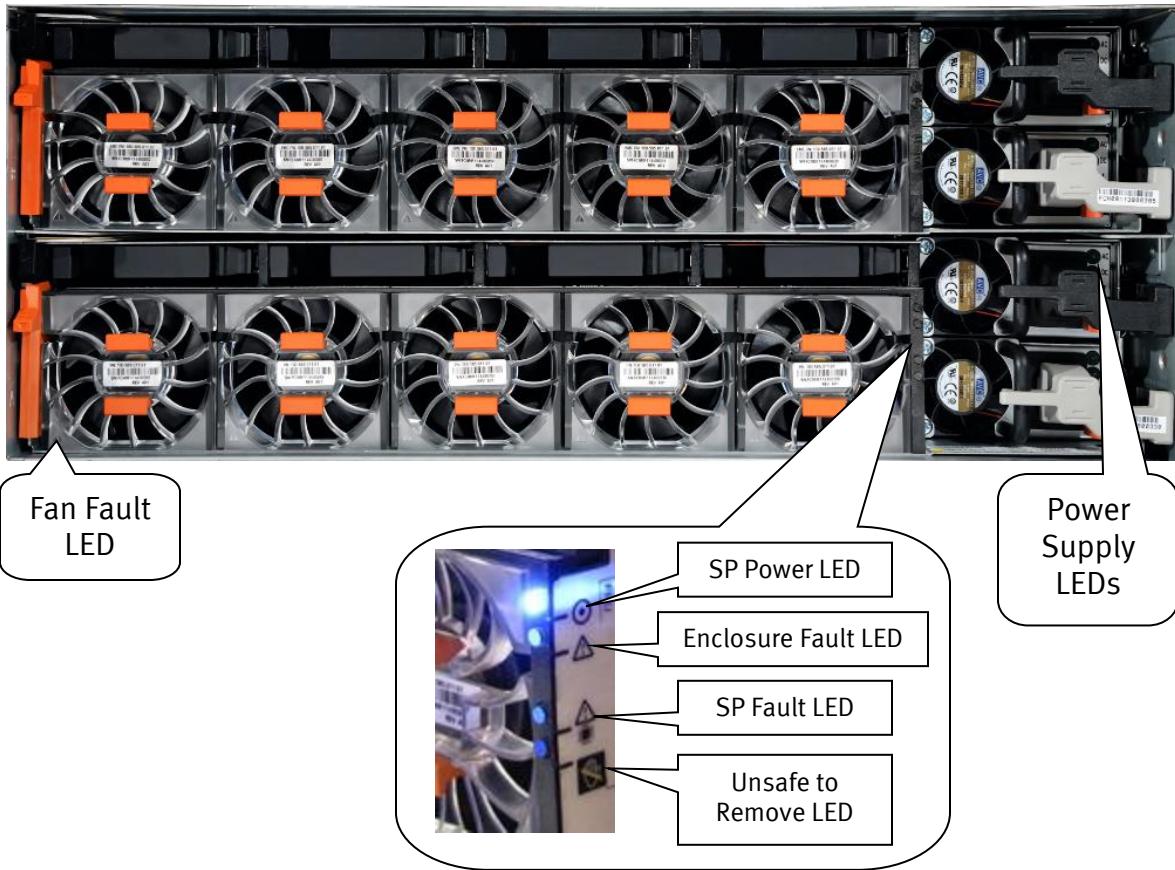


Figure 34. Close-up of the back of the SPE-based storage processor

The front of the SPE houses a total of ten fans (five per SP) and four power supplies (two per SP). System status LEDs are located to the right of each SP. The LEDs are: SP power LED (blue), enclosure fault LED (amber if there is a fault), SP fault LED (bi-color blue/amber for SP boot or fault), and unsafe to remove LED (white). Fan packs have an amber LED that only lights in the case of a fault. [Figure 35](#) shows the LEDs.



[Figure 35. Front of the VNX8000 SPE](#)

The VNX8000 uses two 2U dual 2.2KW Li-Ion standby power supplies (SPSs) with removable battery packs and upgradeable firmware. These SPSs provide battery power to the SPE and to the first DAE (bus 0, enclosure 0). This battery power allows the storage processors to de-stage data in-flight to the vault area of the reserved space in the event of a power failure. Once power is restored to the array, any writes that were de-staged are reconciled and persisted to the target back-end disks to ensure that no data is lost.

Unlike traditional SPSs, VNX8000 SPSs feature removable battery packs. A color wheel status indicator, located on the SPS tray, provides visual indication as to whether the battery packs are engaged (green), parked (yellow), or not installed (red). Both the SPS tray and battery packs have status LEDs. [Figure 36](#) shows the SPS tray and battery packs. [Figure 37](#) shows the SPS LEDs.

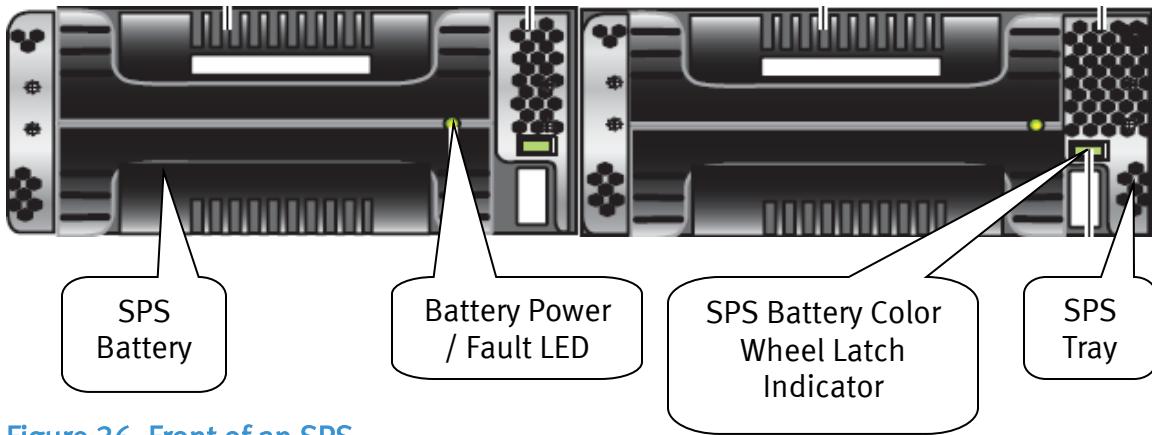
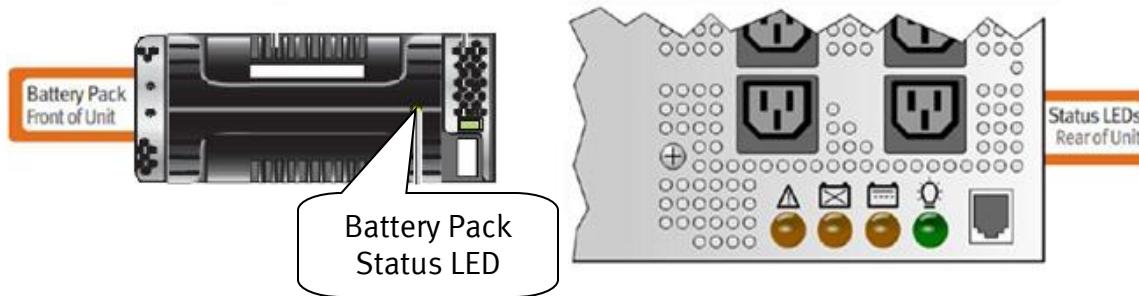


Figure 36. Front of an SPS



| SPS State | LED Activity |
|--------------------------------|--|
| Ready | SPS Power = Solid, Battery Pack Status = Solid |
| Ready/Charging | SPS Power = Blinking, Battery Pack Status = Solid |
| Running on Battery Power | On Battery = Solid, Battery Pack Status = Solid |
| Battery Pack Missing or Parked | SPS Power = Solid, Battery Pack Fault = Blinking, Tray Fault = Solid |
| Battery Pack Fault | All on except On Battery |
| Tray Fault | SPS Power = Solid, Tray Fault = Solid, Battery Pack Status = Solid |

Figure 37. SPS battery pack and tray LEDs

In file and unified configurations, this model uses a DME with blades containing 2.8 GHz, six-core Xeon 5600 processors with 24 GB RAM per blade, with a maximum storage capacity of 512 TB per blade. The model can have between two and eight blades, and each blade has redundant power supplies located in the front of the blade. The file and unified configurations support the following NAS protocol options: NFS, CIFS, and pNFS. The CPU module is also accessible via the front of each blade after removing the power supplies. The rear of each blade houses the slots used for internal/external network connectivity, back-end fibre connectivity, and front-end connectivity options.

The DME can house two blades per 2U enclosure, and each blade can accept a maximum of four I/O modules for front-end connectivity. [Figure 38](#), [Figure 39](#), and [Figure 40](#) provide pictures of the DME.



Figure 38. Front of a DME



Figure 39. Back of a DME

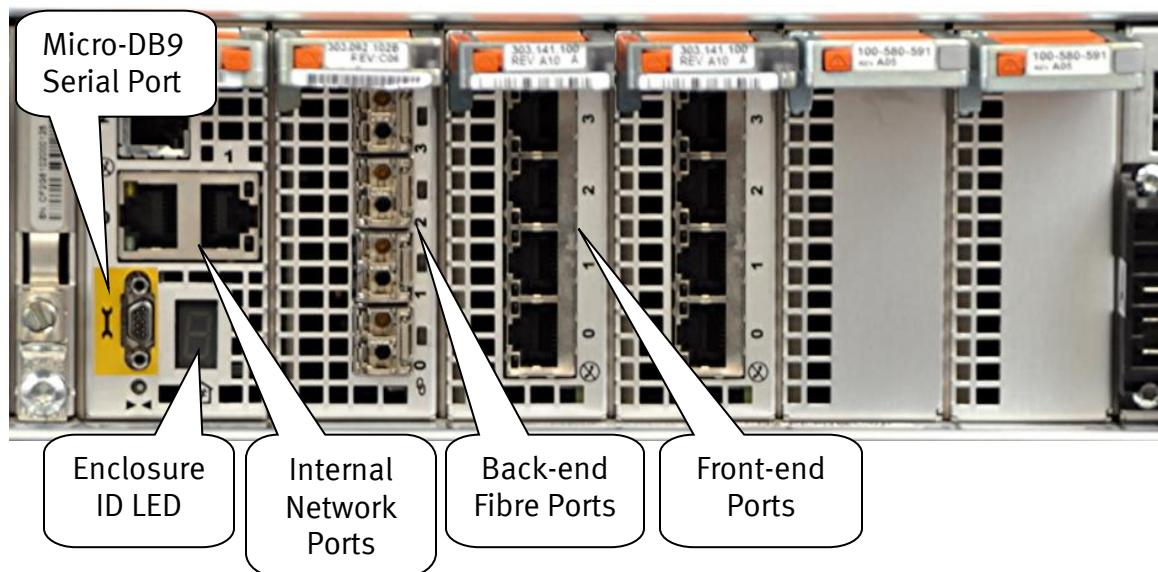


Figure 40. Close-up of the back of a DME

VNX Gateway

The existing VNX Series Gateway products—the VG2 or VG8—are dedicated network servers optimized for file access and advanced functionality in a scalable, easy-to-use package. The Gateway systems can connect to, boot from, and work with Symmetrix®, VNX series, and CLARiiON® back-end array technologies. Each Gateway model supports up to four back-end storage arrays.

The VMAX Gateway products—the VG10 or VG50—can only connect to, boot from, and work with Symmetrix VMAX 10K, 20K, and 40K back-end system technologies. The VNX VG10 and VNX VG50 Gateways are also offered in an integrated model that provides physical integration into a Symmetrix VMAX 10K system.

VNX VG2/VG10

- Up to two Data Movers
- Four core 2.4 Ghz Intel Xeon 5600 processors with 6 GB memory

VNX VG8/VG50

- Up to eight Data Movers
- Six core 2.8 Ghz Intel Xeon 5600 processors with 24 GB memory

I/O modules

I/O modules for the Storage Processor

VNX2 series arrays support a variety of UltraFlex I/O modules on the storage processors, which are discussed in this section.

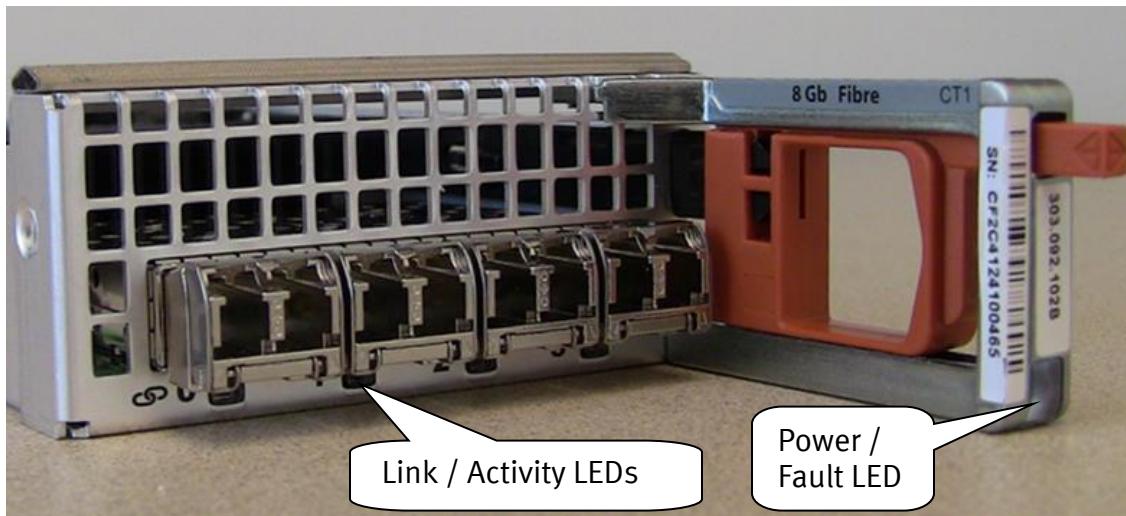


Figure 41. Quad-port 8 Gb/s FC optical I/O module

The quad-port 8 Gb/s FC optical I/O module:

- Auto-negotiates 2 Gb/s, 4 Gb/s, or 8 Gb/s
- 8-lane PCI-E Gen 2 interface
- Used for front-end connectivity from storage processors to hosts
- Used for back-end connectivity from blades to storage processors on the array

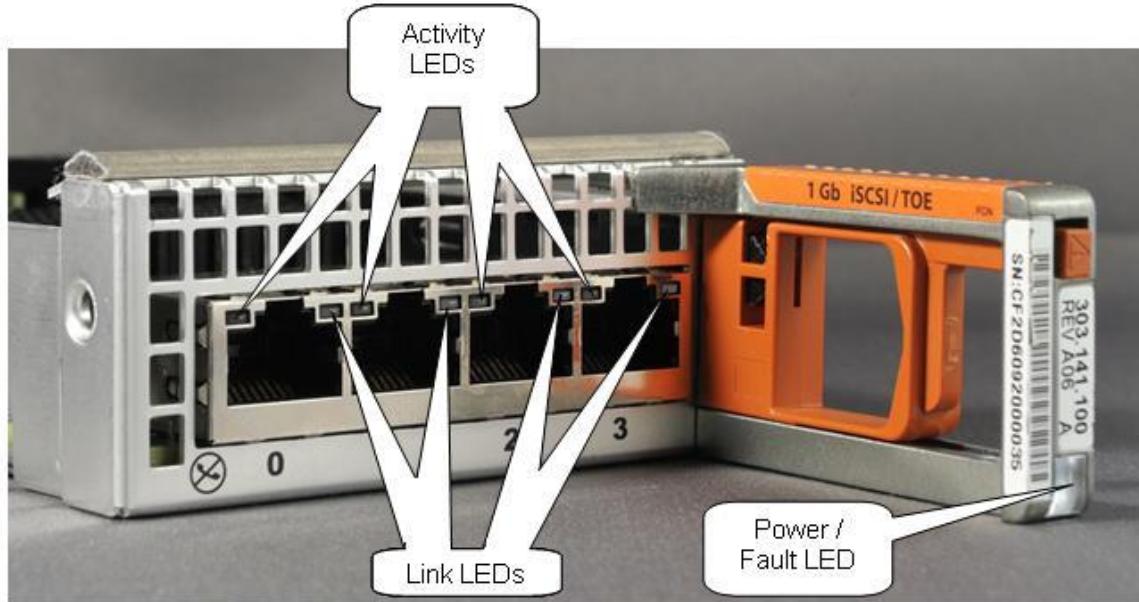


Figure 42. Quad-port 1 Gbase-T iSCSI/TOE module

The quad-port 1 Gbase-T iSCSI/TOE module:

- Operates at 10 Mb/100 Mb/1 Gb
- 4-lane PCI-E Gen 2 interface
- Is used for front-end connectivity to hosts
- Provides four copper ports

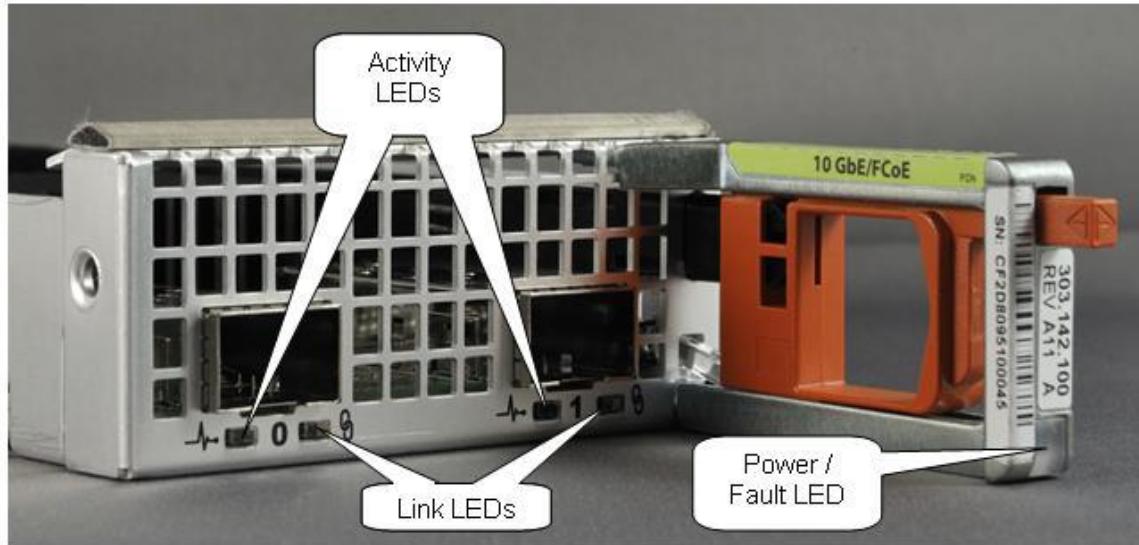


Figure 43. Dual-port 10 Gb/s Ethernet/FCoE module

The dual-port 10 Gb/s Ethernet/FCoE module:

- Operates at 10 Gb/s
- 8-lane PCI-E Gen 2 interface
- Is used for front-end connectivity to hosts
- Supports SFP+ and Active TwinAx cables only (Passive TwinAx cables not supported)

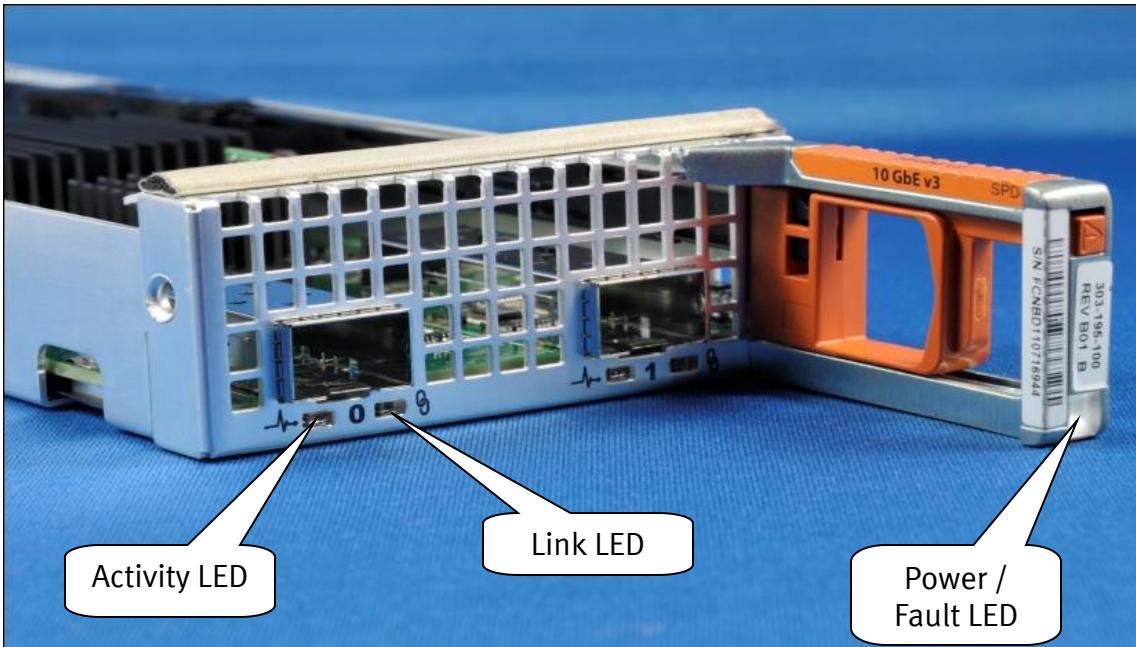


Figure 44. Dual-port 10 GbE iSCSI (optical/TwinAx) I/O module

The dual-port 10 GbE iSCSI (optical/TwinAx) I/O module:

- Operates at 10 Gb/s
- 8-lane PCI-E Gen 2 interface
- Is used for front-end connectivity to hosts
- Supports SFP+ and TwinAx cables

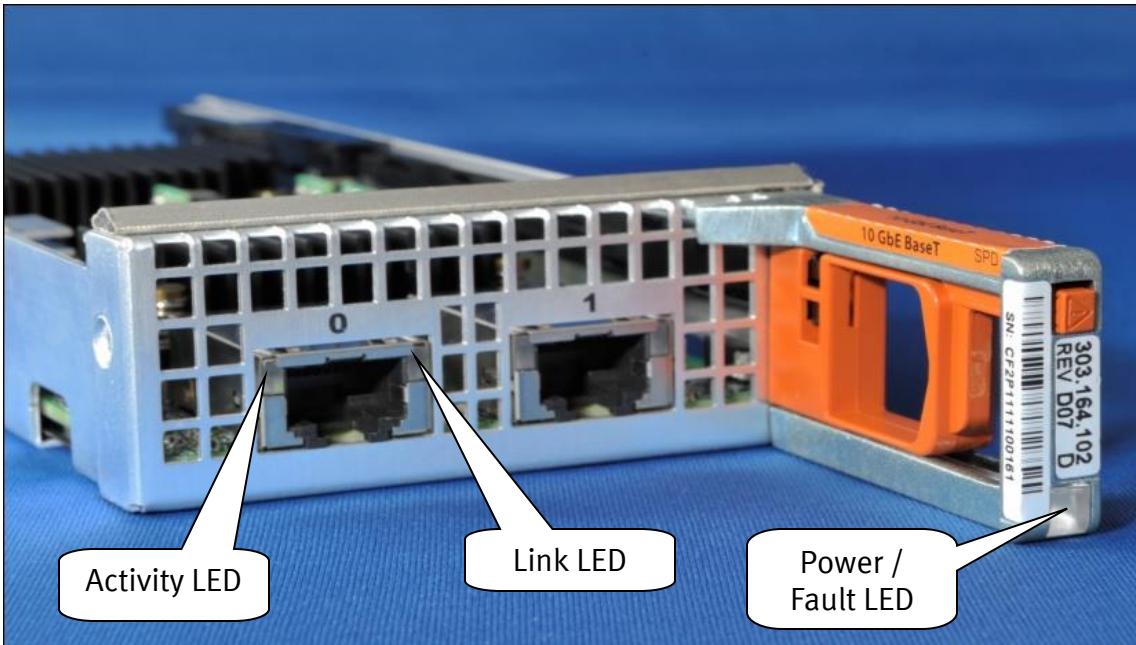


Figure 45. Dual-port 10 G Base -T copper I/O module

The dual-port 10 G Base-T iSCSI copper I/O module:

- Operates at 1 Gb/10 Gb auto
- 8-lane PCI-E Gen 2 interface
- Is used for front-end connectivity to hosts
- Provides two copper ports



Figure 46. Quad-port 6 Gb SAS I/O module

The quad-port 6 Gb SAS I/O module:

- Supported on VNX5600, VNX5800, VNX7600, and VNX8000 storage processors for back-end connectivity to DAEs
- 8-lane PCI-E Gen 3 interface
- Provides either:
 - Four ports of four lane, 6 Gb/s SAS per port (4x4x6G)
 - Two ports of eight lane, 6 Gb/s SAS per port (2x8x6G)
 - Requires x 8 SASHD “Y” cable; port width determined by cable used

I/O modules for the Data Mover

VNX2 series arrays support a variety of UltraFlex I/O modules on the blades, which are discussed in this section.

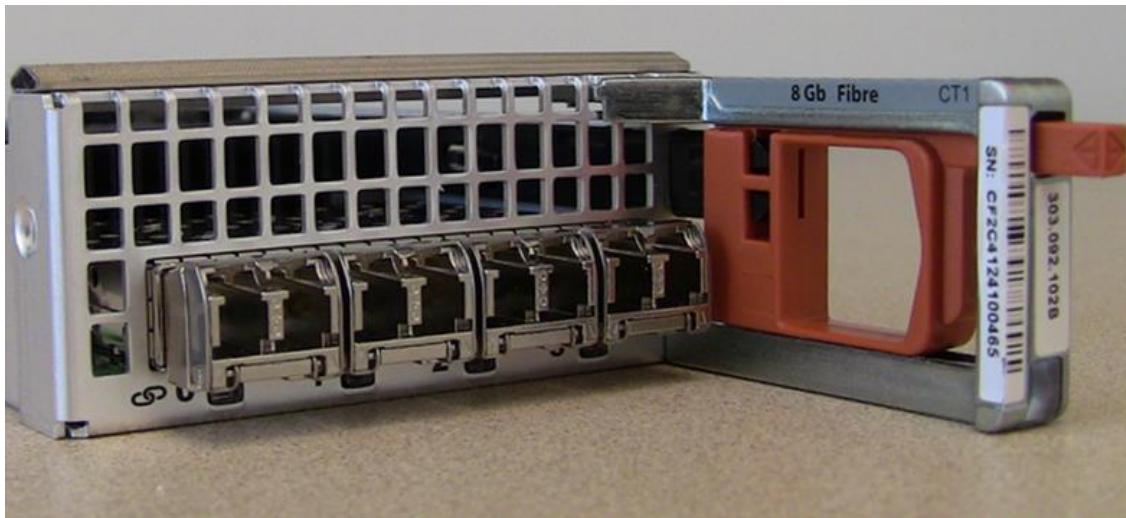


Figure 47. Quad-port 8 Gb/s FC optical I/O module

The quad-port 8 Gb/s FC optical I/O module:

- Auto-negotiates 2 Gb/s, 4 Gb/s, or 8 Gb/s
- Configured in slot 0 of every blade and used only for:
 - Connectivity between blades and storage processors on the array
 - AUX ports for NDMP-based backups

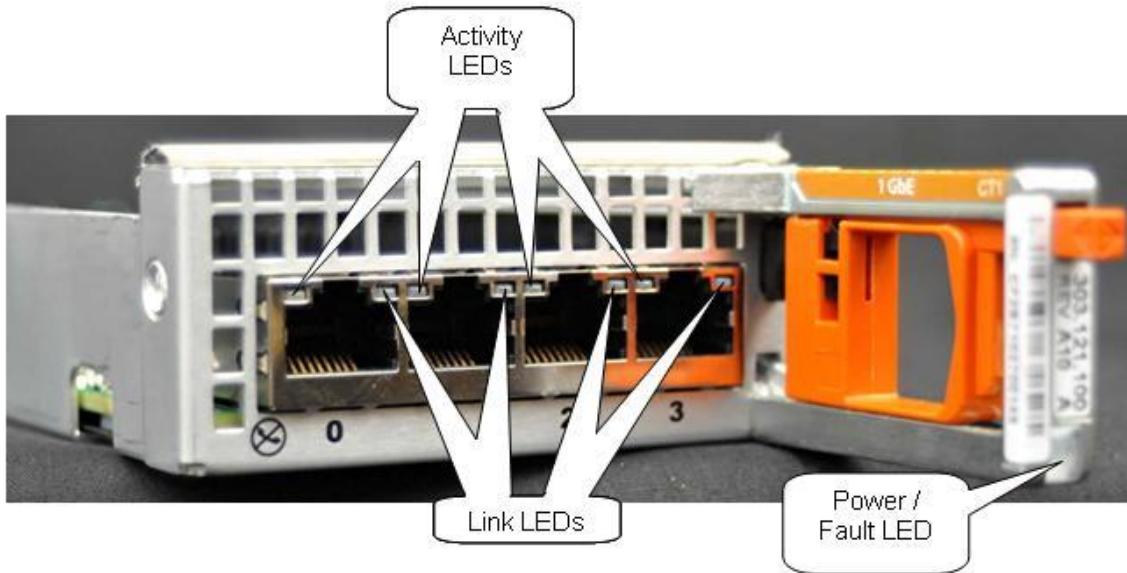


Figure 48. Quad-port 1 G base-T IP module

The quad-port 1 G base-T IP module:

- Operates at 10 Mb/100 Mb/1 Gb auto
- Enables connectivity to NAS clients
- Provides four copper ports

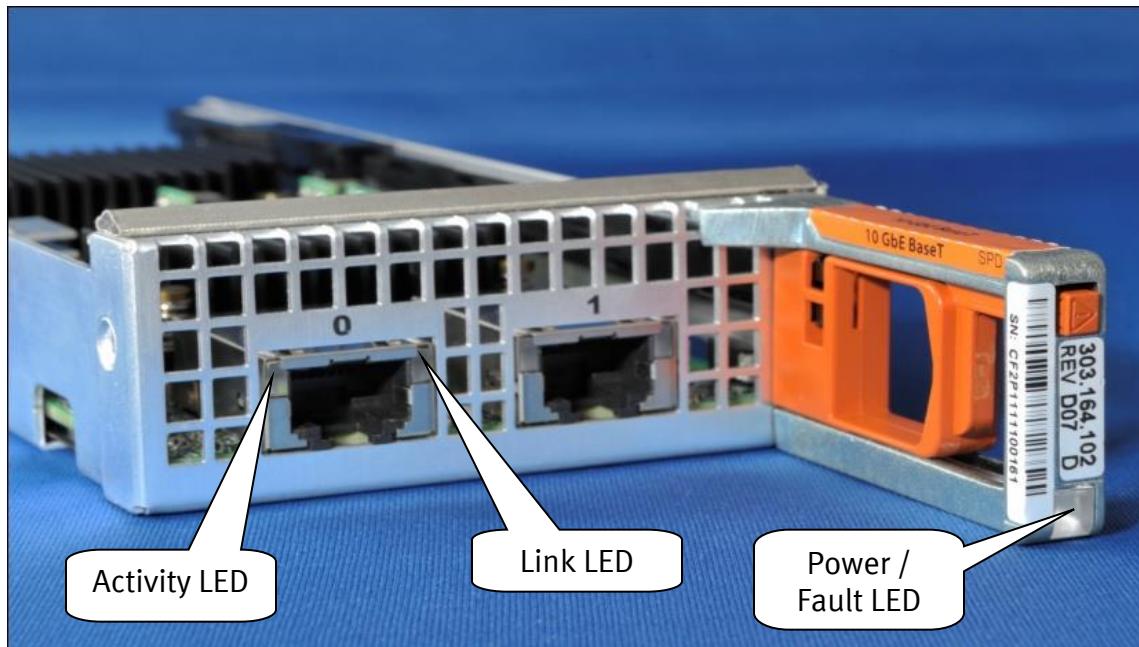


Figure 49. Dual-port 10 G Base -T copper I/O module

The dual-port 10 G Base-T copper I/O module:

- Operates at 10 Mb/100 Mb/1 Gb/10 Gb auto
- Enables connectivity to NAS clients
- Provides two copper ports

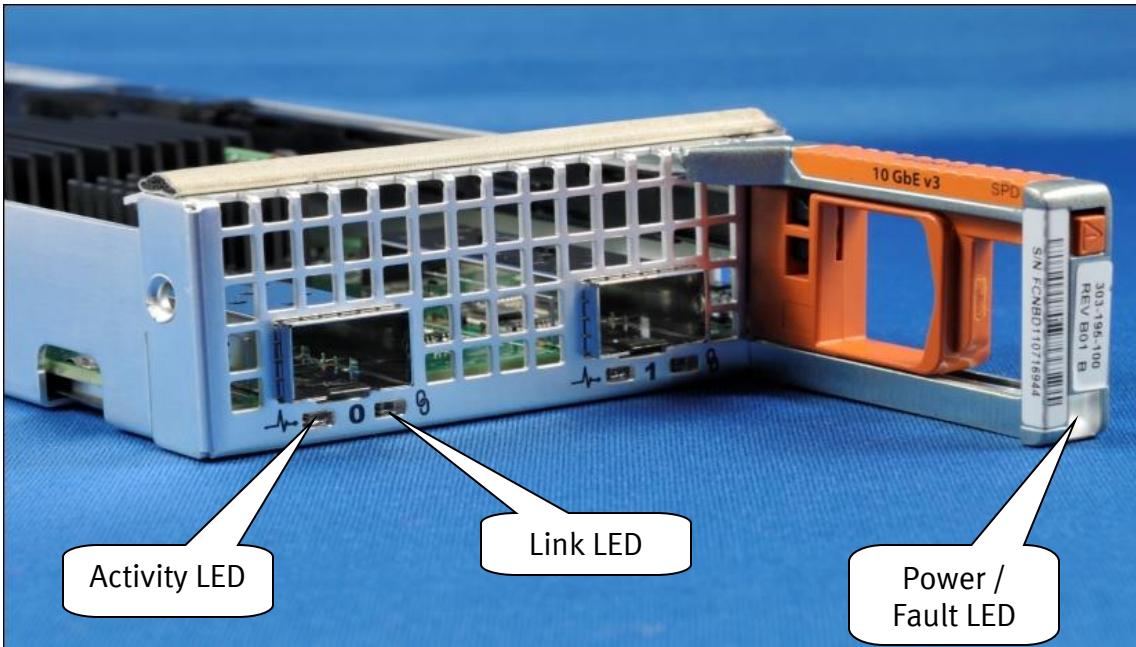


Figure 50. Dual-port 10 GbE optical I/O module

The dual-port 10 GbE optical I/O module:

- Operates at 10 Gb/s
- Enables optical connectivity to NAS clients
- Supports SFP+ and TwinAx cables

Table 2. Ultra-Flex I/O module compatibility chart

| UltraFlex I/O Module | Supported on Blades | Supported on Storage Processors |
|--|---------------------|---------------------------------|
| Quad-port 8 Gb FC optical | Yes ¹ | Yes |
| Quad-port 1G Base-T IP | Yes | No |
| Quad-port 1 G Base-T iSCSI/TOE | No | Yes |
| Dual-port 10 Gb Ethernet/FCoE | No | Yes |
| Dual-port 10 GbE iSCSI (optical/TwinAx) | No | Yes |
| Dual-port 10 Gb Ethernet (optical/twin-ax) | Yes | No |
| Quad-port 6 Gb SAS | No | Yes ² |
| Dual-port 10 G Base-T (copper) | Yes | No |
| Dual-port 10 G Base-T ISCSI | No | Yes |

¹ Used for connectivity between blades and storage processors, and NDMP-based backups only; not supported for host connectivity.

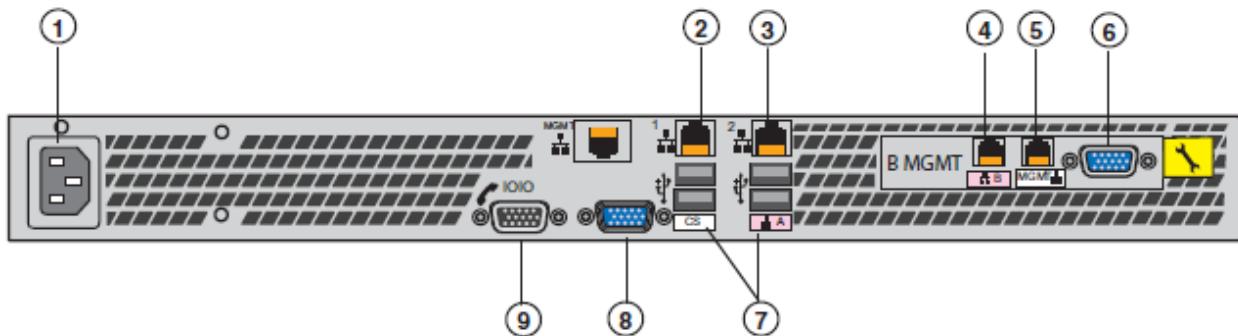
² Used for back-end connectivity only; not supported for host connectivity. VNX5200 and VNX5400 do not support SAS I/O module.

Control Station

The Control Station is a 1U self-contained server, used in unified, file, and gateway configurations. The Control Station provides administrative access to the blades; it also monitors the blades and facilitates failover in the event of a blade runtime issue.

The Control Station provides network communication to each storage processor. It uses Proxy ARP technology to enable communication over the Control Station management Ethernet port to each storage processor's own IP address.

An optional secondary Control Station is available; it acts as a standby unit to provide redundancy for the primary Control Station.



| | | | |
|---|------------------------------------|---|---|
| 1 | AC power in connector | 6 | DB-9 serial console plug connector |
| 2 | RJ-45 Ethernet port (labeled CS) | 7 | Four USB 2.0 connectors (not used) |
| 3 | RJ-45 Ethernet port (labeled A) | 8 | DB-15 video (VGA) socket connector (not used) |
| 4 | RJ-45 Ethernet port (labeled B) | 9 | DB-9 modem plug connector |
| 5 | RJ-45 Ethernet port (labeled MGMT) | | |

Figure 51. Back of Control Station

The RJ-45 Ethernet NIC port (number 2 in [Figure 51](#)) uses an Intelligent Platform Management Interface V2 (IPMIv2) cable to connect to an optional secondary Control Station. This IPMI port is labeled CS on the Control Station.

Software on the VNX2 series

MCx™

The VNX2 series introduces an entirely new Block Operating environment known as MCx. MCx is a combination of Multicore Cache, Multicore RAID, and Multicore FAST Cache combining to enable the array to fully leverage the new Intel multicore CPU architecture. A re-architecture of the core Block OE stack within the VNX2, MCx ensures optimum performance in an adaptive architecture and at high scale with little to no customer intervention. MCx delivers core functionality improvements that make the VNX2 platform more robust, more reliable, more predictable, and easier to use. The MCx architecture is a true enterprise-ready storage platform.

MCx is designed to scale performance across all cores and sockets. Along with the ability to scale across processor cores, MCx offers significant improvements in I/O path latency.

Multicore Cache

Multicore Cache removes the need to manually separate space for read vs. write cache, so there is no management overhead in ensuring the cache is working in the most effective manner, regardless of the I/O mix coming into the system. SP Cache management is now fully automated and implements highly advanced caching algorithms to optimally handle varying sequential and random read and write workloads. Write flushing is highly intelligent and tracks arrival rates, as well as the ability of the back-end disks to write the data out of cache, and can throttle write arrival rates so that forced flush situations are a thing of the past. Cache allocation occurs on the fly for both reads and writes--dynamically adjusting, self-tuning, and constantly optimizing regardless of changing workloads.

Multicore RAID

Multicore RAID enhances handling of I/O to the permanent back end storage (HDDs and SSDs). Modularization of back-end data management processing allows for a seamless scale across all processors.

In addition, RAID processing is highly mature and the VNX2 series delivers improved flexibility, ease of use, performance, and reliability with new features:

- Permanent Sparing: Instead of having to define disks as permanent hot spares, the sparing function is now significantly more flexible. Any unassigned drive in the system can operate as a hot spare. The ability to specify different types of policies is available, allowing for control over sparing. The “Recommended” policy merely implements the same sparing model as today (1 spare per 30 drives). When a drive is used in a sparing function, that particular drive becomes a permanent member of the RAID group. There is no need to re-balance and copy back (i.e., equalize) the spare drive to a new drive, thereby reducing the exposure and performance overhead of sparing operations.
- Drive Mobility: Also known as Portable Drives, allows users to move VNX2 disks within the array (online drive movement). Drive Mobility is very closely related to the

Permanent Sparing feature. RAID group data continues to be available after the drive is pulled out. When a drive becomes unavailable (for example, it fails, is pulled out of the slot, encounters a firmware error, etc.) MCx starts a 5-minute counter. Drive sparing is invoked after the 5-minute interval passes. Pulling any active drive out degrades its RAID group. After the drive is re-inserted into the array, the RAID group returns to a healthy, operational state. Move drives within a VNX2 array with caution, and note that the Copy-To-Disk operation (using the CLI) is the preferred method of migrating data to another drive.

- RAID 6 Parallel Rebuild: Multicore RAID supports the rebuild of two drives in parallel in RAID 6 configurations. This allows for improved resiliency and protection, as the degraded RAID group is reconstructed and restored faster.

Symmetric Active/Active

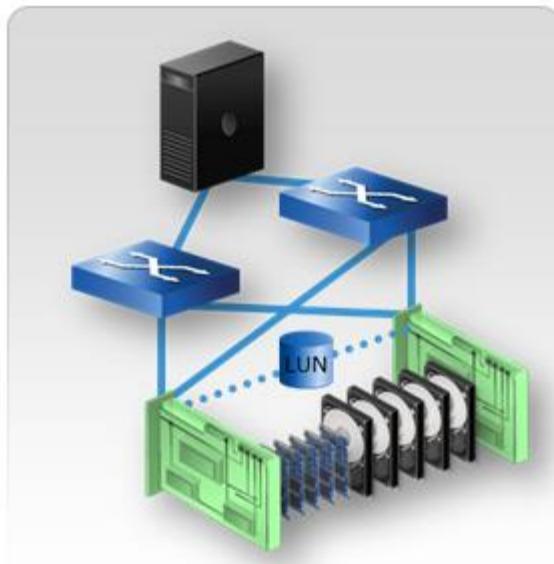


Figure 52. Symmetric Active/Active

Symmetric Active/Active allows clients to access a Classic LUN simultaneously through both SPs for improved reliability, ease-of management, and improved performance. Since all paths are active, there is no need for the storage processor "trespass" to gain access to the LUN "owned" by the other storage processor on a path failure, eliminating application timeouts. The same is true for an SP failure, as the SP simply picks up all of the I/Os from the host through the alternate "optimized" path.

Symmetric Active/Active is not supported on pool LUNs.

For more information on MCx, refer to the white paper titled, *VNX MCx*, available on EMC Online Support.

Reserved area on VNX2 series storage systems

The first four drives in enclosure 0 bus 0 house the array's operating environment, boot image, and file control LUNs. (These first four drives are disks 0 through 3 in either the DPE in the VNX5200/VNX5400/VNX5600/VNX5800/VNX7600 or the first DAE in the VNX8000, also known as *The Vault*) This reserved area consumes 300 GB per disk and provides the landing area for data in-flight that is de-staged from the cache in the event of a power failure. If using 300 GB drives in the vault, there will be no user space available on these drives. NL-SAS drives can be used for vault drives on the VNX5200, VNX5400, and VNX5600 only.

Unified management

EMC Unisphere provides a flexible, integrated experience for managing VNX2 storage systems.

Unisphere provides simplicity, flexibility, and automation—all key requirements for optimal storage management. Unisphere's ease of use is reflected in its intuitive task-based controls, customizable dashboards, and single-click access to real-time support tools and online customer communities. Unisphere's wizards help you provision and manage your storage while automatically implementing best practices for your configuration.

Unisphere is completely web-enabled for remote management of your storage environment. Unisphere Management Server runs on the SPs and the Control Station. To launch the Unisphere server, by point your browser to the IP address of either SP or the Control Station.

Unisphere offers all the existing features and functionality of previous interfaces, such as VMware awareness, LDAP integration, Analyzer, and Quality of Service Manager. Unisphere also adds many new features like dashboards, task-based navigation, and online support tools. For more information on Unisphere, refer to the white paper titled, *EMC Unisphere: Unified Storage Management Solution for the VNX2 Series*, available on EMC Online Support.

[Figure 53](#) displays the new system dashboard. You can customize the widgets (also referred to as *panels*) in the dashboard.

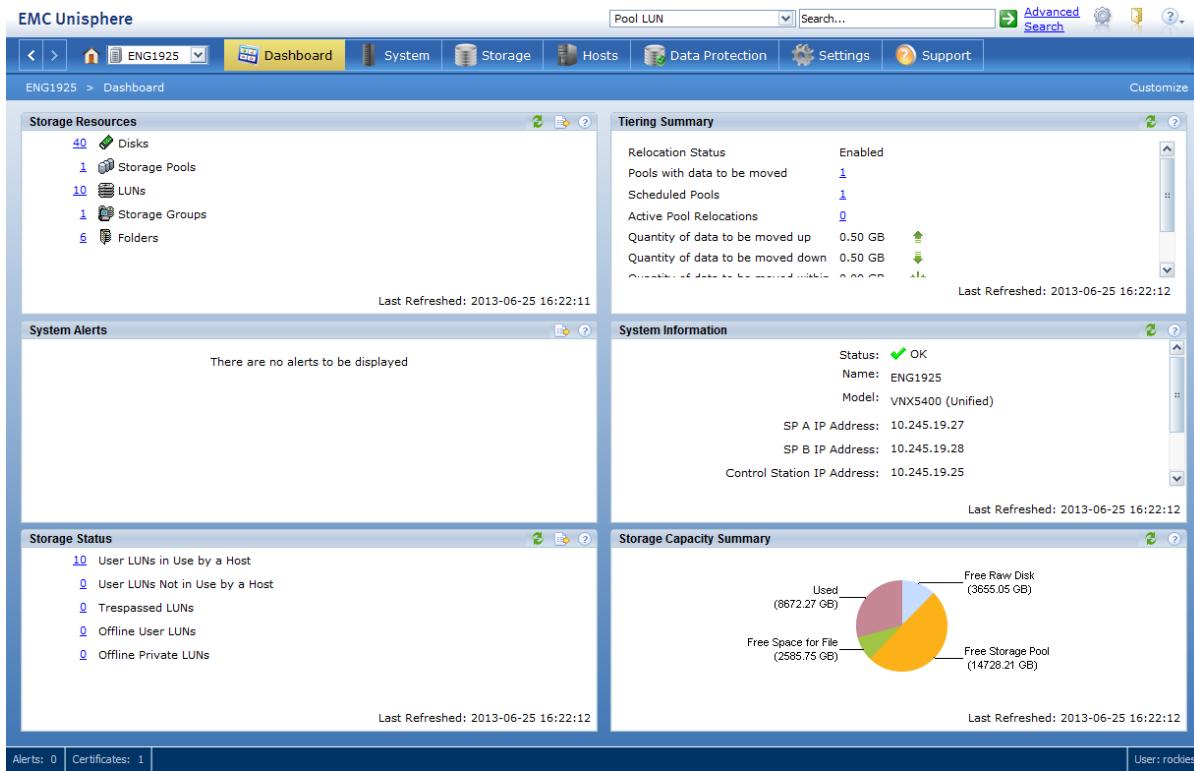


Figure 53. Unisphere dashboard has customizable panels (widgets)

Software for efficiency

Fully Automated Storage Tiering for Virtual Pools (FAST VP)

EMC leverages FAST VP to migrate data to high-performance drives or high-capacity drives, depending on end-user access. Customers require fewer drives and receive the best ROI from those that are configured.

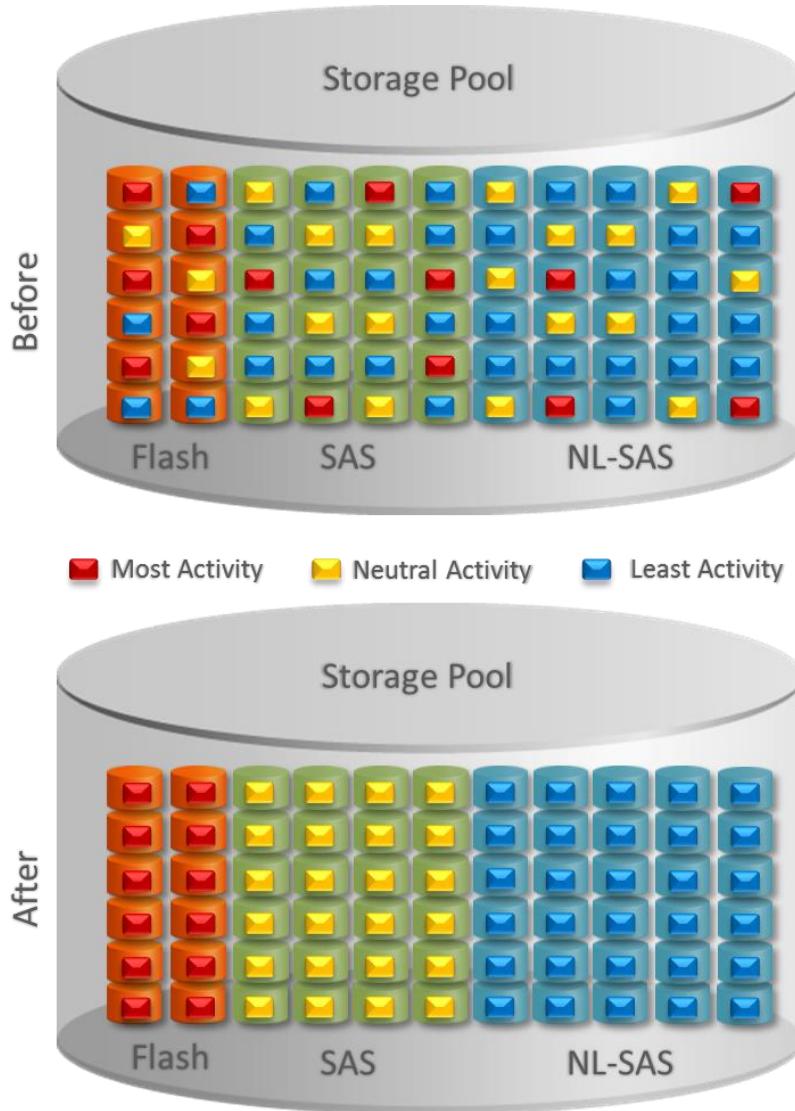


Figure 54. The FAST VP process

FAST VP functionality is enhanced on the VNX2 series, and is available for both block and file data. FAST VP optimizes storage utilization by automatically moving data between storage tiers (for example, Flash, SAS, and NL-SAS). Data also moves within tiers.

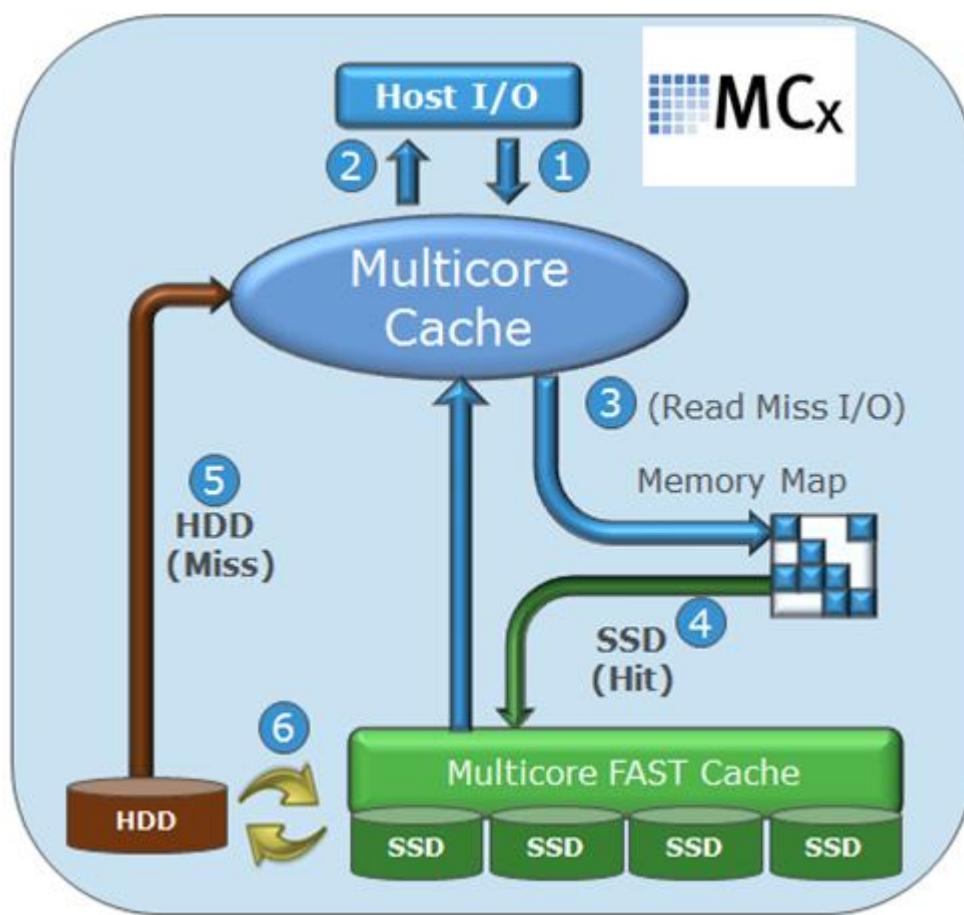
FAST VP optimized SSD drives are now available with the VNX2 series. When comparing these drives to other SSD's, FAST VP optimized drives are more cost effective and

appropriate when data change rates are more moderate. FAST VP optimized drives cannot be used for FAST Cache.

With the VNX2 series, data is moved in 256 MB slices (previous series was 1 GB) based on the access patterns of the I/O. The storage pools on the left in [Figure 54](#) show the initial storage configuration. After implementing FAST VP (shown on the right), the system proactively optimizes the storage pool by moving the 256 MB slices of sub-LUN data to the most effective drive. This ensures that the appropriate data is housed on the right tier at the right time, significantly increasing efficiency and performance.

You can set policies and schedules to help determine how and when the data is moved. For more information on FAST VP, refer to the *EMC VNX2 FAST VP white paper*, available on EMC Online Support.

Multicore FAST Cache



[Figure 55. FAST Cache process](#)

FAST Cache remains an industry-leading feature for EMC storage arrays. The VNX2 series uses this feature to extend the array's read-write cache and ensure that unpredictable I/O spikes are serviced at Flash speeds, which benefits all applications. FAST Cache perfectly complements FAST VP, as it works at a more granular level by copying 64 KB chunks onto Flash drives reserved for FAST Cache, depending on I/O characteristics. Multicore FAST Cache allows for faster initial cache warm-up, resulting in immediate FAST Cache benefits.

Repeated access of the same 64 KB chunk of data causes the policy engine to promote that data to FAST Cache. With a response time in the order of microseconds to milliseconds, FAST Cache also works in faster cycles than does FAST VP. FAST Cache reacts to I/O spikes and maintains access levels by acting as an extension to onboard memory.

FAST Cache is most appropriate for workloads with a high locality of reference, for example, applications that access a small area of storage with very high frequency, such as database indices and reference tables. FAST Cache is not designed for very large I/O streams that are sequential, such as backups, because each 64 KB chunk is accessed only once. Multicore Cache, however, uses various algorithms to optimize sequential I/O and handle these workloads. FAST Cache is most useful for handling spikes in I/O, and it benefits applications that may have unpredictable I/O profiles. For more information, refer to the *EMC VNX2 Multicore FAST Cache* white paper, available on EMC Online support.

Deduplication and compression

With VNX2 deduplication and compression, users can significantly increase storage utilization for file and block data. Often, effective utilization is increased two to three times compared with traditional storage.

Management is simple and convenient. Once capacity-optimization technologies are turned on, the system intelligently manages capacity-optimization processes as new data is written.



| | | | | | | |
|-----------------|----------------|-----------------|-----------------|----------------|-----------------|----------------|
| 8KB 8KB 8KB 8KB | LUN 1 Index | 8KB 8KB 8KB 8KB | 8KB 8KB 8KB 8KB | LUN 2 Index | 8KB 8KB 8KB 8KB | LUN 3 Index |
| 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | |
| 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | |
| 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | |
| 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | |
| 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | |
| 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | |
| 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | 8KB 8KB 8KB 8KB | | 8KB 8KB 8KB 8KB | |

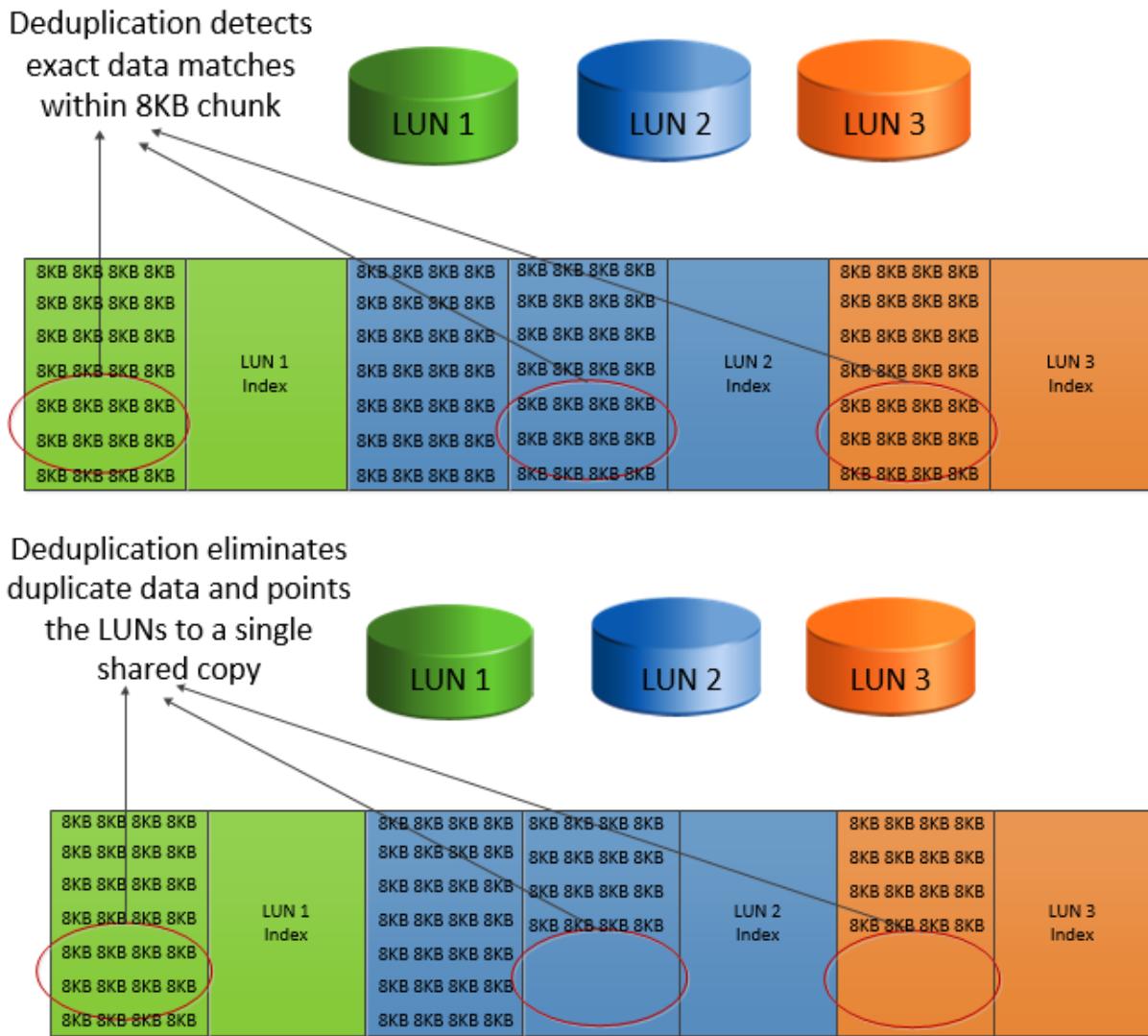


Figure 56. Block deduplication process eliminating 8KB chunks

Block deduplication makes its debut in the VNX2 series. Block deduplication occurs at the 8KB block level within the slices of the deduplication container within the pool. The deduplication container is the set of LUNs that the deduplication engine compares against each other to identify common data blocks.

The deduplication engine compares 8KB blocks of the LUNs in the deduplication container during its pass of the LUNs. The deduplication engine runs per pool, and identifies candidates for deduplication in the background. The end result of block deduplication is that 8KB data blocks within pool slices shared by multiple LUNs or within a single LUN. When a candidate for deduplication is found, the system does a bit-by-bit comparison to verify that the data is in fact the same.

Blocks freed by deduplication can be used for other writes to this LUN. If there are 256MB of blocks freed or one slice, then that slice returns to the pool.

When a host writes to an address range previously deduplicated to a shared block of storage, deduplication software sends the write to a new location and that portion of the data is no longer shared. The deduplication software examines that data for possible deduplication on the next pass.

The File deduplication feature includes file-level compression and file-level single instancing. This asynchronous feature works in the background, scanning for inactive files that may contain duplicate data. If there is more than one instance of a file, it will be single-instanced and compressed.

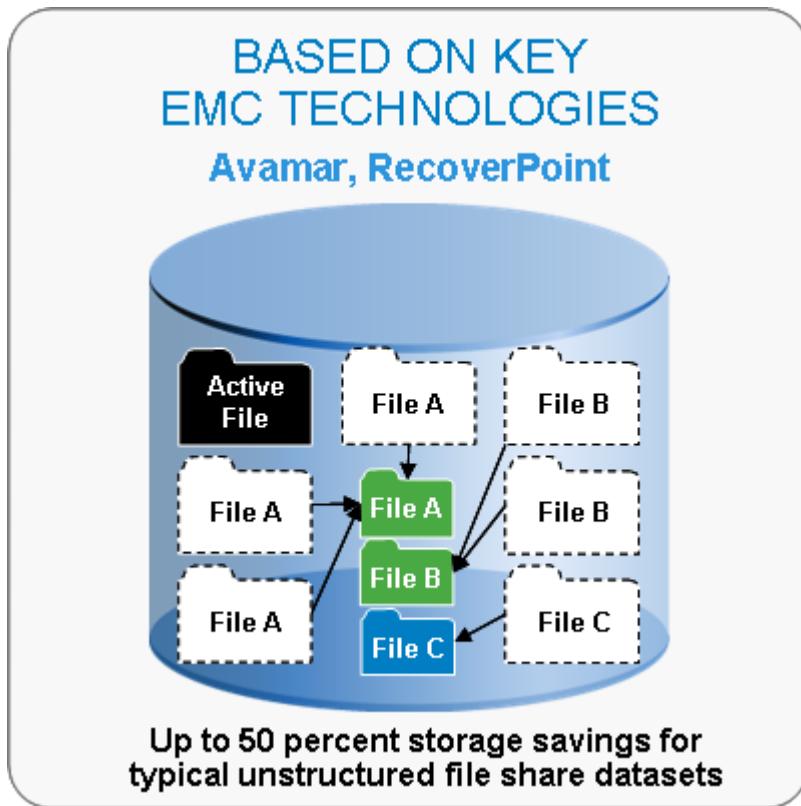


Figure 57. File deduplication

This feature helps increase the file storage efficiency by eliminating redundant data within file systems, thereby reducing storage costs. It has user-configurable settings that can filter certain files from being processed. It can be turned on or off on a per-file-system basis at any time.

For more information on both Block and File deduplication, refer to the *EMC VNX Deduplication and Compression* white paper, available on EMC Online Support.

Windows 8.1 and Server 2012 R2

The VNX2 series supports the SMB 3.0 protocol, which is available with Microsoft Windows 8 and Microsoft Windows Server 2012 systems. It offers significant improvements over previous SMB versions.

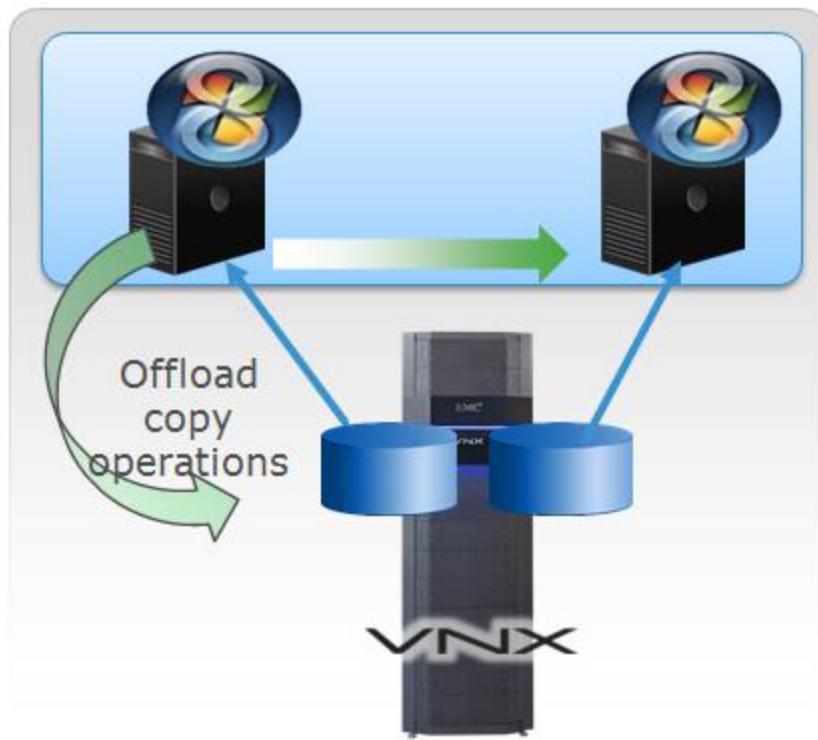


Figure 58. Offloaded Data Transfer (ODX)

The VNX2 series supports SMB 3.0 enhancements, including:

- **Continuous Availability (CA):** Continuous Availability enables applications to be less affected during a Data Mover or cluster failover. With CA, if the application timeout does not exceed the failover period, application access to all open files present prior to the failover is re-established and the failover is transparent to end users.
- **Multichannel:** Multiple TCP connections can now be associated with a single SMB 3.0 session, and a client application can use several connections to transfer I/O on a CIFS share. This capability optimizes bandwidth, and it enables failover and load balancing with multiple NICs.
- **Directory Lease:** SMB2 introduced a directory cache that allowed clients to cache a directory listing to save network bandwidth, but it did not see new updates. SMB3 introduces a directory lease so the client is now automatically aware of changes made in a cached directory.
- **Offload Copy:** Copying data within the same Data Mover can now be offloaded to the array, reducing the workload on the client and network.

- **SMB Encryption:** This capability provides secure access to data on CIFS shares, protecting data on untrusted networks and providing end-to-end encryption of data in-flight.
- **Remote Volume Shadow Copy Service (RVSS):** With RVSS, point-in-time snapshots can be taken across multiple CIFS shares, providing improved performance in backup and restore.
- **BranchCache V2:** BranchCache can be used when you have branch offices that connect to the main office via a WAN. This connection mode is generally very slow and expensive. The idea behind BranchCache is that it's faster to download the file directly from another computer at the same branch office using the LAN, instead of going over the WAN. In BranchCache V2, there is no concept of blocks. Files are divided into segments and segments are hashed, and the VNX2 uses a fixed segment size of 128KB.

In addition to SMB 3.0 support, the VNX2 series also supports the following:

- **Storage Management Initiative Specification (SMI-S) File:** SMI-S is the primary storage management interface for Windows Server 2012 and SCVMM. It can be used to provision storage directly from Windows Server 2012 and supports heterogeneous storage environments. It is based on the WBEM, CIM, and CIM/XML open standards.
- **Offloaded Data Transfer (ODX):** When a host performs a large data transfer within the same array, the data needs to travel from the array to the host and then back to the array. This path wastes bandwidth and host resources. ODX is a SCSI token-based copy method that offloads data copies to the array, saving both bandwidth and host resources.
- **Thin Provisioning Support:** When a storage pool high water-mark is met with a thin LUN, Server 2012 is alerted and the event log updated. Server 2012 supports space reclaim when files are deleted from an NTFS formatted Thin LUN. Space is returned from a thin LUN to the pool in 256MB slices.
- **N_Port ID Virtualization (NPIV):** NPIV support has been added to the Unisphere Host Agent on Windows Server 2012. This addition allows multiple virtual FC initiators to use a single physical port, giving Hyper-V VMs a dedicated path to the array. Now push registrations from virtual machines are allowed through the virtual port.

Virtual Data Movers (VDMs)

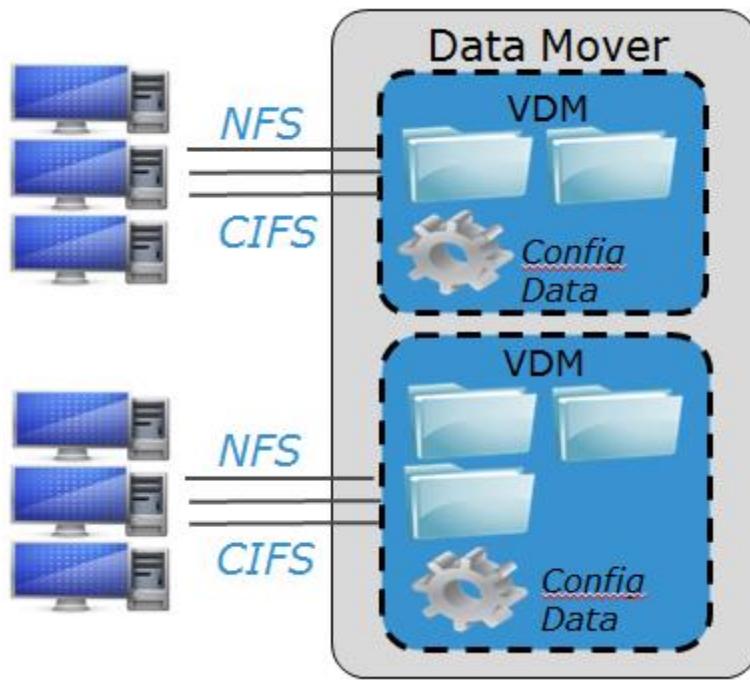


Figure 59. Virtual Data Movers

Virtual Data Movers (VDMs) are used for isolating Data Mover instances within a secure logical partition. VDMs are important for in-company multi-tenancy, as well as ease of use when deploying replication solutions. VDMs support multi-protocol implementations concurrently to the same file system.

VDMs are file system containers that provide a Virtual Data Mover with independence from other VDMs in the same physical Data Mover. A VDM is a security mechanism as well as an enabling technology that simplifies the DR failover process. It maintains file system context information (meta-data) to avoid rebuilding these structures on failover. File systems can be mounted beneath VDM's which are logically isolated from each other.

VDMs can be used to support multiple LDAP domains within a customer environment, and they can also be used to allow for easier re-balancing of file load across physical blades by simply moving VDMs and their underlying file systems between Data Movers.

Thin Provisioning

EMC's Thin Provisioning feature allows storage administrators to allocate storage on demand, and is easy to set up and monitor. While it presents a host with the total amount of storage requested, it only allocates storage on the array that is actually being used.

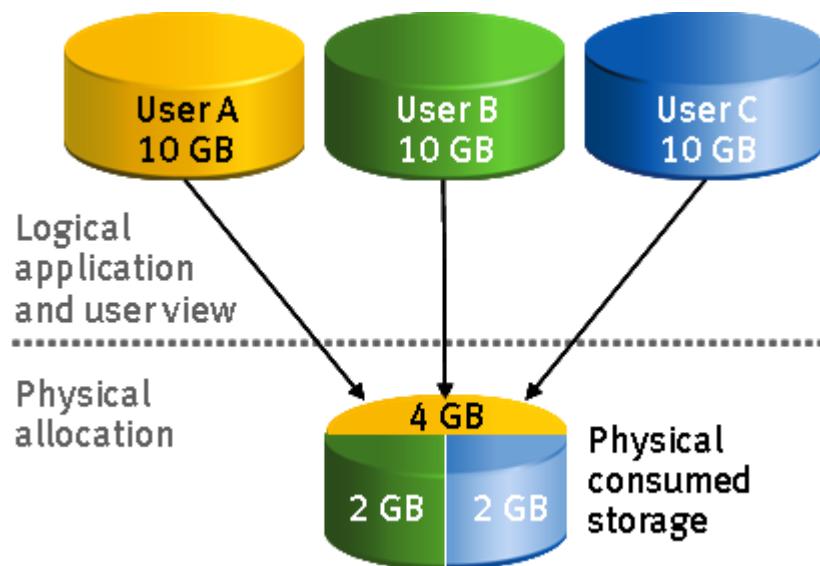


Figure 60. Thin Provisioning

For example, a 100 GB file system that has been thin provisioned will be seen by hosts and users as 100 GB. If only 50 percent of the file system is actually in use (contains data), only 50 GB will be used on the array. This feature prevents overprovisioning unused storage.

Thin Provisioning increases storage utilization, brings down costs associated with maintaining the storage (such as power and cooling), and lowers acquisition costs of new storage hardware. When using this feature on the block components, an administrator creates thin LUNs instead of thick LUNs. Thin LUNs will allocate 1.75 GB at LUN creation; however, this will not reserve the space necessary for the entire size of the newly created LUN. Additional space is assigned 256 MB at a time; however, only 8 KB chunks are reserved as needed.

Administrators should understand the growth rate of their pools and file systems to know what percentage is practical and allow enough time to address potential oversubscription issues. For more information on Thin Provisioning, refer to the *EMC VNX Virtual Provisioning for the VNX2 Series* white paper, available on EMC Online Support.

Software for protection

VNX Replicator

EMC VNX Replicator is an asynchronous file-based replication solution. This feature is used for file-system-level replication, and provides point-in-time views of the source file systems on the replica file systems.

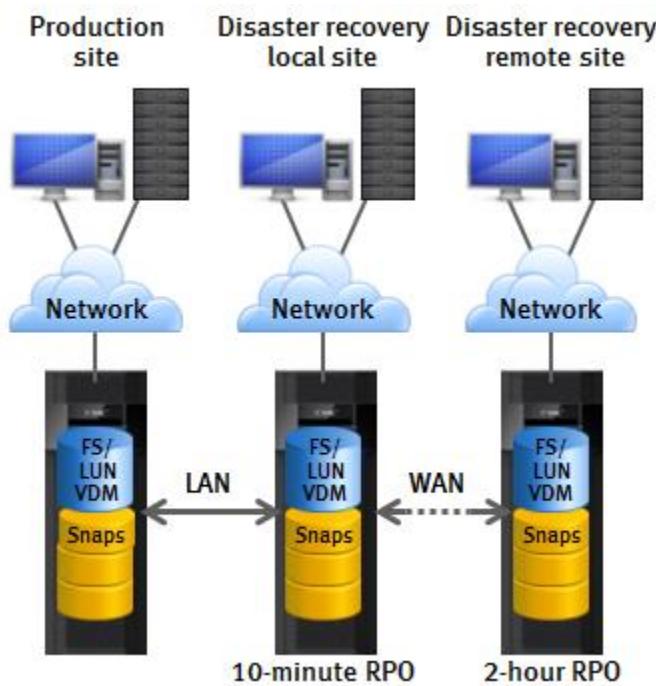


Figure 61. EMC VNX Replicator

VNX Replicator uses an adaptive scheduling technology that responds to changing network conditions by monitoring two key pieces of information:

- The amount of change (delta) that has built up in the production object since the last transfer
- The average transfer rate that was observed during the last transfer

This adaptive-scheduling technology dynamically allocates resources to ensure that objects are replicated in compliance with their customer-configurable recovery point objectives (RPOs). An RPO is a measurement of how much data may be lost before it negatively affects the business. Each file system can have a different RPO because the importance of each file system's contents may differ.

VNX Replicator also allows bandwidth throttling based on a schedule, e.g., change the throughput during specific times throughout the week. This is very useful in environments where VNX Replicator shares network resources with other applications.

RecoverPoint integration

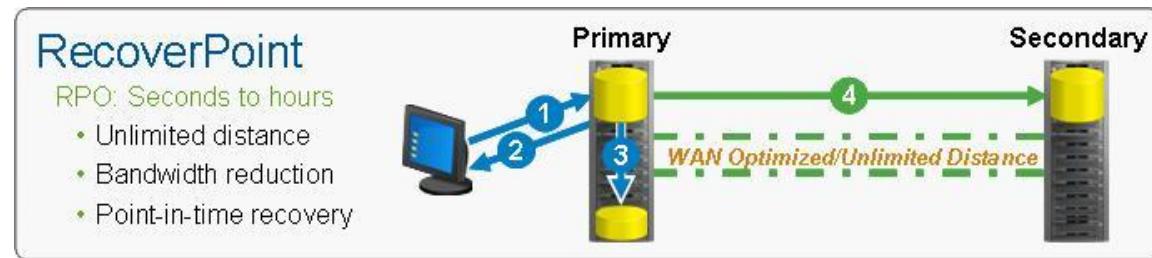


Figure 62. How RecoverPoint works

RecoverPoint provides a synchronous/asynchronous replication solution to allow file and block (consistency group) cabinet-level business continuation on a remote VNX series array in the event of a disaster. Unisphere is designed to accept plug-ins that will extend its management capabilities. VNX series arrays are managed with the latest version of Unisphere that includes RecoverPoint integration for replication of block and file data.

This support includes active/passive, and active/active modes, using continuous remote replication (CRR). Because RecoverPoint uses a single consistency group to provide array-level replication for files and does not provide point-in-time views, it is most appropriate for control LUNs and critical file systems. It is, therefore, still recommended that you use EMC VNX Replicator for file system-level replication.

MirrorView/A

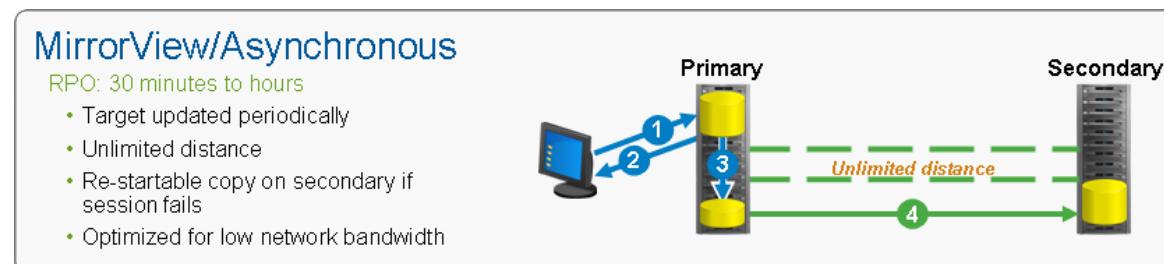


Figure 63. How MirrorView/A works

EMC VNX MirrorView™/A is a block feature for remote mirroring that works asynchronously to copy information on a LUN periodically from one storage system to another. As an asynchronous process, it provides replication over long distances on the order of hundreds to thousands of miles and has an RPO from 30 minutes to hours. MirrorView/A is optimized for low network bandwidth.

MirrorView/S

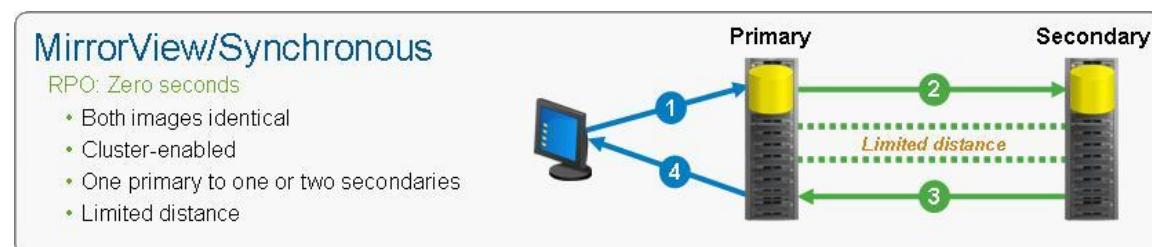


Figure 64. How MirrorView/S works

EMC VNX MirrorView/S is a block feature for remote mirroring that works synchronously to copy information on a LUN from one storage system to another. The synchronous nature of this feature means that for every write to a LUN on the primary storage system, the same write is copied to the secondary storage system before the write acknowledgement is sent to the host.

With Dense Wavelength Division Multiplexing (DWDM), MirrorView/S provides replication over distances of up to 200 km. Without DWDM, MirrorView/S provides replication over distances of up to 60 km. In each case, the RPO is zero seconds, because both copies of data are identical.

SAN Copy

EMC VNX SAN Copy™ is a block feature that copies data between EMC and qualified third-party storage systems. SAN Copy copies data directly from a source LUN on one storage system to destination LUNs on other systems without using any host resources. SAN Copy can be used to create full and incremental copies of a source LUN.

SAN Copy can be used for a number of purposes, including data movement for consolidated business processing activities, backup to tape, backup to disk, data warehouse refreshes, and replication of databases from one storage system to another over the SAN without the need for host-based replication software.

For more information on VNX Replication options, see the *EMC VNX Replication Technologies* white paper. For information on VDMs and the ability to migrate them, see the *Virtual Data Movers on EMC VNX* white paper. Both of these white papers are available on EMC Online Support.

Business continuance

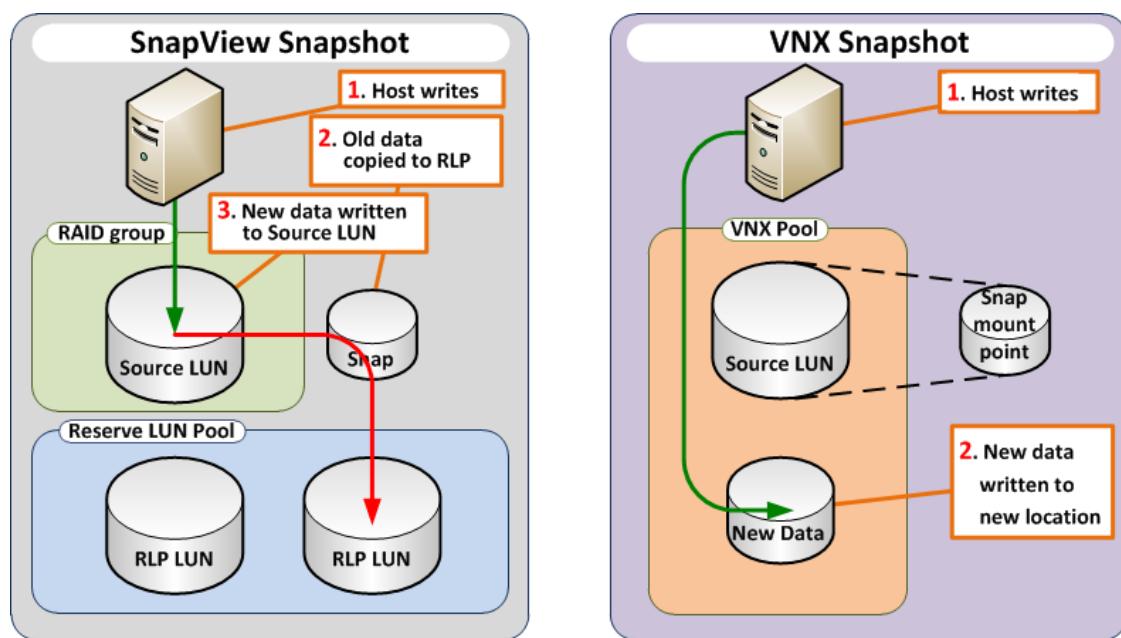
VNX Snapshots

VNX Snapshots is a feature created to improve snapshot capability for VNX Block. VNX Snapshots are point-in-time views of a LUN that can be made accessible to another host, or be held as a copy for possible restoration. VNX Snapshots use a redirect-on-write algorithm, and are limited to pool-based provisioned LUNs (i.e., not Classic LUNs), and they support 256 writable snaps per pool LUN. Branching, or snap of a snap, is also supported. VNX Snapshots support Consistency Groups, allowing several pool LUNs to be snapped at the same time. For more information, see the *EMC VNX Snapshots* white paper, available on EMC Online Support.

SnapView snapshots

EMC VNX SnapView snapshots are point-in-time views of a LUN that can be made accessible to another host, or be held as a copy for possible restoration. SnapView snapshots use a pointer-and-copy-based algorithm. A memory map keeps track of *chunks* (blocks) of data.

Before chunks of data are written to the source LUN, they are copied to a reserved area in private space, and the memory map is updated with the new location of these chunks. This process is referred to as *Copy on First Write*. The source LUN, reserved LUN, and memory map work together to create the snapshot.



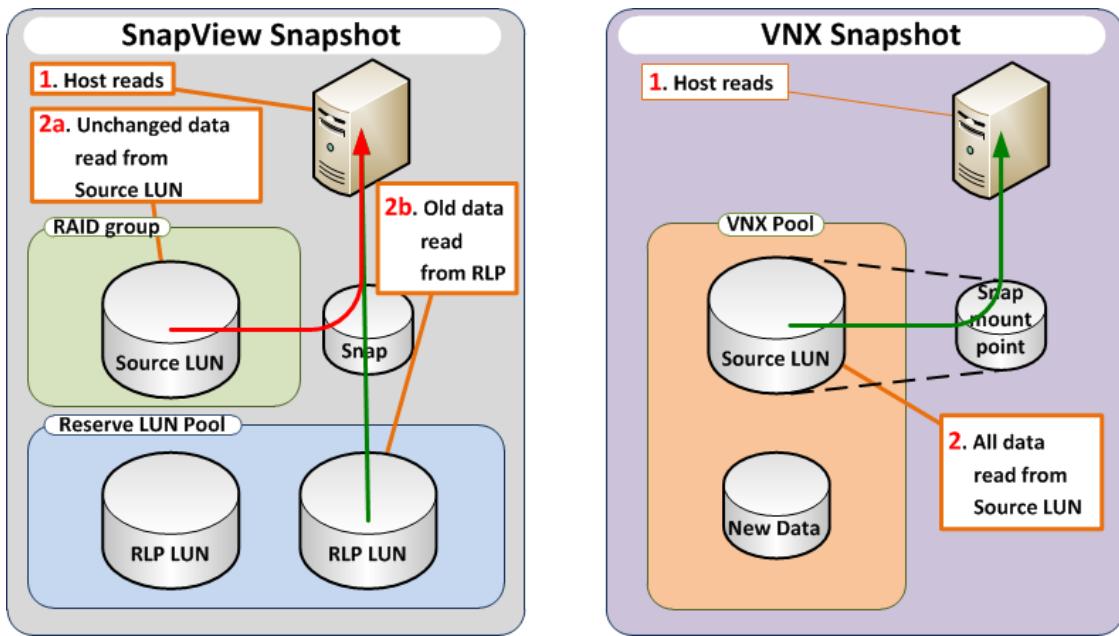


Figure 65. VNX Snapshots vs. SnapView Snapshots

SnapSure checkpoints

EMC VNX SnapSure™ checkpoints are point-in-time snapshots for file systems. This feature allows creation of multiple non-disaster recoverable copies of production data. Checkpoints enable end users to restore their files by integrating with Microsoft Volume Shadow Copy Services. UNIX and Windows clients may also access checkpoints to restore individual files through a hidden directory.

The Unisphere GUI gives the storage administrator a quick and easy way to restore entire file systems from checkpoints. SnapSure is the underlying technology that supports checkpoints, and it uses a Copy-on-First-Write algorithm to maintain checkpoint views.

SnapView clones

SnapView clones are fully populated point-in-time copies of LUNs that allow incremental synchronization between source and destination LUNs. Unlike snapshots that provide point-in-time views of data, clones provide fully populated point-in-time copies that maximize the flexibility of the storage environment. These point-in-time copies allow you to perform additional storage management tasks with minimal impact to production data. These tasks include backup/recovery, application testing, warehousing, and data movement.

Security

Data-At-Rest Encryption

The VNX2 series introduces Data-at-Rest Encryption (D@RE) that uses hardware embedded in the SAS controllers to encrypt data stored on disk. D@RE is available on the entire VNX2 series, starting with the VNX5200 through the VNX8000.

The purpose of the VNX D@RE solution is to encrypt all data written to the array by using a regular data path protocol. This is accomplished by encrypting the information as it is written to disk using a unique key per disk. If any drives are removed from the array (for example, due to drive failure or theft), the information on the drive is unintelligible. In addition, the VNX D@RE solution provides a mechanism to quickly erase encrypted data by deleting the keys associated with the drives in a RAID group or Storage Pool once those entities are deleted. This allows an array to be safely and quickly repurposed.

Some of the highlights of D@RE include:

- Encryption of all user data¹
- Embedded, fully-automated, and secure key generation, storage, deletion, and transport within the system:
 - RSA BSAFE for key generation
 - RSA Common Security Toolkit (CST) Lockbox for key storage
 - VNX Key Manager for monitoring status changes on drives
 - Encryption of all Data Encryption Keys (DEKs) prior to movement within the array
- Minimal performance impact for typical mixed workloads
- Support for all drive types, speeds and sizes
- Support for all advanced data services (e.g., compression, deduplication)
- Designed to be largely invisible to the user once enabled, with the exception of the keystore backup for administrators

D@RE also provides the benefit of crypto-erasure when the data is no longer needed. An example is the ability to return a faulted drive without needing to sanitize the disk first, since the encrypted data cannot be read outside of the array. Another example is when a pool or RAID Group is deleted, the DEKs associated with those drives are also permanently deleted. This means the drives can be quickly and safely repurposed without a risk of exposing the data that was previously on those drives.

For more information, see the *EMC VNX2: Data-At-Rest Encryption* white paper, available on EMC Online Support.

¹ Some unencrypted data could be in the system partition (for example, hostnames, IP addresses, dumps, and so on). All data written to the array using regular I/O protocols (iSCSI, FC) is encrypted. Anything that comes into the array using the control path will not be encrypted by this solution. However, sensitive information (for example, passwords) is encrypted by a different mechanism (as they are on non-encrypting arrays).

Anti-virus software

The Common Event Enabler (CEE) allows VNX to integrate with industry-leading anti-virus applications, such as Symantec, McAfee, Computer Associates, Sophos, Kaspersky, and Trend Micro.

The anti-virus feature works with an external system that houses one of the supported anti-virus applications. Once configured, files on a file system are scanned before they are delivered to the requesting client. The file is either validated and sent to the client or denied if any issues are identified during the scan. A scan also occurs after a file is modified and closed. If no modifications are performed on the file, it is not rescanned when closed. This feature can be configured to either scan files on write (default) or scan files on read. In addition, there is the capability to scan all files in the file system with a separate command. This feature helps protect files from viruses and malware while still allowing you to benefit from the advanced VNX array features, such as high availability and performance.

Quota management and auditing

The CEE allows the VNX to integrate seamlessly with industry-leading content/quota management software applications (CQM applications). This enhanced functionality extends the built-in management capability to improve content and quota management along with auditing on file systems. This feature is comprised of a host framework and an agent that have been validated to support several of the leading CQM application vendors.

File-Level Retention

The File-Level Retention (FLR) feature protects files from deletion or modification until a user-specified retention date elapses. FLR prevents users from deleting or modifying locked and protected files. There are two levels of FLR protection enabled at the file system level upon creation:

- FLR-C File-Level Retention (Compliance level): Protects data from changes made by users through CIFS, NFS, and FTP, including administrator actions. This level of FLR also meets the requirements of SEC Rule 17a-4(f). A file system that contains files that are locked with FLR-C cannot be deleted.
- FLR-E File-Level Retention (Enterprise level): Protects data from changes made by users through CIFS, NFS, and FTP, but not including administrator actions. This means that only a VNX administrator with the appropriate authorization can delete an FLR-E file system containing FLR-E protected files. However, administrators still cannot target individually locked files for deletion or modification.

Figure 66 illustrates the workflow for FLR.

FILE-LEVEL RETENTION WORKFLOW

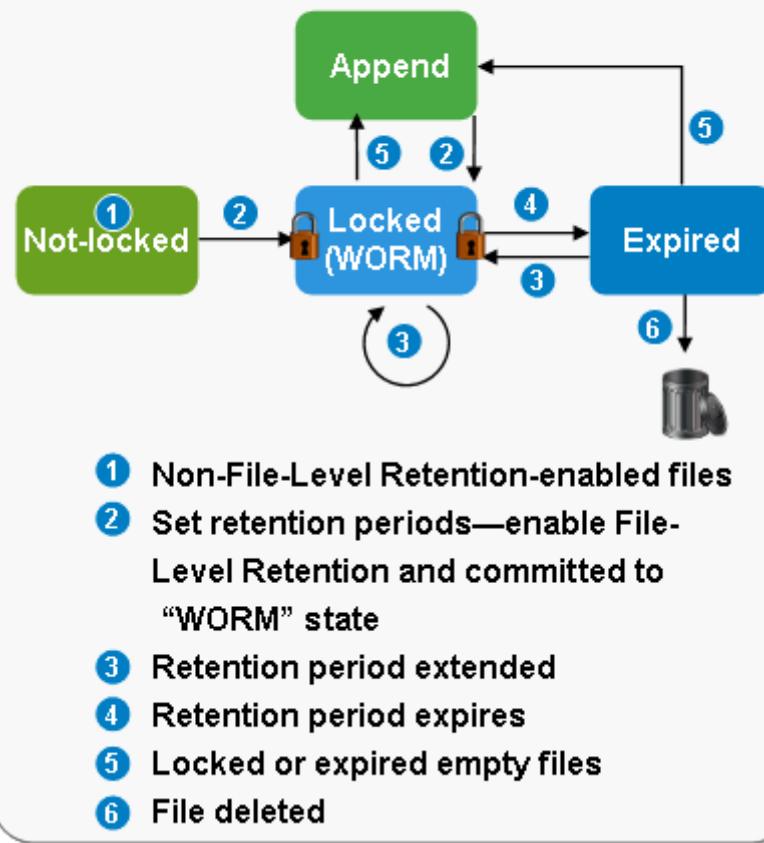


Figure 66. FLR Workflow

Advanced Data Services support for file

This feature allows VNX File to use pool-based LUNs, create file objects, and use FAST VP. When a file object (such as a file system) is created on a LUN, configuring and changing the LUN could adversely affect the file system it supports. To prevent this from happening, Unisphere provides the Advanced Data Service Support for file feature.

This feature allows the VNX system to account for the relationship between these file and block capabilities when certain functions are performed. The system warns the user, and even prevents certain actions when they can cause undesired results. For example, VNX displays an error and prevents the action when the end user tries to change the mirror status of a storage-pool LUN (from mirrored to non-mirrored or vice versa); this change would result in a pool having mirrored and non-mirrored LUNs.

VNX displays a warning (but still allows the action) when:

- LUNs underneath the same file system span multiple AVM pools.
- A new storage pool is discovered, and it contains mirrored and non-mirrored LUNs. Only one type of LUN will be mapped over to file; the rest will be skipped.
- A LUN is added to the “~filestorage” storage group from a pool with “mixed” data services. Data services include:
 - Tiering Policy (Start High then Auto-Tier/Auto-Tier/Highest/Lowest/No Movement)
 - Thick/thin LUN
 - Compression
 - Deduplication

A warning is displayed because the system cannot guarantee file system performance when supported by LUNs with different data services. Although not guaranteed, the system uses a “best effort” algorithm to find LUNs in the pool that have matching data services during file system creation and extension. The ability for the system to find LUNs with matching data services depends on LUN availability.

Serviceability, availability, and performance

Unisphere one-button shutdown

The VNX2 series introduces the ability to safely power down a unified, block, file, or gateway system right from Unisphere. Shutdown is performed from the Enterprise Dashboard System List page. For a planned power down event, shutting down a VNX2 series array is as simple as selecting the VNX2 system from the list and clicking the Power Off button. Unisphere reaches out to the storage system and initiates the shutdown sequence. For unified, block, and file arrays, the Control Station, Data Movers, and Storage Processors are powered down. For gateway systems, only the Control Station and Data Movers are powered down.

For more information regarding the shutdown procedure and sequence, refer to the *EMC VNX Series System Operations Guide – Release 8.1*, available on EMC Online Support.

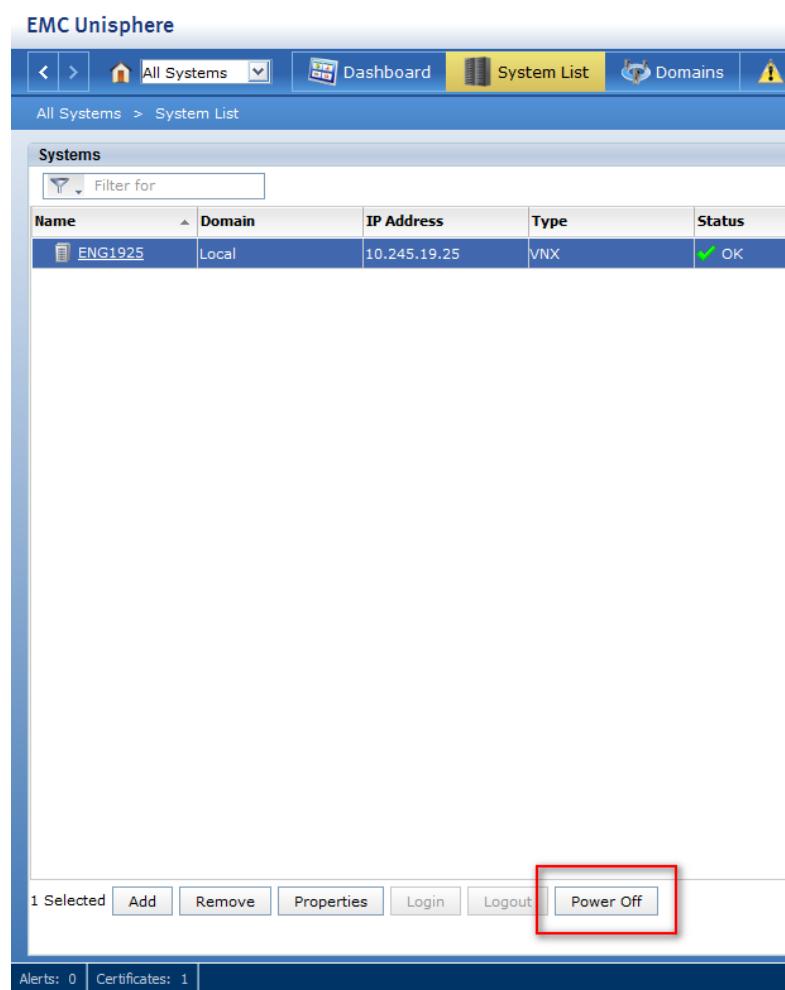


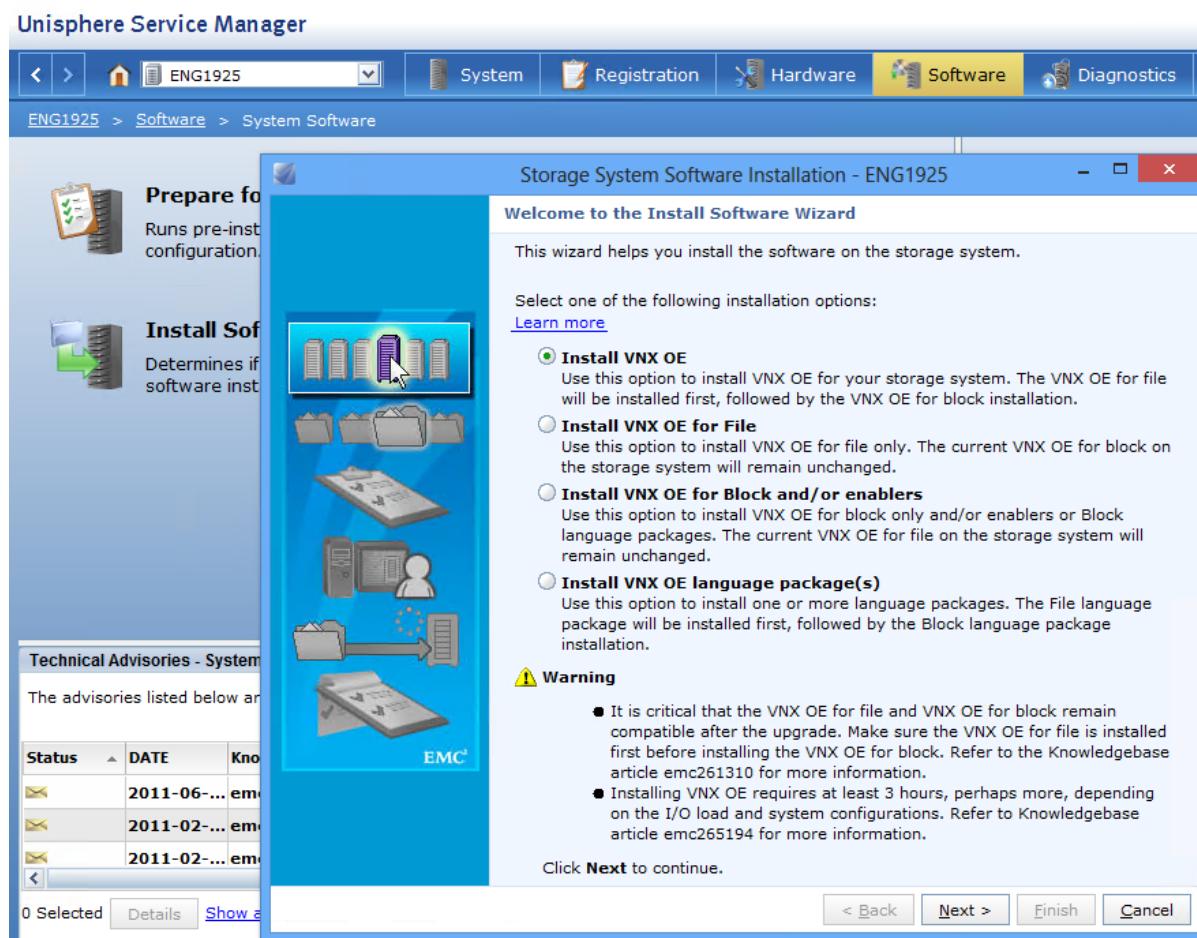
Figure 67. Power off a VNX2 through Unisphere

File-component control LUN protection

To ensure the safety and stability of the unified system, control LUNs for file have been moved to the VNX Private Space. Control LUNs are added automatically to a special system storage group named “~filestorage” that is visible in the Unisphere GUI. The system protects these LUNs by preventing them from being deleted or removed from the “~filestorage” group in the GUI. As further protection, navisecscsi commands cannot be used to manipulate these Control LUNs.

Unified software upgrade

The VNX series provides software upgrades as a single process using Unisphere Service Manager (USM). USM is a single utility that allows you to download updates, perform health checks, and install the new updates for both block and file. USM is also used to install software enablers and Unisphere language packs. [Figure 68](#) shows this support.



[Figure 68. Unisphere Service Manager software installation wizard](#)

Unified remote support

The VNX2 series offers fully unified remote support by leveraging EMC Secure Remote Services, known as EMC Secure Remote Support (ESRS). This secure IP-based system

allows dial home and remote access to the entire VNX using a secure and encrypted tunnel. ESRS allows organizations complete control over policies that dictate who may access their VNX2 and when that access may occur. There are several ESRS implementation options, including:

- Embedded device client on the Control Stations (Unified/File only arrays)
- Embedded device client on the Storage Processors (Block only arrays)
- IP Client
- VNX Gateway

For more information, refer to the *EMC Secure Remote Support for VNX* guide, available on EMC Online Support.

VNX2 scalability and performance

Improved overall performance

The VNX2 series is highly scalable and provides significantly more performance than the previous VNX series. The new MCx architecture takes full advantage of the Intel Xeon E5 multicore CPUs and allows cache and back-end processing software to scale in a linear fashion. In addition, other hardware improvements [such as the 6 Gb/s x 4 lanes SAS back end with an x 8 wide (6 Gb/s x 8 lanes) high-bandwidth option, PCIe Gen 3 I/O modules, and increased memory] integrate to deliver:

- Up to 4X more file transactions
- Up to 4X more Oracle and SQL OLTP transactions
- Up to 4X more virtual machines
- Up to 3X more bandwidth for Oracle and SQL data warehousing

Advanced availability and flexibility

The VNX2 series improves simplicity, resiliency, and flexibility with MCx. There is no requirement for explicitly defining hot spares, and hot spares now become a permanent member of a RAID group with no equalization required. There is no slot-to-drive location dependency, as drives are now identified by serial numbers and can be relocated between busses or shelves for bus balancing.

Optimized for Flash

The VNX2 series systems are designed to take better advantage of Flash drives than ever before. This efficiency comes from a combination of MCx and multicore processors. FAST Cache has an increased promotion queue so that it can handle even more promotions. A proactive clean process has been introduced to improve FAST Cache flushing, and FAST Cache itself now has a more aggressive policy on initial warm-up, performing like a standard extension of Multicore Cache.

Conclusion

The VNX2 series offers increased scalability, efficiency, and performance in a unified form factor and is managed using a single pane of glass, offering an unparalleled unified experience. The advances in hardware, introduction of the MCx architecture, and the enhancements to Flash and FAST, place the VNX2 series in the forefront of midrange offerings.

Whether workloads are on FC, NFS, or CIFS, the VNX2 series delivers industry-leading performance, efficiency, protection, and ease.

MCx enables the VNX2 series to:

- Scale on multi-processor architectures
- Deliver Active/Active capability
- Improve performance and scalability
- Improve memory efficiency

This new architecture offers not only significant performance benefits, but also greater efficiency, better protection, and simplicity. The VNX2 can:

- Reduce CAPEX with Block Deduplication
 - Improve VDI efficiency and VM deployment costs
- Reduce OPEX with FAST Suite
 - Lower \$/GB with FAST VP optimized drives and 256MB FAST VP granularity
- Increase application availability with Active/Active
 - Zero delay on path failure
 - Multi-path load balancing
- Lower TCO with Hyper-V deployments over NAS
- No management overhead to ensure effective cache operation
 - Fully automated SP cache management

The VNX2 series platform combined with MCx leverages the most advanced Intel multicore processor technologies to deliver more firepower, more efficiency, and more protection, all while simplifying management and reducing complexity.

Appendix A: System, block, and file level components

Table 3. System, block, and file level components

| Components Configuration | VNX5200 | VNX5400 | VNX5600 | VNX5800 | VNX7600 | VNX8000 |
|---|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|--------------------------------------|
| SYSTEM LEVEL COMPONENTS | | | | | | |
| Max FAST Cache memory | 600 GB | 1 TB | 2 TB | 3 TB | 4.2 TB | 4.2 TB |
| Max FAST Cache drives | 6 | 10 | 20 | 30 | 42 | 42 |
| Max drives per array | 125 | 250 | 500 | 750 | 1000 | 1500 |
| Min drives per storage system | 4 | 4 | 4 | 4 | 4 | 4 |
| Max raw capacity | 500 TB | 1 PB | 2 PB | 3 PB | 4 PB | 6 PB |
| Minimum configuration rack space | Block only: 3U File/Unified: 6U | Block only: 10U File/Unified: 13U |
| BLOCK COMPONENTS | | | | | | |
| Processor clock speed/number of cores/architecture (per SP) | 1.2 GHz 4-core Xeon E5 | 1.8 GHz 4-core Xeon E5 | 2.4 GHz 4-core Xeon E5 | 2.0 GHz 6-core Xeon E5 | 2.2 GHz 8-core Xeon E5 | Dual Socket 2.7 GHz 8-core Xeon E5 |
| Physical memory per SP (GB) | 16 | 16 | 24 | 32 | 64 | 128 |
| Max combined 8 Gb/s FC ports per SP (FE ports) | 12 | 16 | 20 | 20 | 20 | 36 |
| Max combined 1 Gb/s & 10 Gb/s iSCSI ports per SP (FE only) | 12 | 16 | 16 | 16 | 16 | 16 |
| Max FCoE ports per SP (FE only) | 8 | 8 | 10 | 10 | 10 | 18 |
| Max initiators per FC port | 256 | 256 | 256 | 256 | 256 | 512 |
| Max initiators per 1 Gb/s iSCSI port | 256 | 256 | 256 | 512 | 1024 | 1024 |
| Max initiators per 10 Gb/s iSCSI port | 256 | 256 | 256 | 512 | 1024 | 1024 |
| Max initiators per FCoE port | 256 | 256 | 256 | 256 | 256 | 512 |
| Max VLANs per 1 Gb/s | 8 | 8 | 8 | 8 | 8 | 8 |

| Components Configuration | VNX5200 | VNX5400 | VNX5600 | VNX5800 | VNX7600 | VNX8000 |
|--|--|----------------|----------------|----------------|----------------|----------|
| iSCSI port | | | | | | |
| Max VLANs per 10 Gb/s iSCSI port | 8 | 8 | 8 | 8 | 8 | 8 |
| Max initiators per SP | 1024 | 1024 | 1024 | 2048 | 4096 | 8192 |
| Max FE ports per SP (all types) | 20 | 20 | 20 | 20 | 20 | 40 |
| Max UltraFlex I/O module slots (per SP) | 3 | 4 | 5 | 5 | 5 | 11 |
| Max usable UltraFlex I/O module slots (front-end) (per SP) | Please see Table 5. Block configuration | | | | | |
| Embedded I/O ports per (per SP) | 2 back-end SAS | 2 back-end SAS | 2 back-end SAS | 2 back-end SAS | 2 back-end SAS | 0 |
| Max 6 Gb SAS ports for DAE connectivity (per SP) | 2 | 2 | 6 | 6 | 6 | 16 |
| Max Pools per storage system | 15 | 20 | 40 | 40 | 60 | 60 |
| Max Disks per pool | 121 | 246 | 496 | 746 | 996 | 1496 |
| Max LUNs per pool | 1000 | 1000 | 1100 | 2100 | 3000 | 4000 |
| Max LUNs per storage system | 2048 | 2048 | 4096 | 4096 | 8192 | 8192 |
| Max user-visible LUNs ¹ | 3816 | 3816 | 3816 | 6864 | 8376 | 14496 |
| LUN ID range | 0-2047 | 0-2047 | 0-2047 | 0-4095 | 0-4095 | 0-8191 |
| Max LUNs per storage group | 4096 | 4096 | 4096 | 4096 | 4096 | 4096 |
| RAID options | 0, 1, 1/0, 3, 5, 6 | | | | | |
| Max RAID groups per storage system | 62 | 62 | 125 | 250 | 500 | 1000 |
| Max drives per RAID group | 16 | 16 | 16 | 16 | 16 | 16 |
| DPE/SPE rack space | 3U (DPE) | 3U (DPE) | 3U (DPE) | 3U (DPE) | 3U (DPE) | 4U (SPE) |
| Max SnapView sessions (LUNs) per source LUN | 8 | 8 | 8 | 8 | 8 | 8 |
| Max SnapView snapshot | 256 | 256 | 256 | 256 | 512 | 512 |

| Components Configuration | VNX5200 | VNX5400 | VNX5600 | VNX5800 | VNX7600 | VNX8000 |
|--|---------|---------|---------|---------|---------|---------|
| source LUNs | | | | | | |
| Max SnapView snapshot sessions per array | 512 | 512 | 512 | 512 | 1024 | 2048 |
| Max SnapView snapshot source LUNs in a Consistent Start | 32 | 32 | 32 | 32 | 64 | 64 |
| Max clones | 256 | 256 | 1024 | 2048 | 2048 | 2048 |
| Max clone source LUNs | 128 | 128 | 512 | 1024 | 1024 | 1024 |
| Max clones in a Consistent Facture | 32 | 32 | 32 | 32 | 64 | 64 |
| MirrorView/S objects | 128 | 128 | 128 | 256 | 512 | 1024 |
| MirrorView/A objects | 256 | 256 | 256 | 256 | 256 | 256 |
| SAN Copy | Yes | | | | | |
| Max VNX Snapshots per LUN | 256 | 256 | 256 | 256 | 256 | 256 |
| Max VNX Snapshots per array | 8000 | 8000 | 8200 | 16400 | 32000 | 32000 |
| Max VNX Snapshot consistency groups | 128 | 128 | 128 | 256 | 256 | 256 |
| Max source LUNs in consistency group | 64 | 64 | 64 | 64 | 64 | 64 |
| Max VNX Snapshot LUNs (Host Visible) | 1000 | 1000 | 1000 | 2000 | 3000 | 4000 |

FILE COMPONENTS

| | | | | | | |
|---|----------------------------|----------------------------|----------------------------|---------------------------|---------------------------|---------------------------|
| Processor clock speed / number of cores / architecture (per blade) | 2.13 GHz, 4-core Xeon 5600 | 2.13 GHz, 4-core Xeon 5600 | 2.13 GHz, 4-core Xeon 5600 | 2.4 GHz, 4-core Xeon 5600 | 2.8 GHz, 6-core Xeon 5600 | 2.8 GHz, 6-core Xeon 5600 |
| Physical memory per blade (GB) | 6 | 6 | 12 | 12 | 24 | 24 |
| Data Movers (min-max) | 1-3 | 1-4 | 1-4 | 2-6 | 2-8 | 2-8 |
| Capacity per blade (TB) | 256 | 256 | 256 | 256 | 512 | 512 |
| Max # of file | 4096 | 4096 | 4096 | 4096 | 4096 | 4096 |

| Components Configuration | VNX5200 | VNX5400 | VNX5600 | VNX5800 | VNX7600 | VNX8000 |
|---|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| systems and snaps per array | | | | | | |
| Max file system size (TB) | 16 | 16 | 16 | 16 | 16 | 16 |
| Number of snaps per file system (SnapSure) | 96 read 16 write |
| Number of replication file systems (Replicator) | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Number of concurrent replication sessions | 256 | 256 | 256 | 256 | 256 | 256 |
| Host connectivity | NFS, CIFS, pNFS | | | | | |
| Control Stations | 1-2 | 1-2 | 1- 2 | 1- 2 | 1- 2 | 1- 2 |
| Max usable UltraFlex I/O module slots (front-end, per blade) ² | 2 | 2 | 2 | 3 | 3 | 4 |
| RAID options | 1,1/0,5,6 | | | | | |

¹ These numbers include FLUs + pool LUNs + snapshot LUNs (SV and Adv) + MV/A LUNs

² Each blade requires one I/O module slot for back-end (fibre) connectivity. This has been deducted from the numbers shown in the chart.

Appendix B: Storage processor UltraFlex I/O slot availability

The following tables show SP I/O module availability in Unified and Block configurations.

Table 4. Unified configuration

| Configuration | VNX5200 | VNX5400 | VNX5600 | VNX5800 | VNX7600 |
|---|------------------|------------------|------------------|------------------|------------------|
| SAS back-end buses | 1-2 | 1-2 | 1-6 ¹ | 1-6 ¹ | 1-6 ¹ |
| Number of blades | 1-2 ² | 1-2 ² | 1-2 ² | 1-3 ² | 2-4 ² |
| Total number of configurable host I/O connectivity slots | 2 ³ | 3 ⁴ | 3 | 3 | 3 |

¹ Slot 0 on VNX5600/VNX5800/VNX7600 is reserved for 4-port 6 Gb SAS I/O module.

² In VNX5200/VNX5400/VNX5600/VNX5800/VNX7600, slot 4 is reserved for 4-port 8 Gb Fibre Channel I/O module. This I/O module in slot 4 of each SP is used to connect up to four blades.

³ VNX5200 supports a maximum of 3 I/O modules per SP, and no I/O module is supported in slots 0 and 1.

⁴ VNX5400 supports a maximum of 4 I/O modules per SP, and no I/O module is supported in slot 0.

| Configuration | VNX8000 | | | | | |
|---|------------------|-----|------|-----|-------|-----|
| | 1-8 ¹ | | 9-12 | | 13-16 | |
| SAS back-end buses | 2-4 | 5-8 | 2-4 | 5-8 | 2-4 | 5-8 |
| Number of blades | 8 | 7 | 7 | 6 | 6 | 5 |
| Total number of configurable host I/O connectivity slots | | | | | | |

¹ VNX8000 ships with a minimum of two 4-port 6 Gb SAS I/O modules.

Table 5. Block configuration

| Configuration | VNX5200 | VNX5400 | VNX5600 | VNX5800 | VNX7600 |
|---|----------------|----------------|------------------|------------------|------------------|
| SAS back-end buses | 1-2 | 1-2 | 1-6 ¹ | 1-6 ¹ | 1-6 ¹ |
| Total number of configurable host I/O connectivity slots | 3 ² | 4 ³ | 4 | 4 | 4 |

¹ Slot 0 on VNX5600/VNX5800/VNX7600 is reserved for 4-port 6 Gb SAS I/O module.

² VNX5200 supports a maximum of 3 I/O modules per SP, and no I/O module is supported in slots 0 and 1.

³ VNX5400 supports a maximum of 4 I/O modules per SP, and no I/O module is supported in slot 0.

| Configuration | VNX8000 | | |
|---|------------------|------|-------|
| SAS back-end buses | 1-8 ¹ | 9-12 | 13-16 |
| Total number of configurable host I/O connectivity slots | 9 | 8 | 7 |

¹ VNX8000 is shipped with a minimum of two 4-port 6 Gb SAS I/O modules.

For File only configurations, there is only one configurable slot available for the RecoverPoint Fibre Channel option. As a File only configuration, no other host connectivity is allowed from the storage processors.

Appendix C: Drive Support

The following tables show the supported drives of the VNX2 series arrays.

Table 6. 2.5" supported drives and enclosures

| Drive Type | Capacity | 15 Drive DAE** | 25 Drive DAE | 60 Drive DAE** | 120 Drive DAE |
|--------------------------|----------|----------------|--------------|----------------|---------------|
| FAST Cache Optimized SSD | 100 GB | ✓ | ✓ | ✓ | ✓ |
| FAST Cache Optimized SSD | 200 GB | ✓ | ✓ | ✓ | ✓ |
| FAST VP Optimized SSD | 100 GB | ✓ | ✓ | ✓ | ✓ |
| FAST VP Optimized SSD | 200 GB | ✓ | ✓ | ✓ | ✓ |
| FAST VP Optimized SSD | 400 GB* | ✓ | ✓ | ✓ | ✓ |
| FAST VP Optimized SSD | 800 GB* | ✓ | ✓ | ✓ | ✓ |
| FAST VP Optimized SSD | 1.6 TB* | ✓ | ✓ | ✓ | ✓ |
| 15K RPM SAS | 300 GB* | ✓ | ✓ | ✓ | ✓ |
| 15K RPM SAS | 600 GB* | ✓ | ✓ | ✓ | ✓ |
| 10K RPM SAS | 600 GB* | ✓ | ✓ | ✓ | |
| 10K RPM SAS | 900 GB* | ✓ | ✓ | ✓ | |
| 10K RPM SAS | 1.2 TB* | ✓ | ✓ | ✓ | ✓ |
| 7.2K RPM NL-SAS | 1 TB* | | ✓ | | |

* Supported as Vault drives.

** 2.5" drives supported in 3.5" carriers.

Table 7. 3.5" supported drives and enclosures

| Drive Type | Capacity | 15 Drive DAE | 60 Drive DAE |
|--------------------------|----------|--------------|--------------|
| FAST Cache Optimized SSD | 100 GB | ✓ | ✓ |
| FAST Cache Optimized SSD | 200 GB | ✓ | ✓ |
| 15K RPM SAS | 300 GB* | ✓ | |
| 15K RPM SAS | 600 GB* | ✓ | |
| 7.2K RPM NL-SAS | 2 TB | ✓ | ✓ |
| 7.2K RPM NL-SAS | 3 TB | ✓ | ✓ |
| 7.2K RPM NL-SAS | 4 TB | ✓ | ✓ |

* Supported as Vault drives.