INTRODUCTION TO THE EMC VNXe1600
A Detailed Review

ABSTRACT

This white paper introduces the architecture and functionality of the EMC® VNXe1600. This paper also discusses some of the advanced features of this storage system.

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EXECUTIVE SUMMARY

The EMC® VNXe1600 storage system is an entry-level block storage solution that brings the proven enterprise-level feature set of the VNX Family to the low-end market. It is an ideal solution for small and medium-size businesses (SMB) as well as the Remote Office/Branch Office (ROBO) deployments of larger organizations. Flexible I/O configurations allow the VNXe1600 to address the challenges of any complex storage environment, while retaining the award-winning ease of use of the VNXe3200. The VNXe1600 system is designed with simplicity in mind so that administrators with limited storage expertise are able to leverage the enterprise-level features provided by the system. The major benefits of the VNXe1600 storage system include:

- **Performance and Efficiency** – By using many of the same MCx technologies available in the VNX2 and VNXe3200 systems, the VNXe1600 includes the ability to better utilize Flash storage, processor cores, and other technologies to offer better price/performance ratios.

- **Expanded Connectivity Support** – VNXe1600 systems include an onboard Converged Network Adapter (CNA) which can be configured for either 8Gb Fibre Channel, 16Gb Fibre Channel, 10GbE Optical, or 10GbE TWINAX connectivity for deployment flexibility. VNXe1600 systems also support additional connectivity via an optional 8Gb Fibre Channel, 10 GbE Optical, or 1 GbE copper I/O module.

- **Replication** – The VNXe1600 offers native asynchronous replication to provide a local and remote replication solution that is compatible with other VNXe1600 and VNXe3200 systems.

- **Snapshots** – For local protection, the VNXe1600 is able to take point-in-time snapshots of block data using the same storage space as the target resource. Snapshots on the VNXe1600 are based on redirect-on-write technology, which can also be found on VNX2 and VNXe3200 systems.

- **High Availability** – The VNXe1600 has many High Availability considerations, such as hardware redundancy and RAID protection ensuring constant data flow to users and administrators. Furthermore, administrators can take advantage of multipathing software on hosts to manage multiple connection paths to the VNXe1600.

- **VMware Integration** – The VNXe1600 provides best-in-class VMware integration. By utilizing VASA, VAAI, and VMware Aware Integration, the VNXe1600 is able to integrate fully with VMware vCenter and ESXi hosts. This enables the monitoring of storage directly from VMware interfaces and the creation of datastores from Unisphere. In addition, support for VMware Site Recovery Manager (SRM) helps the VNXe1600 fit into a user’s disaster recovery plan.

AUDIENCE

This white paper is intended for IT planners, storage architects, administrators, partners, EMC employees and any others involved in evaluating, acquiring, managing, operating, or designing an EMC networked storage environment using VNXe1600 storage systems.
**TERMINOLOGY**

- **Converged Network Adapter (CNA)** – A flexible onboard VNXe1600 I/O adapter that can be configured with SFP’s to support either iSCSI or Fibre Channel for front-end connectivity.

- **Dynamic Host Control Protocol (DHCP)** – A protocol used to assign dynamic IP addresses to devices on a network from a centralized server. A management IP address can be assigned automatically to a VNXe1600 system that is connected to an organization’s network that utilizes DHCP.

- **Fibre Channel Protocol** – Transfer protocol used to communicate Internet Protocol (IP) and Small Computer Systems Interface (SCSI) commands over a Fibre Channel network.

- **Internet Small Computer System Interface (iSCSI) protocol** – Provides a mechanism for accessing raw block-level data over a network connection. The iSCSI protocol is based on the standard client/server model with iSCSI initiators (hosts) acting as storage clients and iSCSI targets acting as storage servers.

- **Logical Unit Number (LUN)** – The identifying number of a SCSI storage resource that processes SCSI commands. The LUN is an ID for the logical unit, but the term often refers to the logical unit itself. The LUN is the last part of the SCSI address for a SCSI object.

- **MCx** – “Multicore Everything” initiative that delivers high performance and platform efficiency in VNXe1600 systems. On the VNXe1600, MCx is composed of Multicore Cache, Multicore FAST Cache, and Multicore RAID.

- **Multicore Cache** – VNXe1600 cache that optimizes Storage Processor’s DRAM and core usage to increase host write and read performance.

- **Multicore FAST Cache** – Large capacity secondary cache that uses SLC Flash Drives. This secondary cache most greatly benefits applications that are prone to unpredictable spikes in I/O.

- **Multicore RAID** – MCx component that defines, manages, creates, and maintains VNXe1600 RAID protection.

- **Storage Pool** – A single repository of homogeneous physical disks from which storage resources may be created. In VNXe1600, all storage pools are comprised of a single storage tier: Flash, SAS or NL-SAS. Multiple storage pools may be created, each with a specific drive technology.

- **Storage Processor (SP)** – A VNXe1600 hardware component that provides the processing resources for performing storage operations as well as servicing I/O between storage and hosts.

- **Thin Provisioning** – A storage feature used to allocate storage on an as-needed basis from a larger reserved resource. The amount of storage a Thin storage resource consumes is shown on the VNXe1600 as the Allocated value.

- **Snapshot** – A point-in-time view of data stored on a storage resource. A user can restore a storage resource from a snapshot or attach a snapshot to a host.

- **Unisphere Command Line Interface (CLI)** – An interface that allows a user to perform tasks on the VNXe1600 by using commands typed into a command line.

- **Unisphere for VNXe** – A web-based management environment for creating storage resources, configuring and scheduling protection for stored data, and managing and monitoring other storage operations.
VNX UNIFIED STORAGE FAMILY

VNX FAMILY

The VNXe1600 is a part of the VNX Family of storage systems. They are simple, efficient, powerful, and protected. They utilize the new MCx architecture which optimizes the use of all CPU cores available thereby improving performance and scalability. MCx, along with other features, makes these storage systems powerful products in the storage market with various models for different customer needs. At the one end of the spectrum, the VNX8000 stands as the high workload, high IOPS system that serves mid-range to enterprise level customers. At the other end, the block-only VNXe1600 uses the same technology to offer customers incredible storage functionality while boasting a small 2U form factor. This makes the VNXe1600 a powerful, low cost entry-level system.

For more information on the VNX5200-VNX8000 models, please see the paper titled Introduction to the EMC VNX2 Series on EMC Online Support.

Figure 1. VNX Family Models

VNXe1600

The VNXe1600 storage system is a block storage array based on the proven VNXe3200 architecture and feature set. As a result, the VNXe1600 is an ideal platform for many of the same use-cases as VNXe3200, when the file connectivity and higher performance of the VNXe3200 are not required. VNXe1600 is equally beneficial for businesses with physical server infrastructures, as well as those making the move to server virtualization for drive consolidation and greater efficiency. As an entry-level block storage system, the VNXe1600 provides high value for smaller user configurations with lighter performance needs than the VNXe3200. It is designed to support smaller businesses and applications with a smaller number of users. VNXe1600 systems are available with a comprehensive set of features including increased capacity utilization, data protection solutions, availability solutions, and advanced support capabilities.

The VNXe1600 supports iSCSI and Fibre Channel protocols, making it compatible with most SAN infrastructures. The small footprint of the system makes it an ideal solution for small to medium-sized businesses and ROBO deployments. The Unisphere management interface is a simple and intuitive interface for IT generalists that enables storage provisioning, management, and monitoring operations. Some of the major benefits of VNXe1600 storage systems include:

- **Simple and efficient block storage** – VNXe1600 systems deliver block storage provisioning, high-availability, and an extensive feature set in a small 2U enclosure. Unisphere provides a fast, simple user experience for completing everyday tasks, and embeds best practices into the user interface. This results in streamlined management operations.

- **Flexible configuration options** – The VNXe1600 introduces the first Converged Network Adapter (CNA) in a VNX Family array, providing the option for embedded Fibre Channel or iSCSI. When combined with support for additional I/O modules, the VNXe1600 is the most flexible entry-level array on the market.

- **VNX Family features** – MCx, FAST Cache, Replication, Snapshots and more are all available with the VNXe1600, providing enterprise features at a low-end price point.
HARDWARE OVERVIEW

DUAL-CORE CPU
The VNXe1600 leverages an Intel® Xeon® E5 2.6 GHz Dual-Core CPU on each Storage Processor. The VNXe1600 takes advantage of that processing power by leveraging its MCx architecture to ensure that both cores are being used optimally.

DISK PROCESSOR ENCLOSURE (DPE)
The VNXe1600 has two possible DPE configurations and both consume 2U of storage rack space:

- 25-drive DPEs paired with 2.5” drives
- 12-drive DPEs paired with 3.5” drives

The following figures show the front of the 25-drive DPE that houses 2.5” SAS and Flash drives (Figure 2), and the front of the 12-drive DPE that houses 3.5” NL-SAS drives (Figure 3). Both enclosures have LEDs for enclosure fault and power. The 2.5” disks have separate drive power and fault LEDs while the 3.5” disks include a single LED showing power/fault statuses. Note that the front views of the 25-drive and 12-drive Disk Array Enclosures (DAEs) resemble that of the 25-drive and 12-drive DPEs, respectively.

The first four drives in every DPE are called system drives. The system drives hold important system information for the storage array. Because of this, the first four drives are not portable and need to be replaced immediately if faulted.

Figure 2. Front of 25-drive 2.5” DPE/DAE
Figure 3. Front of 12-drive 3.5” DPE/DAE
The back of the DPE looks the same for both 25-drive and 12-drive DPE configurations (Figure 4). The DPE includes an onboard 2-port Converged Network Adapter (CNA) for each SP which can be configured for 8Gb FC, 16 Gb FC, 10GbE Optical or 10GbE TWINAX depending on the infrastructure (Figure 5). CNA personality is set at the time of factory install and cannot be changed on an active system. Also, there are two SAS ports allowing for expansion of storage through DAEs. Both the management and service ports are 1 GbE ports which can auto-negotiate between 1 GbE/100 MbE/10 MbE. The management port is where GUI and CLI commands communicate with the system. If the system is unavailable through the management port, the service port can be utilized using the Serial Over LAN feature over a direct connection or switch. I/O expansion modules are available for the VNXe1600 to add Fibre Channel, 10 GbE Optical, or 1 GbE copper connectivity to the system.

![Figure 4. Back of DPE](image)

![Figure 5. Close-up of SP Ports](image)

<table>
<thead>
<tr>
<th>Number</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fan Modules</td>
</tr>
<tr>
<td>2</td>
<td>Power Supply</td>
</tr>
<tr>
<td>3</td>
<td>CNA Ports</td>
</tr>
<tr>
<td>4</td>
<td>6 Gb/s SAS Ports</td>
</tr>
<tr>
<td>5</td>
<td>SP Power LED</td>
</tr>
<tr>
<td>6</td>
<td>Unsafe to Remove LED</td>
</tr>
<tr>
<td>7</td>
<td>SP Internal Fault LED</td>
</tr>
<tr>
<td>8</td>
<td>SP Fault LED</td>
</tr>
<tr>
<td>9</td>
<td>Mini USB Port</td>
</tr>
<tr>
<td>10</td>
<td>I/O Module</td>
</tr>
<tr>
<td>11</td>
<td>Management Port</td>
</tr>
<tr>
<td>12</td>
<td>Service Port</td>
</tr>
</tbody>
</table>
DISK ARRAY ENCLOSURE (DAE)

The VNXe1600 has two possible DAE configurations:
- 25-drive DAEs paired with 2.5” drives
- 12-drive DAEs paired with 3.5” drives

Both DAE configurations take up 2U of rack space. The following figures show the back of the 25-drive DAE (Figure 6), and the back of the 12-drive DAE (Figure 7). Both DAEs include LEDs to indicate power supply power and power supply fault status, and the 12-drive DAE includes a power supply fan fault LED.

Figure 6. Back of 25-drive DAE

Figure 7. Back of 12-drive DAE
The backs of the 25-drive DAE and 12-drive DAE have similar port configurations (Figure 8 and Figure 9). They both have primary SAS ports to connect to a DPE and expansion ports to connect to other DAEs for extra storage. The back-end bus LEDs show the bus number that the DAE is connected while the enclosure ID LED shows the ID of the DAE respective to the number of other DAEs on the same bus. There are also LEDs to show power, fault, and SAS link status.

<table>
<thead>
<tr>
<th>Number</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6 Gb/s SAS Primary Port</td>
</tr>
<tr>
<td>2</td>
<td>6 Gb/s SAS Extension Port</td>
</tr>
<tr>
<td>3</td>
<td>SAS Link LEDs</td>
</tr>
<tr>
<td>4</td>
<td>Back-End Bus LEDs</td>
</tr>
<tr>
<td>5</td>
<td>Enclosure ID LED</td>
</tr>
<tr>
<td>6</td>
<td>Fault LED</td>
</tr>
<tr>
<td>7</td>
<td>Power LED</td>
</tr>
<tr>
<td>8</td>
<td>SPS Port (not used)</td>
</tr>
</tbody>
</table>

Figure 8. Close-up of 25-drive DAE

Figure 9. Close-up of 12-drive DAE
CUSTOMER REPLACEABLE UNITS (CRU)
Most of the components in a VNXe1600 are customer replaceable units. The only non-replaceable components are the DPE and DAE enclosures themselves. Here are some examples of CRUs in the VNXe1600 storage system.

STORAGE PROCESSOR
Every VNXe1600 storage system comes with two Storage Processors (SPs). Each SP can be removed individually from the DPE making it easy to service and replace parts. While an entire SP may be replaced, its individual components may also be customer serviced. Note that the SP will need to be removed in order to service these parts.

LITHIUM-ION BATTERY BACKUP UNIT (BBU)
A 3-cell Lithium-Ion BBU is located within each SP enclosure (Figure 10). The battery is designed to power systems long enough to flush the SP cache contents to an internal mSATA device in the case of a power failure or in the case of SP removal from the DPE. At least one BBU is required to be operating normally for SP cache to remain enabled. The BBUs are tested upon every SP power up and every 7 days thereafter to ensure the hardware is functioning properly.

POWER SUPPLY
Each DPE has two power supply modules (Figure 11), one for each SP. One of the two power supplies must remain in service for the system to stay in an operational state.
FAN MODULES
Each SP has three fan modules above it to dissipate heat away from the system (Figure 12). For the system to stay operational, at least two of the three fans on each SP must be active. If either SP has two or more fans inactive, the system will save cache contents and shut down automatically.

Figure 12. Storage Processor Fan Module

DUAL-INLINE MEMORY MODULE (DIMM)
There is one DDR3 memory slot used within each SP. Each SP holds one 8 GB DIMM (Figure 13), for a total of 16 GB of system memory per VNXe1600 system. If a faulted DIMM is detected upon boot-up, the system will boot into service mode so the faulted memory module can be fixed.

Figure 13. DIMM

MSATA (MINI-SERIAL ADVANCED TECHNOLOGY ATTACHMENT)
A 32 GB MLC Flash device or mSATA drive is physically found underneath each SP (Figure 14). This device contains a partition that holds the boot image that is read upon initial boot up. In the event of power failure, the memory contents of SP cache are written to the mSATA device. Even if the mSATA becomes corrupted, cache data can be recovered from the peer SP.

Figure 14. mSATA Device
I/O MODULES

The VNXe1600 supports the option to add an additional I/O module for increased connectivity. It is important to note that the Storage Processor configurations must mirror each other. For example, if a Fibre Channel I/O module is installed in Storage Processor A, then an identical Fibre Channel I/O module must be installed in Storage Processor B.

There are three supported I/O modules for the VNXe1600: 8 Gb/s Fibre Channel, 10 GbE optical, and 1 GbE copper. All three modules are quad-port and used for front-end connectivity from Storage Processors to host(s). The I/O modules installed on the SPs of a VNXe1600 must be matching.

The 8Gb/s Fibre Channel I/O module has an 8-lane PCI-E Gen-2 interface and auto-negotiates to 2 Gb/s, 4 Gb/s, or 8 Gb/s (Figure 15).

The 10 GbE Optical I/O module has an 8-lane PCI-E Gen-3 interface and only operates at 10 Gb/s (Figure 16).

The 1 GbE Ethernet I/O module has a 4-lane PCI-E Gen-2 interface and auto-negotiates to 10 Mb/s, 100 Mb/s, and 1000 Mb/s (Figure 17).
HARDWARE CONFIGURATIONS

Table 1 shows the hardware features available to the VNXe1600 storage system.

<table>
<thead>
<tr>
<th>Model</th>
<th>VNXe1600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of SPs</td>
<td>2</td>
</tr>
<tr>
<td>DPE Form Factor</td>
<td>2U</td>
</tr>
<tr>
<td>CPU per system</td>
<td>2x Intel Xeon E5 2.6GHz Dual Core</td>
</tr>
<tr>
<td>Memory per system</td>
<td>16 GB</td>
</tr>
<tr>
<td>RAID options</td>
<td>1/0, 5, 6</td>
</tr>
<tr>
<td>DPE options</td>
<td>12-drive (3.5&quot;), or 25-drive (2.5&quot;)</td>
</tr>
<tr>
<td>DAE options</td>
<td>12-drive (3.5&quot;), or 25-drive (2.5&quot;)</td>
</tr>
<tr>
<td>Minimum/maximum number of drives</td>
<td>6/200</td>
</tr>
<tr>
<td>Drive options</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>200</td>
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<td></td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>600</td>
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<td></td>
<td>1.2 TB 10K SAS</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>System Drives options</td>
<td>200 GB Flash (MLC)</td>
</tr>
<tr>
<td></td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Back-end connection</td>
<td>6 Gb SAS</td>
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<tr>
<td>Number of back-end ports per SP</td>
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</tr>
<tr>
<td>Embedded I/O ports per SP</td>
<td>2x 8Gb FC, or 2x 16Gb FC, or 2x 10 GbE Optical, or 2x 10GbE TWINAX</td>
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<tr>
<td>Configurable I/O slots per SP</td>
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<tr>
<td>I/O module options per SP</td>
<td>4-port 8 Gb Fibre Channel</td>
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<tr>
<td></td>
<td>4-port 10 GbE Optical</td>
</tr>
<tr>
<td></td>
<td>4-port 1GbE Copper</td>
</tr>
<tr>
<td>Management ports per system</td>
<td>2x 10/100/1000 Ethernet</td>
</tr>
</tbody>
</table>
COMPARISON OF DRIVE TYPES

The VNXe1600 storage systems support Flash, Serial Attached SCSI (SAS), and Near Line-Serial Attached SCSI (NL-SAS) drives. Flash drives are recommended for performance intensive applications or applications with very low response time and high throughput requirements. SAS drives should continue to be the choice for environments with large capacity and high performance requirements. Flash or SAS drives are appropriate for applications such as database applications that require frequent read and write operations. NL-SAS drives are recommended for modest performance and high capacity environments. In addition, NL-SAS drives can provide energy efficient bulk storage capacity at low costs. They are appropriate for storing large amounts of data that is less frequently used and for users with applications that do not have strict performance requirements.

RAID CONFIGURATIONS

With a VNXe1600, drives can be configured into storage pools. Each storage pool has a RAID type, to provide redundancy while meeting the desired capacity and drive requirements. The supported RAID levels are 5, 6, and 1/0.

NOTE: Once a storage pool has been configured, the RAID type cannot be changed for that storage pool.

RAID 5 is best suited for transactional processing, and is often used for general-purpose storage, relational databases, and enterprise applications. This RAID level provides fairly low cost per gigabyte value while retaining redundancy and high availability. RAID 5 stripes data at a block-level across several disks and distributes parity among the disks. It is important to note that a failed disk reduces storage performance and should be replaced immediately. However, data loss will not occur as a result of a single disk failure.

RAID 6 is appropriate for the same types of applications as RAID 5, but more useful in situations where increased fault tolerance is of the utmost importance. RAID 6 is similar to RAID 5, but uses a double parity that is distributed across different disks, offering higher fault tolerance. Because of the added level of parity, RAID 6 groups require additional backend writes and will typically result in lower performance than the equivalent RAID 5 group. For this reason the tradeoff between protection and performance must be sufficiently considered. In a RAID 6 configuration, storage pools can continue to operate with up to two failed disks per RAID group. VNXe1600 systems have the ability to perform a parallel rebuild in the case of two faulted disks, decreasing the time in a faulted state.

RAID 1/0 is a stripe of mirrors, so only half the total capacity of the drives is usable. This provides high performance and reliability, but at a high cost because of lower usable capacity per disk. RAID 1/0 is appropriate for applications with high processing requirements as well as with write-intensive workloads. RAID 1/0 in VNXe1600 systems requires a minimum of two physical disks. Note that a two disk RAID 1/0 configuration does not use striping. Lastly, a faulted disk must be replaced immediately because this configuration cannot handle the loss of more than one disk in the same mirrored pair.
SOFTWARE OVERVIEW

This section discusses the software features available on the VNXe1600.

INITIAL CONFIGURATION

When configuring a VNXe1600 system for the first time, the management interface must be configured with an IP address. An IPv4 or IPv6 address can be assigned dynamically via DHCP, or with a static IP address using Connection Utility, which can be downloaded directly from the EMC Online Support website.

When running the Connection Utility from a computer on the same subnet as the storage system, the program can automatically discover any unconfigured VNXe1600 systems. If the Connection Utility computer cannot be placed on the same subnet, the configuration can be saved to a USB drive and applied to the system by plugging the USB drive into a mini USB port on the back of the DPE.

After configuring an IP address for the VNXe1600 management interface, you can access Unisphere by navigating to the assigned IP address from any web browser.

When connecting to a VNXe1600 storage system for the first time, the Unisphere Configuration Wizard starts automatically. This wizard runs through a series of steps to seamlessly configure the VNXe1600 system and parts of your storage layout in a short amount of time. The following parameters can be set using the Configuration Wizard in Unisphere:

- Password for the administrator user "admin"
- Service password for the "service" account
- Unisphere licenses
- DNS and NTP servers
- Storage pools and FAST Cache
- iSCSI interfaces
- Replication interfaces
- SMTP server for product support options
- EMC Online Support Credentials
- EMC Secure Remote Support (ESRS)

UNISPHERE

Unisphere is a graphical web-based management interface that is the primary monitoring and management tool for VNXe1600 storage systems. It provides tools for configuring and managing storage resources. To make use of those storage resources, access can be given to users, applications, and hosts using iSCSI or Fibre Channel. The files and data stored on the storage system can be protected with an automated scheduler feature to create point-in-time snapshots of stored data. This makes recovering lost files and data quick and easy.

Unisphere enables users to monitor storage operations and system status through a detailed graphical reporting service, which can pinpoint issues to specific components of the storage system. Unisphere also enables monitoring of storage system performance through graphs allowing technical users to see a deeper view of system utilization.

Unisphere provides direct support through ecosystem resources like online documentation, white papers, FAQs, how-to videos, online discussion forums, and chat sessions. Lastly, any software code updates on the VNXe1600 can be easily done through a non-disruptive upgrade (NDU) process in Unisphere.

You can use Unisphere to configure and manage the following types of storage resources:

- **LUNs** – Provides generic block-level storage, in the form of LUNs, for hosts and applications to access using the iSCSI or Fibre Channel protocols.
- **LUN Groups** – Consistency group containing multiple LUNs enabling consistent point-in-time protection and crash-consistent recovery for multi-LUN applications.
- **VMware VMFS Datastores** – Provides storage for VMware environments accessible through either the iSCSI or Fibre Channel protocols.

For more information about Unisphere for VNXe1600 storage systems, please see the paper titled *EMC Unisphere for the VNXe3200: Next-Generation Storage Management*. 
MCX™

MCX is a combination of the Multicore Cache, Multicore RAID, and Multicore FAST Cache features. MCX enables the array to fully leverage Intel's multi-core CPU architecture. It was designed from the ground-up to ensure optimum performance with little to no customer intervention, by using an adaptive architecture. It is the same patented technology seen in the VNX2 models.

- **Multicore Cache** – Also known as SP Cache, optimizes the SP's DRAM to increase host write and read performance. It provides write caching for all VNXe software layers.
- **Multicore RAID** – Defines, manages, creates, and maintains RAID protection for storage pools. Multicore RAID includes features such as Permanent Sparing, Drive Mobility, Hot Spare Policy, and Improved RAID durability.
- **Multicore FAST Cache** – A large-capacity secondary cache built using FAST Cache Optimized SSDs. It is positioned between the SP's DRAM-based memory cache and the hard drives in storage pools to provide Flash drive performance to highly accessed data in your storage pool.

For more information on MCX, please see the white paper titled *EMC VNXe3200 MCX*.

**STORAGE PROVISIONING**

When configuring LUNs or LUN groups, a user has the option to use either iSCSI or Fibre Channel for host access. If a user wants to create VMware datastores, they can provision datastores via VMFS using iSCSI or Fibre Channel.

**LUNS AND LUN GROUPS**

LUNs provide hosts with access to general purpose block-level storage through network-based iSCSI or Fibre Channel connections. After a host connects to a LUN, it can use the LUN as a local storage drive. Unisphere allows users to create, view, manage, and delete LUNs. A LUN's capacity can be increased, but not decreased.

LUN groups are logical containers for LUNs which allow users to organize multiple LUNs into a single application. For example, assume a database application requires one LUN for the database and a separate LUN for log files. The disks can be represented under the same generic storage application in Unisphere by adding the LUNs to a LUN group (Figure 18). LUN groups can be managed as a single entity, allowing for snapshots to be taken of all the LUNs in the LUN group as a whole. This creates a consistency group, since every LUN within the LUN group can be protected on the same timestamp.

![Figure 18. LUN group with two LUNs](image)

**VMWARE VMFS DATASTORES**

Unisphere enables a user to create storage resources optimized for use by VMware vCenter™ servers and ESXi® hosts. VNXe1600 VMware datastores are associated with VMFS storage access.

The Hosts page in Unisphere allows a user to discover and add VMware ESXi hosts and vCenter server information to Unisphere. Once the VMware host information is imported into Unisphere, information about virtual machines is displayed.

A user can configure VMware VMFS datastores by using the VMware Storage Wizard. These datastores, when created, can be scanned and automatically added to the vCenter server or ESXi host.

VMFS datastores require iSCSI initiators or Fibre Channel connections on the storage system to be created. After the creation of a VMFS datastore, the capacity can be increased, but not reduced. When VMFS datastores are created and an ESXi host is given access, the new storage is automatically scanned and made available to the ESXi host. Hosts can be given access to the datastore on a LUN, Snapshot, or LUN and Snapshot level.
STORAGE POOL CHARACTERISTICS

VNXe1600 storage resources are provisioned from storage pools. A storage pool is a homogeneous grouping of physical disks (Figure 19). A homogeneous storage pool is a single tier pool using one type of disk. Once a RAID configuration has been set, it cannot be changed. In addition, there is a built in hot spare policy which is defined as 1 spare drive per 30 drives. This policy is not user configurable.

![Figure 19. Homogeneous Storage Pools](image)

Table 2 shows the default RAID configurations for each tier of a storage pool configuration on a VNXe1600 system.

<table>
<thead>
<tr>
<th>Tier</th>
<th>Drive Type</th>
<th>Default RAID Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Performance</td>
<td>Flash</td>
<td>RAID 5 (4+1)</td>
</tr>
<tr>
<td>Performance</td>
<td>SAS</td>
<td>RAID 5 (4+1)</td>
</tr>
<tr>
<td>Capacity</td>
<td>NL-SAS</td>
<td>RAID 6 (6+2)</td>
</tr>
</tbody>
</table>

If a license for FAST Cache is not available, a Quick Start Mode will be available in the Storage Pool Wizard. This Quick Start Mode will automatically create homogeneous storage pools using a best fit algorithm for all of the available disks on the system while incorporating the built in hot spare policy. Quick Start Mode will configure RAID 5 for the extreme performance and performance pools, and will configure RAID 6 for the capacity pool. If automatic pool creation is not desired, users can create custom homogeneous storage pools.

When creating a custom storage pool, users have the option to specify stripe width or choose maximum capacity which will use a best fit algorithm for the available disks. The allowed stripe widths for each RAID type for VNXe1600 systems are as follows:

- RAID 5: 4+1, 8+1, 12+1
- RAID 6: 6+2, 8+2, 10+2, 14+2
- RAID 1/0: 1+1, 2+2, 3+3, 4+4
ADVANCED FEATURES

Despite being designed with the IT generalist in mind, the VNXe1600 comes packed with advanced functionality. These advanced features are found in sub-menus and in settings tabs. This keeps the main interface clean, simple, and easy to use. VNXe1600 storage systems have the following advanced features:

- Asynchronous Replication
- FAST Cache
- Capacity and Performance Metrics
- Thin Provisioning
- Serial Over LAN
- Snapshots
- Unisphere CLI Support
- LDAP Integration
- User Management

ASYNCHRONOUS REPLICATION

The VNXe1600 supports asynchronous replication. Leveraging the Unified Snapshots technology, asynchronous replication enables users to replicate LUNs, LUN Groups, and VMFS Datastores across VNXe1600 and VNXe3200 systems. The synchronization of data is performed on a user-configurable basis and can be set to automatic or manual execution.

In order to create a replication session, a replication connection must first be established between two storage systems. Once a connection is made, a session is created from the intended source location. A storage resource of matching type (e.g. LUN to LUN) is identified at each side and designated for the replication session. Sessions can be paused, failed over and back, resumed, renamed, and deleted.

For more information about asynchronous replication, please see the white paper titled EMC VNXe3200 Replication Technologies.

CAPACITY AND PERFORMANCE METRICS

VNXe1600 storage systems provide storage administrators the ability to view capacity and performance metrics within the Unisphere and Unisphere CLI interfaces. With this information, storage administrators will have the ability to analyze their storage system's performance and capacity details. This can be useful when diagnosing or troubleshooting issues, planning for future initiatives, or forecasting future needs within their storage environment. For more information on Capacity and Performance Metrics, please see the white paper titled EMC VNXe3200 Capacity and Performance Metrics.

LDAP INTEGRATION

Lightweight Directory Access Protocol (LDAP) is an application protocol for querying and modifying directory services running on TCP/IP networks. LDAP provides a management service for network authentication by centralizing user and group management across the network. Integrating Unisphere users into an existing LDAP environment provides a way to control management access to the VNXe1600 system based on established user and group accounts within the LDAP directory. In Unisphere, LDAP settings can be configured under the Directory Services tab of the Manage Administration page.

NOTE: The LDAP settings mentioned here are used only for controlling access to Unisphere, and not for controlling access to VNXe1600 storage resources.
THIN PROVISIONING

Thin provisioning is the ability to present a server with more capacity than is actually allocated for that specific storage resource.

When a user enables thin provisioning for a storage resource, the amount of storage requested is not allocated to the resource immediately. As an application requires actual storage space from the resource the system automatically allocates additional storage space to the storage resource from the storage pool on an as-needed basis. Thin provisioning is supported on all storage types in a VNXe1600 storage system and is enabled by default via checkbox in the various storage creation wizards.

VNXe1600 systems allows multiple storage resources to subscribe to a common storage pool and, with thin provisioning, the system allocates only a portion of the physical capacity requested by each storage resource (Figure 20). The remaining storage is available in the pool for use by other storage resources.

Figure 20. Thin Provisioning

VNXe1600 systems allow the storage pools to be oversubscribed. Oversubscription is a storage provisioning method that allows storage administrators to provision more capacity than may be physically available in a particular storage pool. When groups of thin-provisioned storage resources are associated with a storage pool, they can request (or subscribe to) more storage capacity than is actually in the pool. This is possible because storage from the pool is incrementally allocated to each storage resource based on the amount of used storage on that resource. When the collective amount of storage used within the pool approaches the pool’s physical capacity (default is 70%), Unisphere generates notification messages that more storage may soon be required.

Thin provisioning allows users to improve storage efficiency since organizations can purchase less storage capacity up front, and increase capacity by adding disks as needed according to actual storage usage. Without thin provisioning, organizations must base disk requirements on predictions or on the requests of application owners.

SERIAL OVER LAN

The Serial Over LAN (SOL) feature allows EMC personnel and storage administrators to service/support the VNXe1600 system in the case that ESRS or SSH is not working or configured. To use the feature, two Ethernet cables need to be connected to the service ports on both SPs with the other ends connected to a laptop set up on the same subnet as the internal IPs of the VNXe1600. To start an SOL session, an Intelligent Platform Management Interface (IPMI) tool must be installed on the laptop. The IPMI tool then communicates with the Baseboard Management Controller (BMC) to redirect serial data over the service port on the SP to establish an SOL session. Once the session is started, regular commands can be run on the system like in SSH.

NOTE: Files cannot be transferred over the service port.

For more information on Serial Over LAN, please see the technical note EMC IPMI Tool 1.0 on EMC Online Support.

SNAPSHOTS

The Snapshots feature creates point-in-time views of data for all types of storage resources. Snapshots are based on Redirect on Write (ROW) technology which redirects new writes to the storage resource to a new location in the same storage pool. Therefore, a snapshot does not consume space from the storage pool until new data is written to the storage resource or to the snapshot itself.

Snapshots are easy to manage and all required operations can be done using Unisphere. VNXe1600 also provides the ability to schedule snapshots. This means users can automatically protect their data periodically and can recover that data in the event of a deletion or corruption. For more information on snapshots, please see the white paper titled EMC VNXe3200 Unified Snapshots.
UNISPHERE CLI SUPPORT

The Unisphere CLI in the VNXe1600 system enables a user to perform the same management of their VNXe1600 as seen in the Unisphere GUI, over a command-line interface. It can serve as a vehicle for creating scripts to automate commonly performed tasks. The VNXe1600 management IP address is used with Unisphere CLI to execute commands on that system.

To use Unisphere CLI, the Unisphere CLI client must be installed on a host machine. The same client can be used to manage multiple VNXe1600 storage systems. For more information about the Unisphere CLI format and options, please see the VNXe Unisphere CLI User Guide on EMC Online Support.

USER MANAGEMENT

VNXe1600 storage systems provide tools for creating user accounts for managers and administrators who configure and monitor VNXe1600 systems. When users access Unisphere, they are prompted to log in with account-based credentials before they can access the system. Unisphere user accounts combine a unique username and password with a specific role for each account. The role determines the types of actions that the user can perform after logging in.

The following user roles are available in Unisphere:

- **Operator** – This role can view Unisphere system and storage status information, but cannot change system settings.
- **Storage Administrator** – This role can view VNXe1600 storage system data, edit Unisphere settings, use Unisphere tools, create/delete storage resources, and create/delete host configurations. This role cannot add user accounts, perform initial configuration of the system, modify network settings, or upgrade system software.
- **Administrator** – This role can perform all tasks accessible through Unisphere.
- **VM Administrator** – This role can only establish a VASA connection from vCenter to the storage system. A VM Administrator does not have access to Unisphere.

HIGH AVAILABILITY (HA)

VNXe1600 storage systems offer several built-in HA features. HA is provided through redundant components, meaning if one component fails, there is another available to take over. The redundant components include SPs, cooling fans, AC or DC power cords, power supplies, I/O modules, and Link Controller Cards (LCCs). Network HA is provided through multipathing.

When accessing storage resources, multiple paths to the storage resource are made available to the host, and requests can be made to either SP. Note that multipathing software must be installed on the host in order for the host to take advantage of this feature. In the event of a failure, the surviving SP will handle residual requests made to the inaccessible SP.

The Unisphere management service runs on one SP at a time. In the event of an SP failure, management will fail over to the other SP with minimal downtime. To achieve high availability of the management interface, the cable on each SP needs to have the same connectivity. For example, if the management port on SPA is plugged into a switch configured for subnet 192.168.0.1, the management port on SPB must also be connected to that subnet.

For additional information about HA in VNXe1600 storage systems, please see the white paper titled EMC VNXe3200 High Availability.
VIRTUAL INTEGRATION WITH VMWARE VSphere

The VNXe1600 storage system offers tight integration with VMware vSphere. VMware administrators can take advantage of this functionality when managing their virtual environment.

VMWARE AWARE INTEGRATION (VAI)

VAI is an end-to-end discovery of a VMware environment from a VNXe1600. VNXe1600 uses VAI to import and view VMware Virtual Centers, ESXi servers, virtual machines, and VM disks. Also, ESXi hosts can be automatically registered when a vCenter is imported. The polling process to import information is done in the background and can poll a single host or all hosts for updated information. The VNXe1600 system can also create and monitor VMware datastores from Unisphere using VAI.

VIRTUAL STORAGE INTEGRATOR (VSI)

VSI allows VMware administrators to provision and manage certain VNXe1600 storage configurations. EMC's VSI for VMware vSphere Web Client can be utilized for the following:

- Creating VMFS datastores and RDM volumes
- Viewing storage property details

For additional information about VSI Storage Management, please see the product guide titled *EMC VSI for VMware vSphere Web Client* on EMC Online Support.

VSTORAGE API FOR ARRAY INTEGRATION (VAAI)

VAAI improves ESXi host resource utilization by offloading related tasks to the VNXe1600. With VAAI storage tasks are processed by the storage system, thus reducing host processor, memory, and network resources required to perform select storage operations. For example, an operation such as provisioning full clones for virtual environments from a template VM can be done while the ESXi host streams write commands to the VNXe1600 target. The VNXe1600 storage system processes these requests internally, performs the write operations on the given SP, and returns an update to the host when the requests are completed. The impacts on the host resources and front-end ports of the VNXe1600 system are significantly reduced when the load is shifted to the storage system.

The following tasks can be offloaded to VNXe1600 storage systems:

- Fully Copy or Hardware-Assisted Move
- Block Zero or Hardware-Assisted Zeroing
- Atomic Test and Set (ATS) or Hardware-Assisted Locking
- Thin Provisioning (Dead Space Reclamation)

VSTORAGE API FOR STORAGE AWARENESS (VASA)

VASA is a VMware-defined, vendor neutral API for storage awareness. The API requests basic information about storage components from a VNXe1600 system, which facilitates monitoring and troubleshooting through vSphere. Using VASA, vSphere can monitor and report storage policies set by the user. It can also tell when datastore capabilities are not compliant with a VM’s configured profile. For example, if a datastore has Thin capabilities without FAST Cache and a VM profile is configured for Thick and FAST Cache, the datastore would be seen as non-compliant when using that VM profile. Lastly, VNXe1600 has native vCenter interfaces so VASA does not need to use a separate plug-in to connect to the system.

REMOTE MONITORING

The status of a VNXe1600 system can be managed remotely by EMC personnel or customers through ESRS and monitoring products such as Unisphere Central.

EMC SECURE REMOTE SUPPORT (ESRS)

The EMC Secure Remote Support (ESRS) feature provides an authorized EMC service provider with remote access capabilities to a configured VNXe1600 system by using a secure and encrypted tunnel. This feature helps EMC technical support more rapidly resolve issues. For outbound access, the VNXe1600 management IP network must allow outbound and inbound HTTPS traffic. This secure tunnel can also be used to transfer files to the VNXe1600 system or transfer support files back to EMC's network.
UNISPHERE CENTRAL

Unisphere Central is a centralized easy-to-use network application that provides administrators with a way to centrally monitor their CX4, VNX, and VNXe storage systems. Unisphere Central enables a user to:

- Monitor up to 1,000 CX4, VNX, and VNXe systems from a single interface.
- View aggregated alerts, health, capacity, and CPU usage for multiple systems.
- Control access to the monitoring interface by setting up local Unisphere remote users, or integrating existing LDAP enabled users and groups.
- Organize views of the storage nodes in logical ways, including by location, type, department, etc.
- Launch Unisphere from Unisphere Central to manage individual systems. With the VNXe1600, “single sign on” and “single sign off” functionality is possible.

**NOTE:** Unisphere Central does not actively manage the systems in a customer’s environment. Instead, it leverages the capabilities in Unisphere by linking to it and launching the specific system to manage.

The Unisphere Central environment consists of a Unisphere Central server running in a VMware virtualized environment, one or more CX4, VNX, and VNXe systems, and a remote system to access the Unisphere Central server. For more information on Unisphere Central, see the paper titled *Unisphere Central for VNX Family: Next-Generation Storage Monitoring* on EMC Online Support.

SUPPORT ECOSYSTEM

VNXe1600 storage systems are customer-installable and customer-maintainable. When there is a hardware or software fault in the system, the user is informed through the alert mechanism in Unisphere. All alerts have a severity associated with it as well as a detailed message describing the alert. Alerts also provide links to context-sensitive knowledgebase articles that help correct the fault. For example, if there is a faulted disk in the VNXe1600 system, an alert message pops up that specifies which disk has faulted. Additionally, there are links to the Online Help and knowledgebase document that provides instructions for ordering a new disk and replacing a faulted disk in the VNXe1600 system.

The Support window in Unisphere provides links to resources for learning about and getting assistance for a VNXe1600 storage system. It provides the following features:

- **How to Videos** – Videos to learn about the storage system. For example, instructions on how to replace a failed component.
- **Online Documentation** – Online documents that provide the latest information about the product. These are routinely updated to ensure the most current information.
- **Online Training** – Videos, slideshows, and other educational material for learning about VNXe1600 systems.
- **Search EMC Support** – Articles, white papers, and other information regarding known issues and solutions related to system installation and management.
- **Community** – A way to interact with other VNXe1600 customers and read, contribute, or ask questions about the storage system.
- **Live Chat** – A way to quickly contact and chat with support personnel who can help a user in real time. Note that this option is available only to VNXe1600 systems that are under a maintenance contract.
- **Service Center** – A place to access information about open service requests.
- **Product Support Page** – Access all the system support needs such as maintaining hardware as well as steps to install and license the system.
- **Customer Replaceable Parts** – Order or return a part for the storage system.

Also, most wizards and screens in Unisphere display help icons that lead you to specific pages in the Unisphere Online Help.

- **Unisphere Online Help** – Includes information to enable users to complete tasks more efficiently and better understand Unisphere features.
DIFFERENCES TO VNXe3200

While much of the management and functionality of the VNXe1600 resembles that of the VNXe3200, there are also some differences. Whether you are familiar with the VNXe3200, or will be referring to VNXe3200 documentation, here are some things to consider:

- **Embedded I/O Connectivity** – VNXe1600 uses a 2 port converged network adapter for embedded I/O connectivity which can be configured for either Fibre Channel or optical iSCSI. This is in contrast to the VNXe3200, which includes 4 embedded 10GbE copper ports per SP. However both models support the same additional I/O module options.

- **FAST Cache** – VNXe1600 FAST Cache supports a maximum of 2 drives, due to the reduced memory resources compared to the VNXe3200. VNXe1600 FAST Cache can be configured as a mirrored pair of either 100GB or 200GB SLC Flash drives, for a maximum capacity of 200GB.

- **FAST VP** – Multi-tier storage pools and FAST VP auto-tiering functionality is not available for VNXe1600 systems.

- **File Provisioning** – The VNXe1600 is a block storage array, and therefore does not support file provisioning or protocols such as CIFS, NFS, FTP, or SFTP. When referencing existing VNXe3200 collateral in the context of VNXe1600, any reference to file features throughout VNXe3200 documentation is not applicable to VNXe1600.

- **Remote Monitoring** – The VNXe1600 is not currently supported by all external EMC monitoring applications that support VNXe3200, including VNX Family Monitoring and Reporting and EMC Storage Analytics. To confirm whether VNXe1600 is supported by a specific EMC product, consult the support matrix for the specific product.

- **Replication** – The VNXe1600 software does not contain the embedded RecoverPoint splitter, and therefore is not supported for use with RecoverPoint.

- **Unisphere CLI** – Some options and features that are not available on the VNXe1600 will not be accessible via Unisphere CLI. For example, provisioning of file resources or creation of multi-tier pools is not possible through Unisphere CLI, as is also the case with the GUI.

Additionally, there are some hardware differences between the VNXe1600 and VNXe3200 systems. The table below highlights the differences and similarities between the systems.

<table>
<thead>
<tr>
<th>Model</th>
<th>VNXe1600</th>
<th>VNXe3200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of SPs</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Form factor</td>
<td>2U</td>
<td>2U</td>
</tr>
<tr>
<td>CPU per system</td>
<td>2x Intel Xeon E5 2.6GHz Dual Core</td>
<td>2x Intel Xeon E5 2.2GHz Quad Core</td>
</tr>
<tr>
<td>Memory per system</td>
<td>16 GB</td>
<td>48 GB</td>
</tr>
<tr>
<td>RAID options</td>
<td>1/0, 5, 6</td>
<td>1/0, 5, 6</td>
</tr>
<tr>
<td>DPE options</td>
<td>12-drive (3.5&quot;), or 25-drive (2.5&quot;)</td>
<td>12-drive (3.5&quot;), or 25-drive (2.5&quot;)</td>
</tr>
<tr>
<td>DAE options</td>
<td>12-drive (3.5&quot;), or 25-drive (2.5&quot;)</td>
<td>12-drive (3.5&quot;), or 25-drive (2.5&quot;)</td>
</tr>
<tr>
<td>Minimum/maximum number of drives</td>
<td>6/200</td>
<td>6/150</td>
</tr>
<tr>
<td>Drive options</td>
<td>100</td>
<td>200 GB Flash SLC</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>800 GB Flash MLC</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>600 GB 15K SAS</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>900 GB</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4 TB NL-SAS</td>
</tr>
<tr>
<td>System Drives options</td>
<td>200 GB Flash (MLC)</td>
<td>200 GB Flash (MLC)</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4 TB NL-SAS</td>
</tr>
<tr>
<td>Back-end connection</td>
<td>6 Gb SAS</td>
<td>6 Gb SAS</td>
</tr>
<tr>
<td>Number of back-end ports per SP</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Embedded I/O ports per SP</td>
<td>2x 8Gb FC, or 2x 16Gb FC, or 2x 10 GbE Optical, or 2x 10GbE TWINAX</td>
<td>4x 10 GbE BaseT</td>
</tr>
<tr>
<td>Configurable I/O module slots per SP</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>I/O module options</td>
<td>4-port 8 Gb Fibre Channel</td>
<td>4-port 8 Gb Fibre Channel</td>
</tr>
<tr>
<td></td>
<td>4-port 10 GbE Optical</td>
<td>4-port 10 GbE Optical</td>
</tr>
<tr>
<td></td>
<td>4-port 1 GbE Copper</td>
<td>4-port 1 GbE Copper</td>
</tr>
<tr>
<td>Management ports per system</td>
<td>2x 10/100/1000 Ethernet</td>
<td>2x 10/100/1000 Ethernet</td>
</tr>
</tbody>
</table>
CONCLUSION

The VNXe1600 storage system provides a consolidated platform for provisioning, managing, and monitoring data storage for a wide range of organizations and networks.

Since VNXe1600 software automatically implements best practices when configuring storage, a user does not need detailed knowledge about storage and application technologies. Along with powerful features like MCx and FAST Cache, VNXe1600 systems are designed to be easily installed, configured, and maintained by an IT generalist. Comprehensive, easy-to-understand guidance is also available through the VNXe1600 support ecosystem.

From a hardware point of view, a user can start with a small configuration based on current requirements, and easily scale up as requirements change. The ability to easily implement advanced storage features with application wizards such as Replication, Thin Provisioning, and Unified Snapshots in a solution that is also integrated with VMware vCenter makes VNXe1600 storage systems unique in the marketplace.

IT departments can greatly benefit from using the VNXe1600 as it helps businesses handle exponentially growing storage capacity demands while providing reliable performance, availability, and support.

REFERENCES

The following documents can be found on the EMC Online Support:

- EMC Unisphere for the VNXe3200: Next-Generation Storage Management
- EMC VNXe3200 Asynchronous Replication
- EMC VNXe3200 Capacity and Performance Metrics
- EMC VNXe3200 High Availability
- EMC VNXe3200 MCx
- EMC VNXe3200 Pool Provisioning
- EMC VNXe3200 Replication Technologies
- EMC VNXe3200 Unified Snapshots
- EMC VSI for VMware vSphere Web Client
- Introduction to the EMC VNX2 Series
- Introduction to the EMC VNXe3200 FAST Suite
- Unisphere Central for VNX Family: Next-Generation Storage Monitoring
APPENDIX A: DRIVE SUPPORT

Below is a list of supported drives for the VNXe1600. The table also shows the type(s) of DAEs that will support the drive type.

<table>
<thead>
<tr>
<th>Drive Type</th>
<th>Capacity</th>
<th>12-Drive DAE</th>
<th>25-Drive DAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAST Cache Optimized SSD</td>
<td>100GB</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>FAST Cache Optimized SSD</td>
<td>200GB</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>FAST VP Optimized SSD</td>
<td>200GB</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>FAST VP Optimized SSD</td>
<td>800GB</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>15K RPM SAS</td>
<td>300GB</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>15K RPM SAS</td>
<td>600GB</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>10K RPM SAS</td>
<td>600GB</td>
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<td>✔</td>
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<tr>
<td>10K RPM SAS</td>
<td>900GB</td>
<td>✔</td>
<td>✔</td>
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