Technical Report

Introduction to NetApp EF600C array

Feature overview with SANtricity

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Abstract

The NetApp® EF600C NVMe high-density all-flash array delivers a performant high-capacity flash solution for customers that is also affordable and reliable. This document provides detailed information about the hardware and software features of the EF600C all-flash array and NetApp SANtricity® OS features.

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Introduction

With the release of SANtricity OS 11.90R1, NetApp EF-Series added two new capacity flash systems with the introduction of the EF300C and EF600C. These systems are still supported on the 11.90R1 and later SANtricity OS releases but are now also supported on the SANtricity OS 12.10 and later releases. These core block storage systems provide the fast, affordable high-performance and high-density options required for demanding block workloads such as media and entertainment, HPC/AI, and high-performance databases.

With high performance and ultra-high throughput, the new EF-Series systems will improve operational efficiency, help accelerate the transition from E-Series HDD-based systems to flash and meet increasing capacity needs without compromising performance or reliability. NetApp EF-Series delivers all of this at a wide range of low-cost, performance and capacity options.

What you already know about the EF600 will still be valid for the EF600C, except for the following:

- The only drives supported will be 30TB or 60TB capacity NVMe drives.
  - 1.9TB, 3.8TB, 7.6TB or 15.3TB performance NVMe SSDs not supported
- Only supports capacity NVMe drives, mixing of capacity and performance NVMe drives is not allowed.
- Available with a minimum of 12x up to a maximum of 24x capacity NVMe SSDs.
- Expansion shelves are not supported.
- Default configuration is a single Dynamic Disk Pool (DDP) which is automatically created using all available drives for simplicity in management. If a new drive is inserted, Dynamic Capacity Expansion (DCE) will start automatically to incorporate the new drive into the existing DDP.
- If the default configuration is used, drive capacities cannot be mixed in the storage array.
- Standard RAID (5,6,10) volume groups are not supported.
- IOP and latency performance of EF600C is reduced using capacity NVMe drives.

Note: The default configuration can be deleted. This allows for manual creation of one or two pools and the use of both 30TB and 60TB drives in the same array.

NetApp® EF600C all-flash arrays have a new badge, as shown in Figure 1, use end-to-end NVMe NE224 drive shelves and are managed by the secure web-based NetApp SANtricity® System Manager UI.

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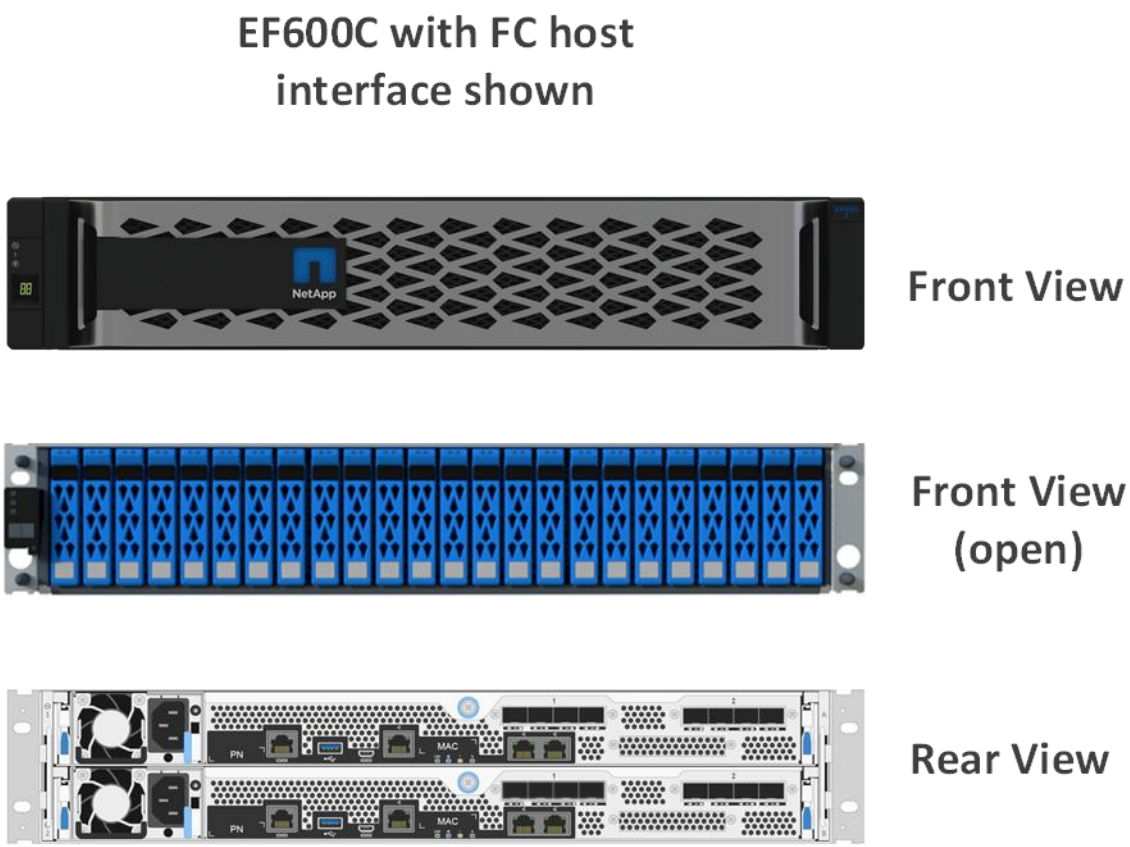
Figure 1) High-density EF600C all-flash array.



In one powerful all-flash array package, the EF600C array delivers optimal performance for both random workloads and large sequential workloads. The array can deliver consistent response times for up to one million 4KB random read IOPS with as few as 24 NVMe SSDs. The same configuration can deliver up to 44GBps large sequential read throughput and about 12.5GBps cache-mirrored large sequential write throughput.

The array supports the SCSI over FC protocol and the NVMe/FC protocol on the 32Gb FC host interface card (HIC). The iSCSI protocol is supported on the 25Gb iSCSI HIC. NVMe/IB, NVMe/RoCE, and iSER/IB are supported on the 200Gb HIC whereas the 100Gb HIC has additional support for SRP/IB as well as the other IB protocols.

This versatility is enhanced by the large capacity SSD choices of either 30TB or 60TB QLC drives to achieve the price/performance combination that fits your business need.

EF-Series products have a documented history of delivering up to 99.9999% availability when systems are properly sized, deployed, and maintained with NetApp Support agreements. EF-Series products also include NetApp Active IQ® technology to enhance your ongoing product experience.

Each EF600C controller provides a single Ethernet management port for out-of-band management. The EF600C array also introduces new, faster host interface options that fit the needs of the world's most demanding storage environments. These options are in one easy-to-install and easy-to-maintain hardware and integrated management software package.

This package includes your choice of the following HICs:

- Two four-port 25Gb iSCSI
- Two four-port 32Gb FC (OM4 fiber required)

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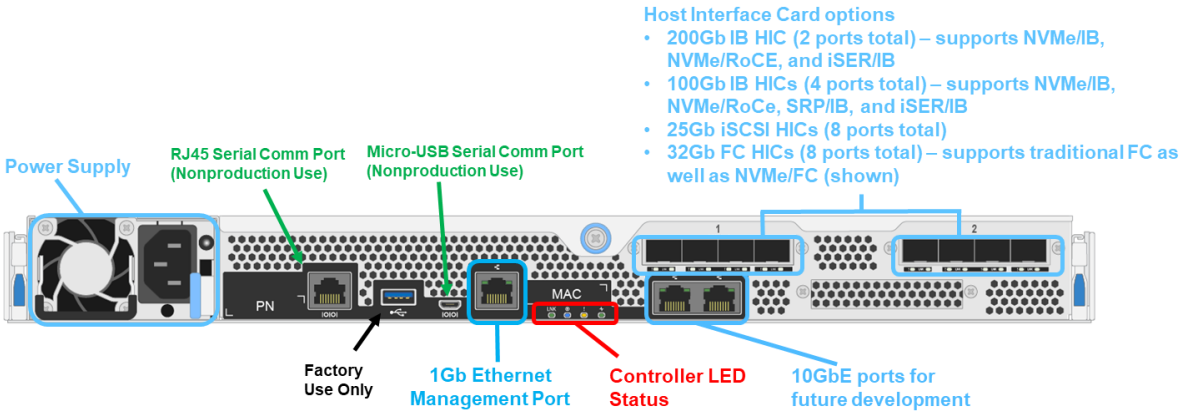
- Two two-port 100Gb IB (requires 100Gb-capable cables and host channel adapters [HCAs])
- One two-port 200Gb IB (requires 200Gb-capable cables and HCAs)

Note: You can download and install a software feature pack in the field to change the host protocol between the various available protocols on each HIC.

Figure 2 identifies the various interface ports on the EF600.

Figure 2) EF600C controller with ports identified.



Note: No mixing of host protocols

Note: Type-A USB port for factory use only is disabled if using SANtricity OS 11.80 or newer.

For optical connections, you must order appropriate SFP modules for your specific implementation. Consult the NetApp Hardware Universe for a full listing of available host interface equipment.

For detailed instructions about how to change host protocols, go to E-Series documentation page and search 'change host protocol'.

The EF600C continues the E-Series legacy of providing fast, simple, reliable, and flexible SAN storage regardless of the workload. NetApp EF600C all-flash arrays can support the workload if the following conditions are met:

- Hosts are qualified with EF-Series arrays.
- The hosts use SAN access to the storage, whether directly connected or fabric connected.
- The storage is managed at the host or file system level.

In fact, some of the world's most demanding online transactional workloads run on EF-Series arrays because these arrays are blazing fast, simple to install and operate, and extremely reliable, providing up to 99.9999% data availability. These highly flexible SAN building blocks can be applied when you need them and can be plugged into your current application environment on demand without disrupting your primary storage management strategy. EF-Series arrays can operate in a space as small as 2U, seamlessly integrate with many software layers, and still deliver consistently low-latency performance. These capabilities make EF-Series arrays an optimal SAN building block for any size enterprise that needs to support demanding online or database-reliant workloads.

Whether you are running Oracle Automatic Storage Management (ASM), Microsoft SQL Server, Splunk real-time analytics, or specialty applications with demanding response-time requirements, the EF600C array maintains its performance profile. To fully maximize performance, only minor setting changes are required when you create disk pools, volume groups, or volumes to switch between high-IOPS configurations and high-throughput configurations. This characteristic makes EF-Series arrays easy to deploy regardless of your workload.

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EF600C arrays use the web-based NetApp SANtricity System Manager UI to manage individual arrays, and SANtricity Unified Manager enables you to organize and manage multiple new-generation E-Series and EF-Series arrays from the new API-based central management application. The built-in web services API integration or the management client-based web services package makes the EF-Series product line easier than ever to integrate with your standard API-driven environment.

The following sections provide broad product information, including technical details about SANtricity features. Some familiarity with basic configuration concepts such as volumes, Dynamic Disk Pools (DDP), and RAID volume groups is assumed.

SANtricity management features

NetApp E-Series and EF-Series arrays have a rock-solid reputation for reliability, availability, simplicity, and security. The NetApp SANtricity 11.70 release builds on that legacy with the addition of 512e, which allows general support of the iSCSI host interface and support for VMware for FC and iSCSI hosts for NVMe-based platforms.

The new-generation E-Series and EF-Series arrays running the latest SANtricity OS are common criteria certified (NDcPP v2 certification).

Deployment

Deciding which components to install on an EF600-based storage array depends on if you want to manage single storage arrays individually or if you are managing multiple arrays.

Note: If you are using asynchronous mirroring features, then Unified Manager is required.

Managing storage arrays individually

If you are not using asynchronous mirroring features, then all configurations can be handled from SANtricity System Manager. Simply bookmark each array in a web browser. Figure 3 illustrates this configuration.

Figure 3) Managing a single EF600C with SANtricity System Manager.

Multiple storage arrays

If you have one or more storage arrays, you can install Unified Manager to manage your overall environment while still managing all storage array-based configuration through SANtricity System Manager. To manage multiple arrays, you can launch SANtricity System Manager from Unified Manager, as shown in Figure 4.

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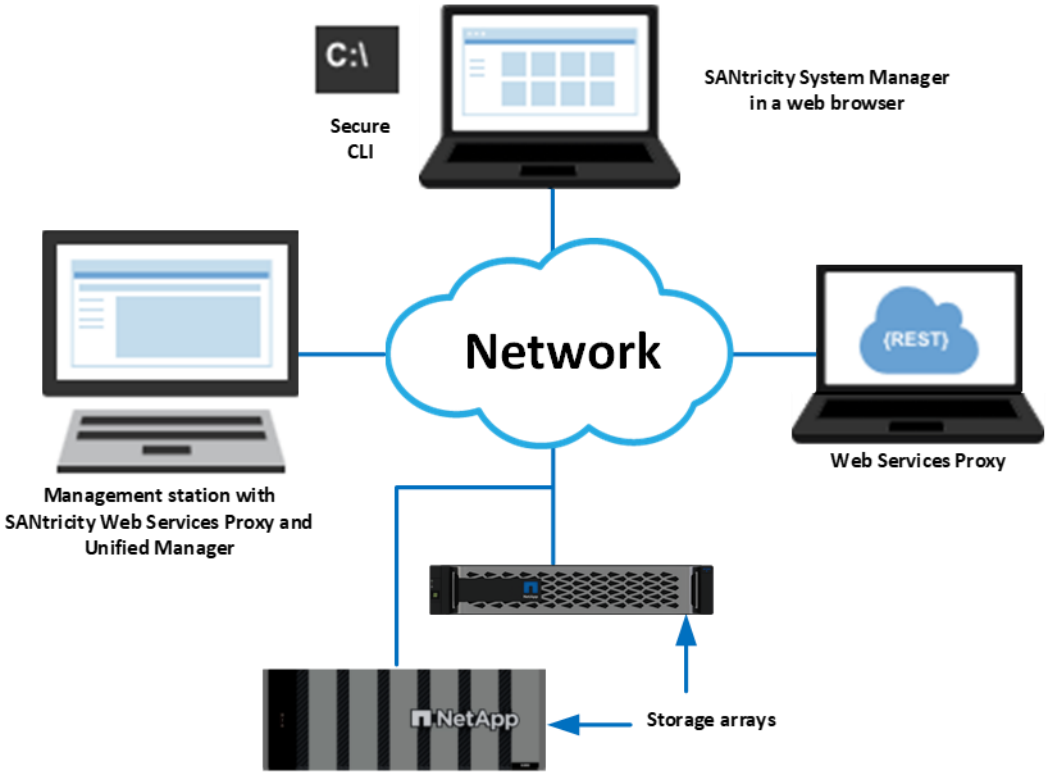
Figure 4) Managing multiple E-Series with SANtricity Unified Manager and SANtricity System Manager.



SANtricity Unified Manager

SANtricity Unified Manager is a web-based central management interface that replaces the legacy SANtricity Storage Manager EMW for managing the new-generation E-Series arrays. The Unified Manager GUI is bundled with the SANtricity Web Services Proxy and installs on a management server with IP access to the managed arrays. Unified Manager can manage hundreds of arrays.

SANtricity Unified Manager adds the following time-saving features:

- Upgrades multiple arrays with the same type of controller at one time.
- Supports Lightweight Directory Access Protocol (LDAP) and role-based access control (RBAC) just like SANtricity System Manager. It includes a simplified certificate management workflow to manage the Unified Manager or Web Services Proxy server certificates (truststore and keystore certificates).
- Supports organizing arrays by groups that you can create, name, and arrange.
- Supports importing common settings from one array to another. You save time by not duplicating setup steps for each array.
- Supports synchronous and asynchronous mirroring for all arrays through the secure SSL interface.

  Note: There is no synchronous mirroring support for EF600C systems.

The E-Series SANtricity Unified Manager or E-Series SANtricity Web Services Proxy is available on the NetApp Support Site's software download page. Either listing takes you to the combined Web Services Proxy with SANtricity Unified Manager download page.

After the installation wizard completes, you can open Unified Manager, or you can directly access the SANtricity Web Services Proxy as shown in Figure 5.

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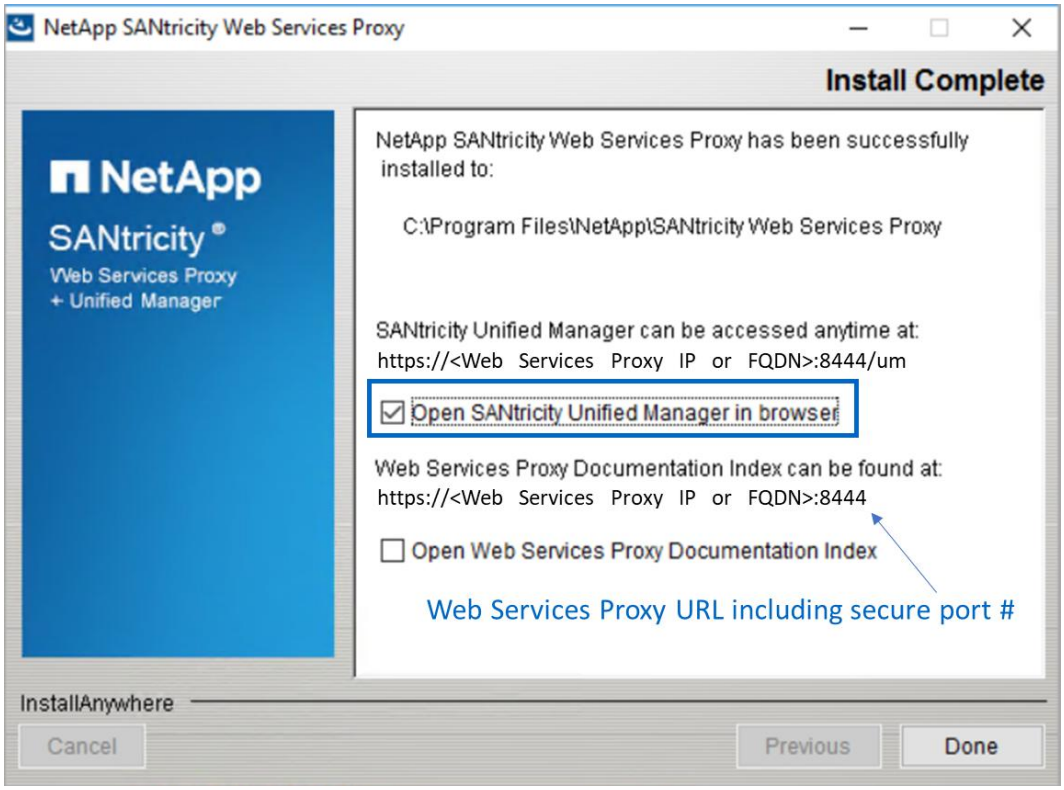
Figure 5) Final dialog box in the Web Services Proxy installation wizard.



If you want to open the Unified Manager UI after the Web Services Proxy installation, open a browser, navigate to the server IP address, and secure port number that was reserved during the Web Services Proxy software installation. For example, enter the URL in the form `https://<proxy-FQDN>:<port #>/`, and then select the link for Unified Manager. You could go directly to the Unified Manager login page (Figure 6) by adding `/um` to the URL—for example, `https://<proxy-FQDN>:<port #>/um`.

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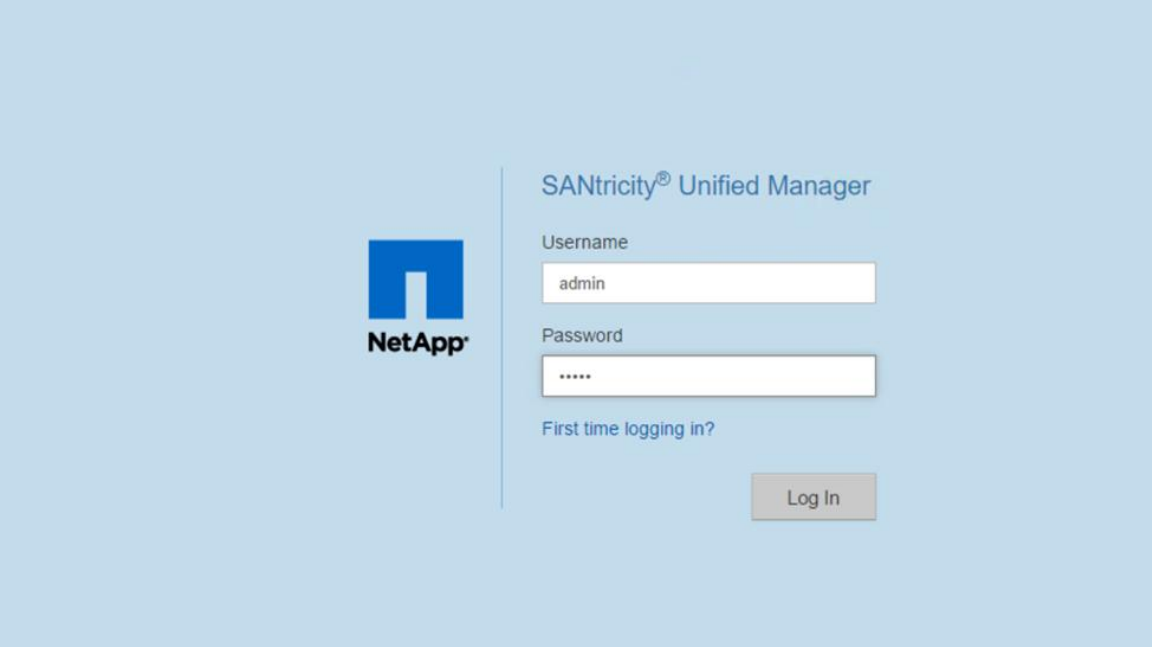
Figure 6) SANtricity Unified Manager login page.



SANtricity Unified Manager navigation

The login page for SANtricity Unified Manager has a similar appearance to SANtricity System Manager and requires administrators to set the array admin password as part of the initial login. SANtricity Unified Manager has a factory default admin account: `admin`.

Discovering and adding storage arrays

SANtricity Unified Manager must discover arrays to manage. You can discover a single array or scan a range of IP addresses to discover multiple arrays simultaneously. Select the tab or link shown in Figure 7 to open the Add/Discover wizard. After discovering arrays, you then choose to add them to be managed by Unified Manager.

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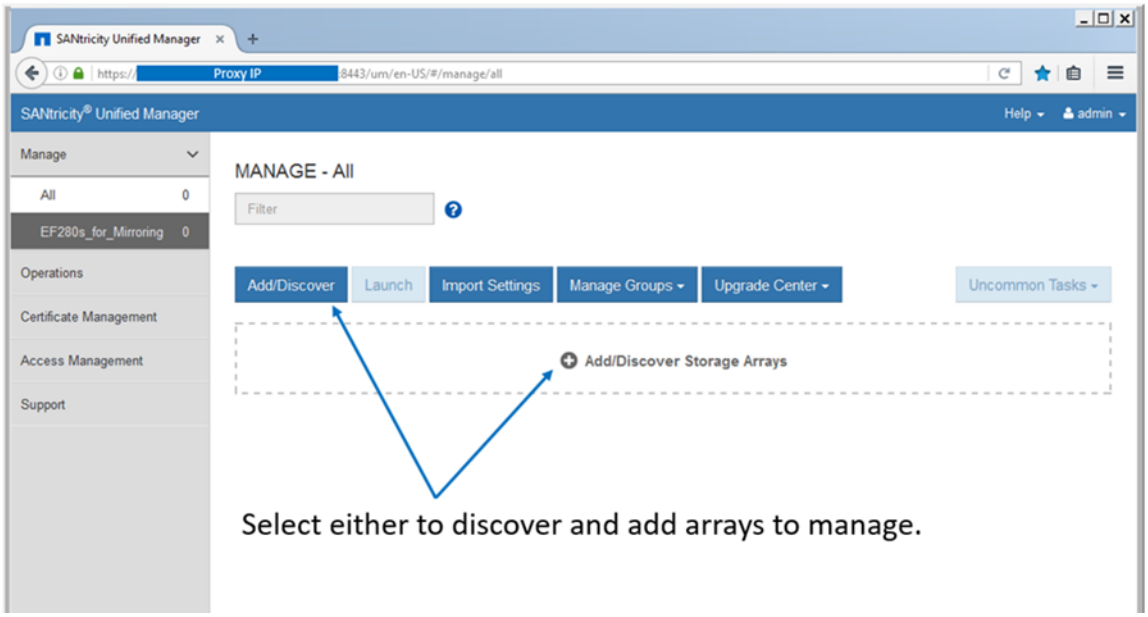
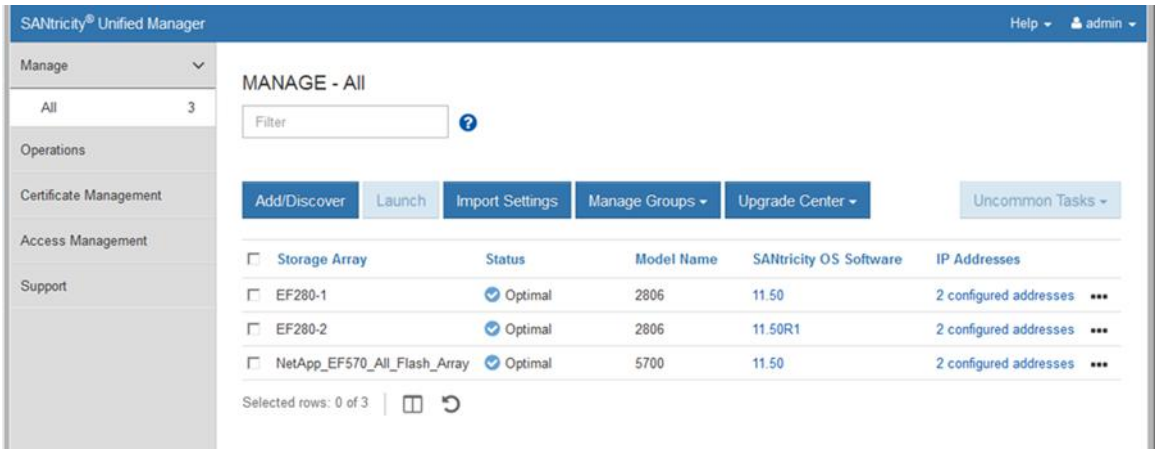
Figure 7) SANtricity Unified Manager landing page—discover and add arrays.



After the arrays are discovered and added, they are displayed on the landing page of Unified Manager (Figure 8).

Figure 8) SANtricity Unified Manager landing page.



Organizing arrays by group

After you add arrays to Unified Manager, you can group them to organize your array management environment. Figure 9 shows the EF280 arrays added to a group. This capability is available for all new-generation E-Series and EF-Series arrays.

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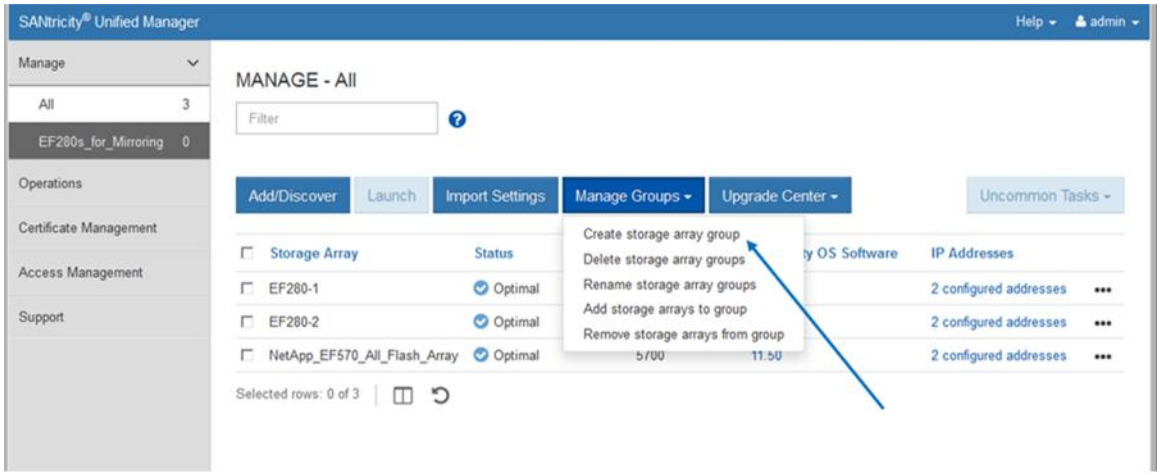
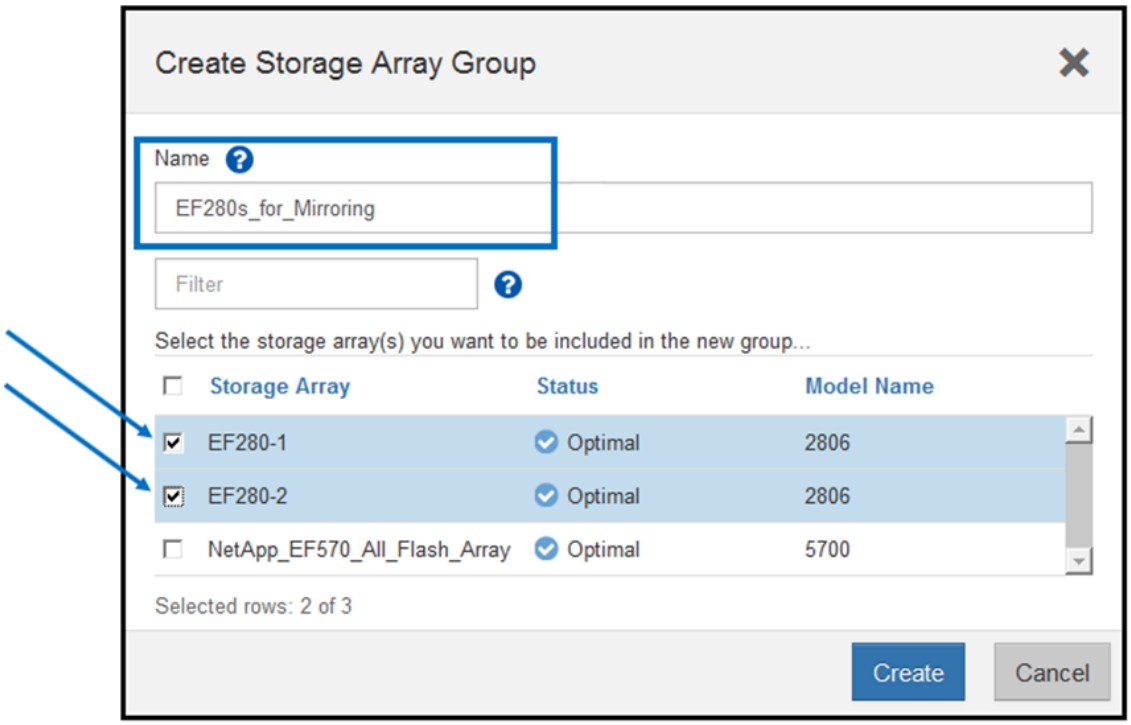
Figure 9) Creating a group to organize arrays in SANtricity Unified Manager.



The built-in wizard makes adding arrays to groups quick and easy, as shown in Figure 10.

Figure 10) Creating a group in Unified Manager.



SANtricity Unified Manager enables you to see just the subset of arrays in the new group, as shown in Figure 11.

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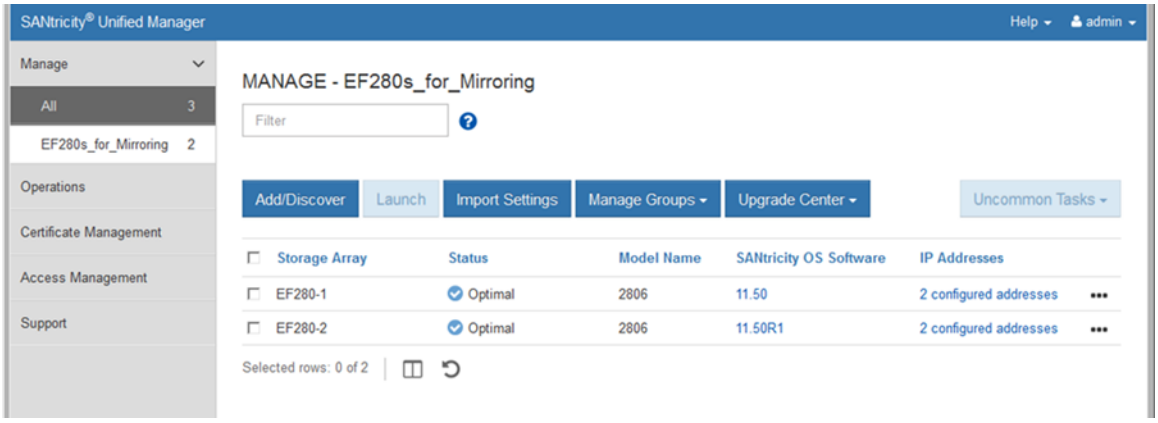
Figure 11) SANtricity Unified Manager showing a newly created group.

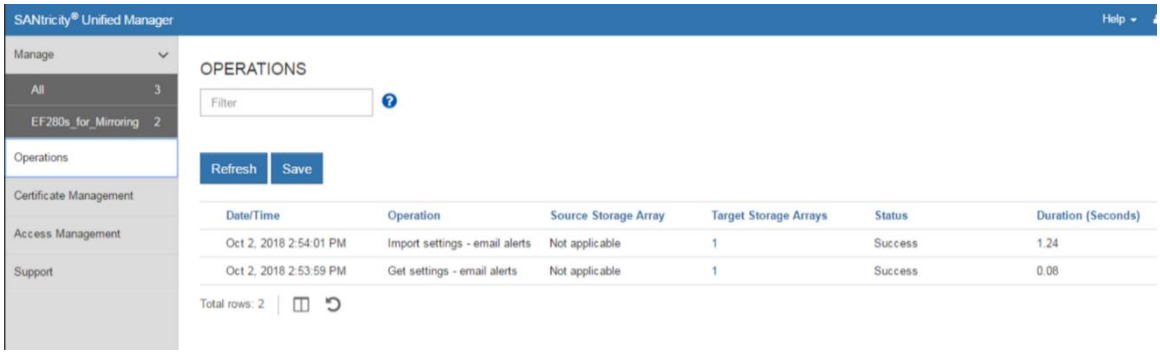


Importing settings and view operations

Other features in SANtricity Unified Manager require the ability to view operations that take some time to complete. One example is importing settings from one storage array to another. This feature is especially helpful and time saving when you install a new array in an environment that already contains E-Series or EF-Series arrays running SANtricity 11.60 or later. For example, if you want the same alerting and NetApp AutoSupport settings on all systems, use the Import Settings wizard to select the setting category, the array to copy from, and the array to import to, and click Finish. The operation to copy the settings is displayed in the Operations view, as shown in Figure 12.

Note: Be careful when importing settings from another storage array, especially if you have different alerting requirements and unique storage configurations. The storage configuration option is successful only when the source and destination arrays have identical hardware configurations. The import feature does not show details about the pending import and does not prompt for confirmation. When you click Finish, you cannot stop the copy/import process.

Figure 12) SANtricity Unified Manager Operations view.



Updating SANtricity OS through Unified Manager

To upgrade the array's firmware, complete the following steps:

1. Import SANtricity OS software into Unified Manager's SANtricity OS Software Repository by using Manage SANtricity OS Software Repository under Upgrade Center on the landing page.

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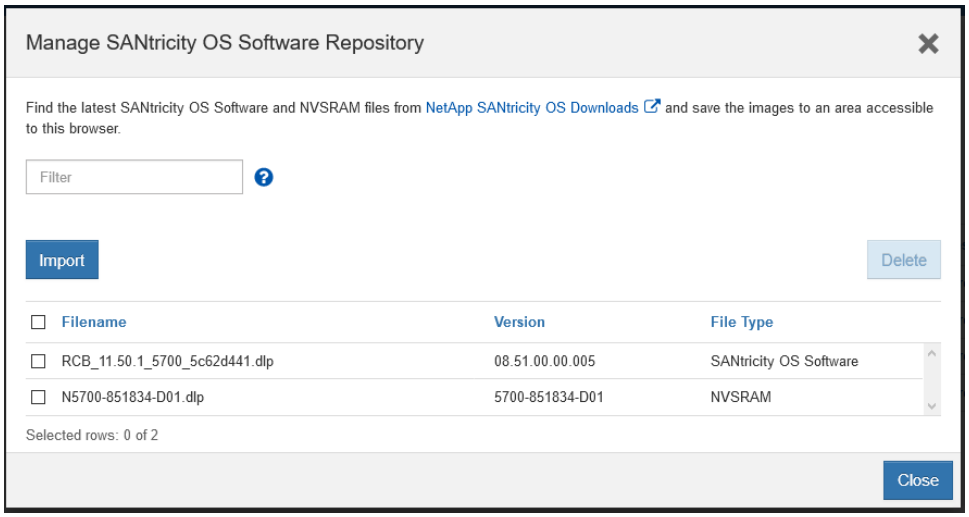
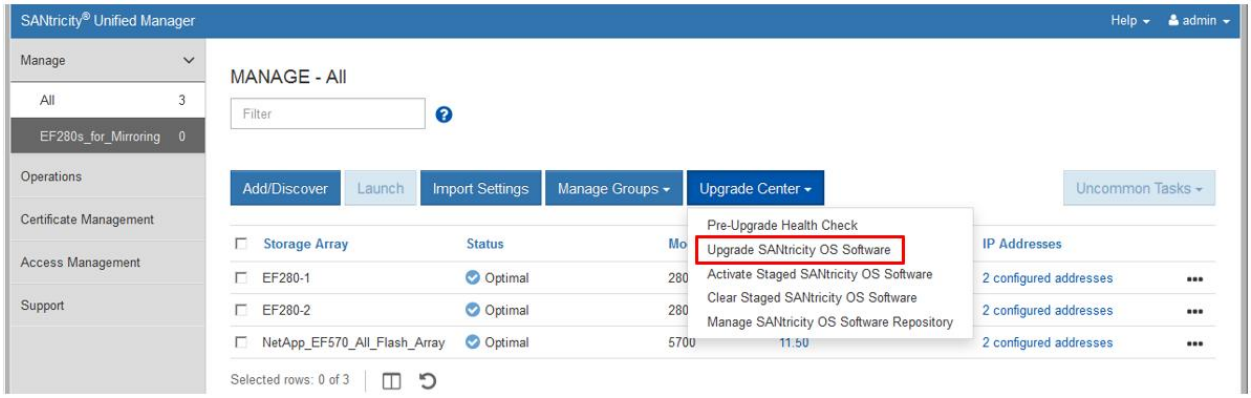


2. On the Unified Manager landing page, click Upgrade Center, and then click Upgrade SANtricity OS Software.



3. In the Upgrade SANtricity OS Software window, select the following items:
   - The desired SANtricity OS and/or NVSRAM files
   - The arrays to be upgraded that are appropriate to the selected SANtricity OS files
   - Whether to transfer and activate the OS files immediately or later
4. Click Start to continue.

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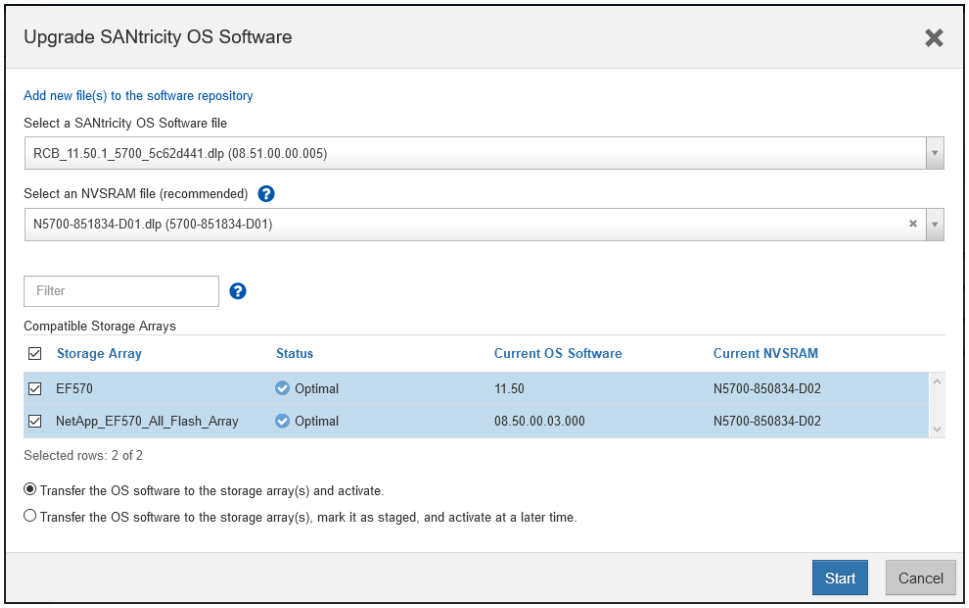
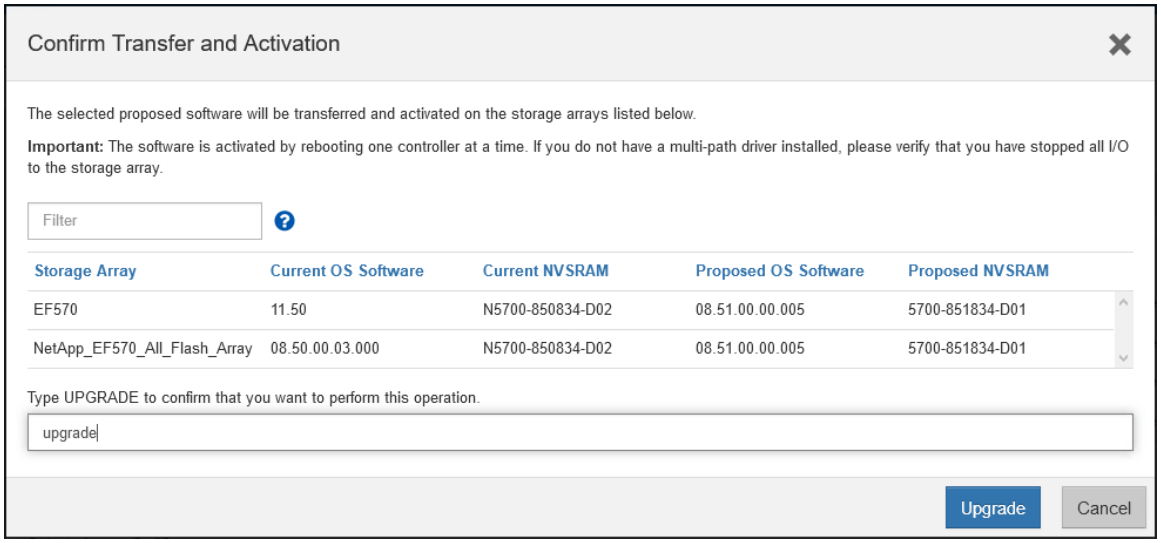


5. On the Confirm Transfer and Activation page, type `upgrade` and then click Upgrade button to begin the SANtricity OS files transfer.



6. After the transfer starts, the Upgrade SANtricity OS Software page is displayed. The status of the selected arrays is displayed throughout the upgrade process. The first status is Health Check in Progress, then File Transfer in Progress, and finally Reboot in Progress.

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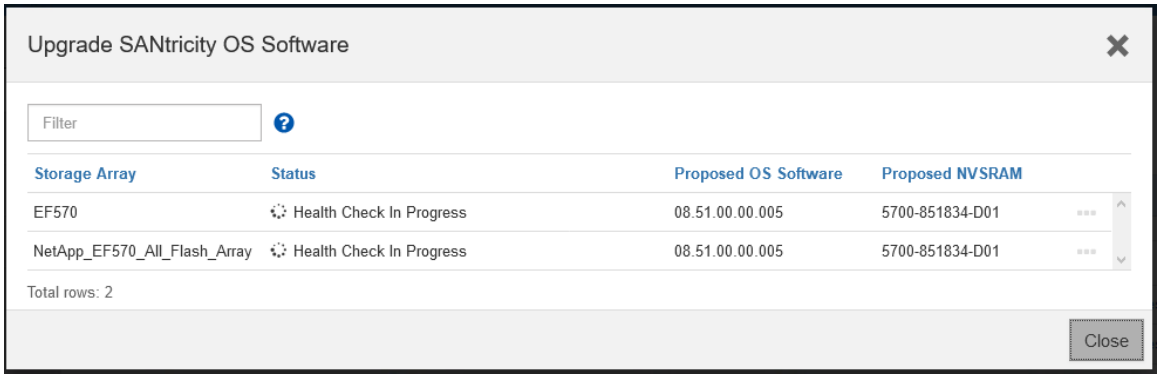
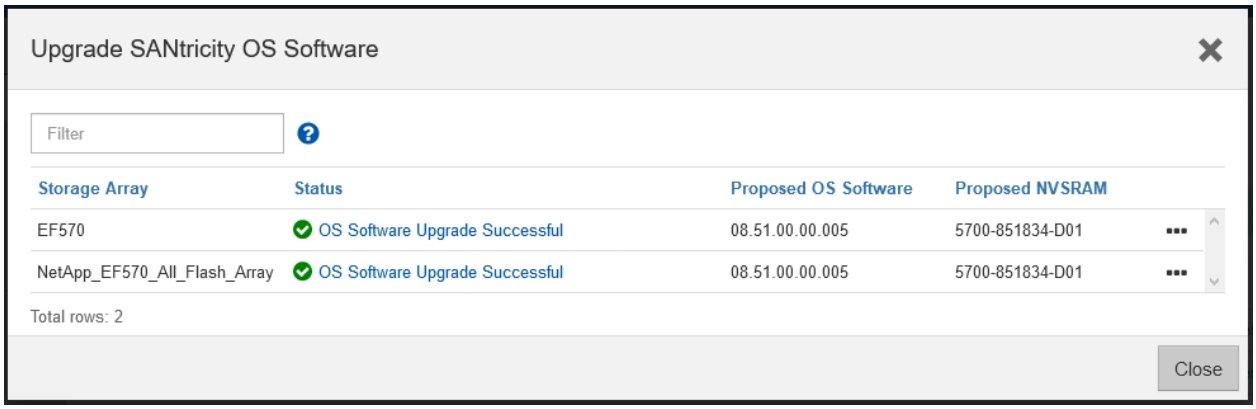
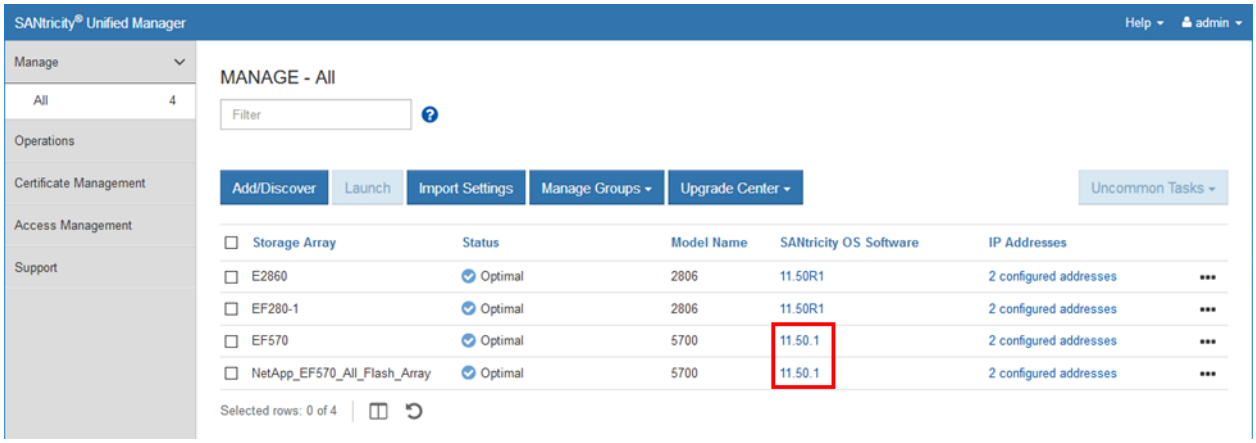


7. After the files have been transferred and the controllers have completed rebooting, the status changes to OS Software Upgrade Successful.



8. On the Unified Manager landing page, the SANtricity OS Software version reflects the newly installed SANtricity OS version.



SANtricity Unified Manager security

SANtricity Unified Manager supports the same secure management features as SANtricity System Manager, including LDAP, RBAC, and SSL certificates. For complete details and workflow examples, browse various E-Series security focused technical reports at the Browse security technical reports (E-Series) site.

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Remote mirroring with SANtricity Unified Manager

With Unified Manager, you can set up remote mirroring between two new generation arrays. Starting with SANtricity 11.62, Unified Manager is used to create mirror relationships. See TR-4839 SANtricity Synchronous and Asynchronous Mirroring (11.62 and later) or the Online Help in SANtricity Unified Manager for a complete description. SANtricity Unified Manager must be version 4.2 or later and SANtricity System Manager must be OS version 11.62 or later.

Note: Drive types should be the same on source and destination. Either both NVMe drives or both non-NVMe drives. NVMe 4Kn volumes mirror only to another NVMe 4Kn volume, and 512e to 512e.

Note: EF600C does not support synchronous mirroring.

Prior to SANtricity 11.62, for a description of mirroring between two new generation E-Series arrays or between a new generation E-Series array and a legacy E-Series array, see TR-4656 SANtricity Synchronous and Asynchronous Mirroring (11.61 and earlier).

SANtricity System Manager

SANtricity System Manager provides embedded management software, web services, event monitoring, secure CLI, and AutoSupport for EF600C arrays.

EF600C storage systems are shipped preloaded with SANtricity OS, which includes SANtricity System Manager. To discover multiple EF600C storage systems running SANtricity OS from a central view, download the latest version of the Web Services Proxy, which includes the latest version of SANtricity Unified Manager.

If you do not want to use SANtricity Unified Manager to discover and manage your E-Series arrays, you do not need to download and install the Web Services Proxy software. When customers implement E-Series with Windows and Linux operating systems, they can use the settings in the Host Utilities to properly configure each host, according to the latest Interoperability Matrix Tool (IMT) guidance. See the appropriate OS Express Guide for host setup requirements, instructions, and references. The guides are available on the SANtricity software documentation site.

Note: Host packages are not required for NVMe-oF installations. See the appropriate OS Express Guide for host setup requirements, instructions, and references. The guides are available from the NetApp Support Site at E-Series systems documentation site, then look under Deploy software for desired operating system.

Note: For first-time customers, creating an account on the NetApp Support Site can take 24 hours or more. New customers should register for Support site access well before the initial product installation date.

System Manager navigation

After you log in to SANtricity System Manager for a system running SANtricity 11.90x, the home page is displayed, as shown in Figure 13.

- The icons on the left let you navigate through the System Manager pages and are available on all pages. The text can be toggled on and off.
- The items on the top right (Preferences, Help, Log Out) are also available from any location in System Manager.
- At the bottom-right corner is an architectural view of your array that lets you provision the storage.

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Figure 13) SANtricity 11.90x System Manager home page.

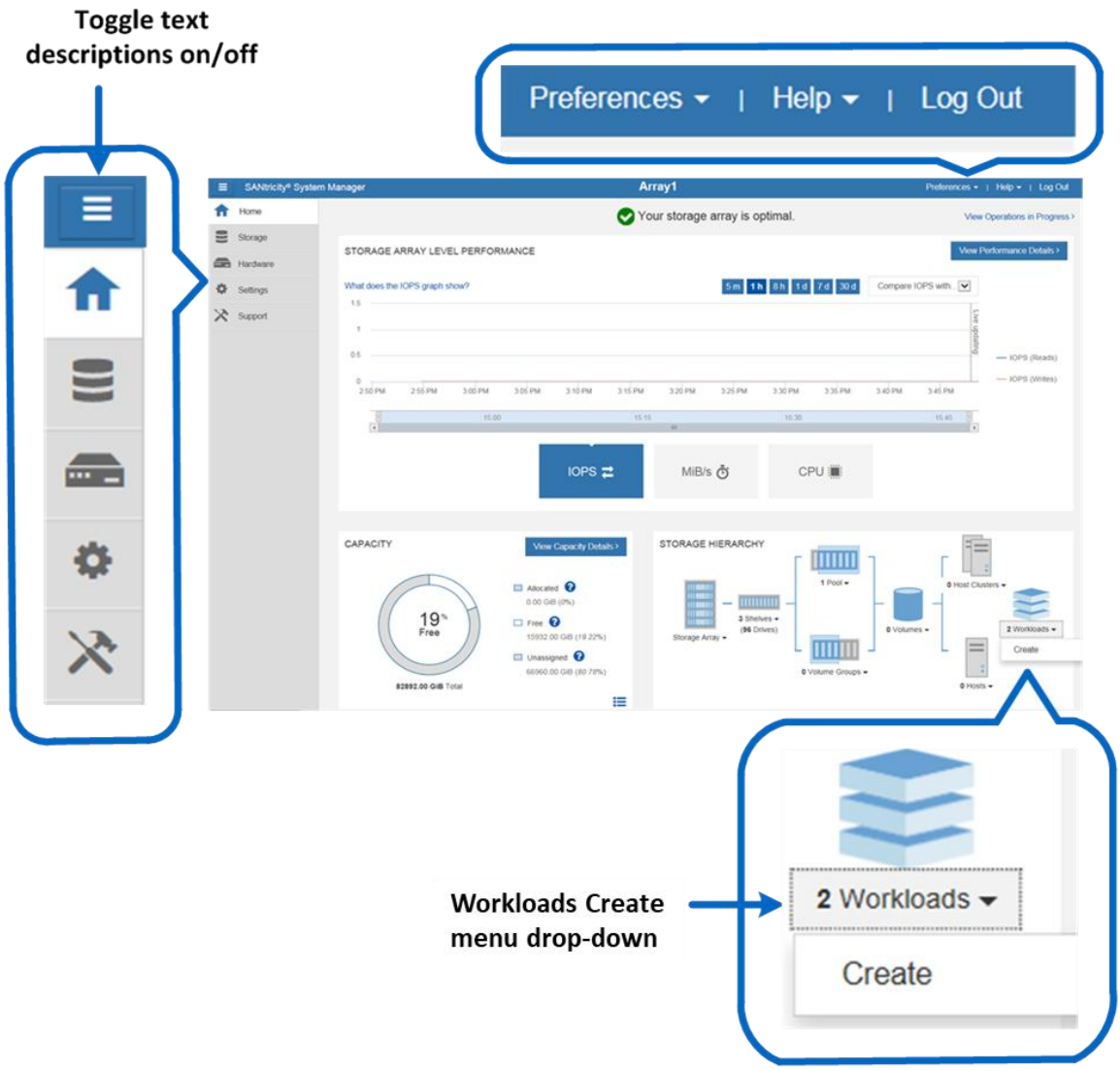

Figure 14, Figure 15, Figure 16, and Figure 17 show the other four main pages that are used in SANtricity 11.90x System Manager and that are accessible from anywhere in the application.

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Figure 14) System Manager 11.90x Storage page.

Figure 15) System Manager 11.90x Hardware page.

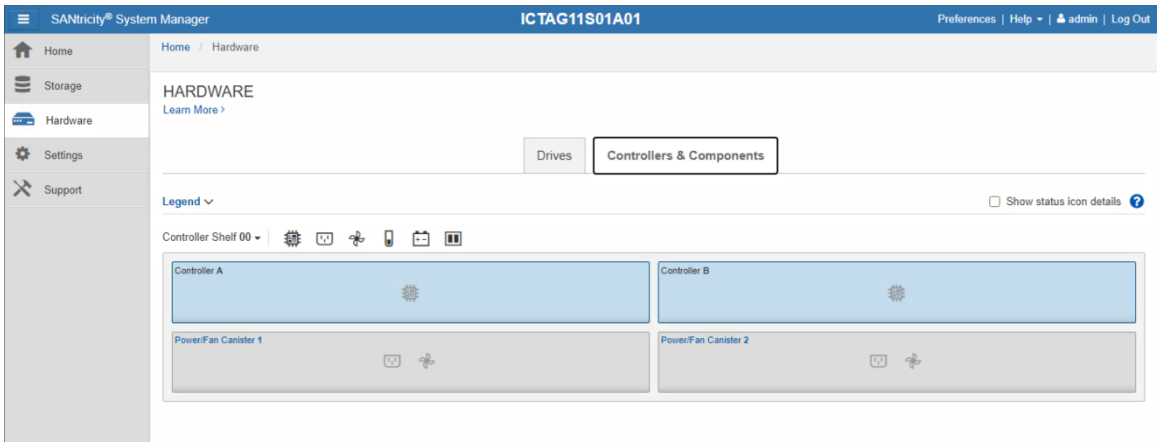
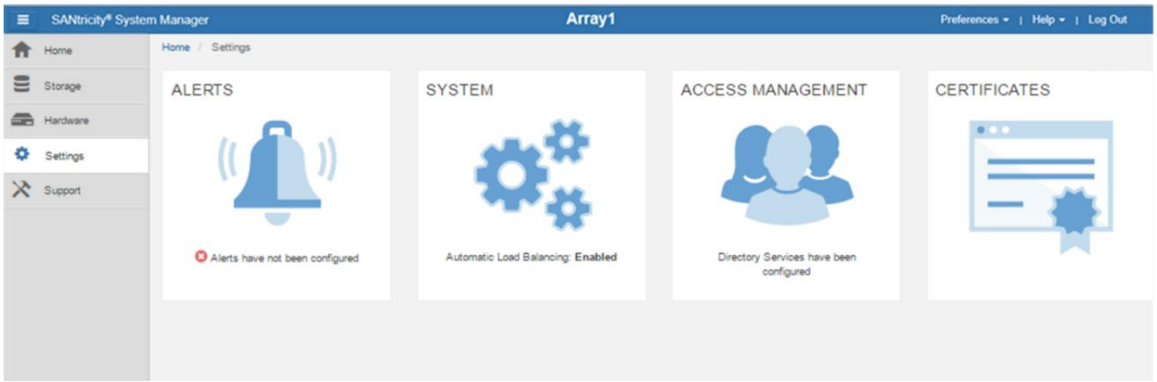


Figure 16) System Manager 11.90x Settings page with new security tiles.



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Note: Figure 16 shows the view for an administrator or security administrator. Others with a lower access permission level will see only the Alerts and System tiles.

Figure 17) System Manager 11.90x Support page.

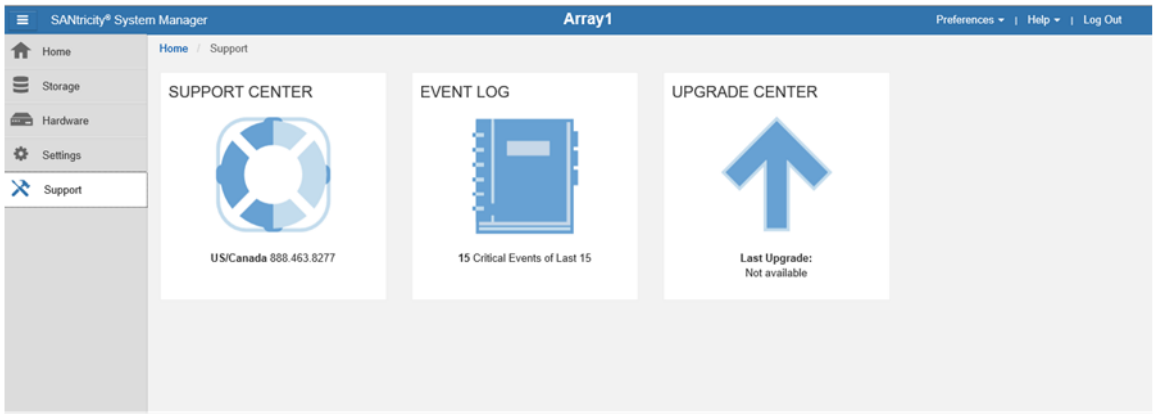
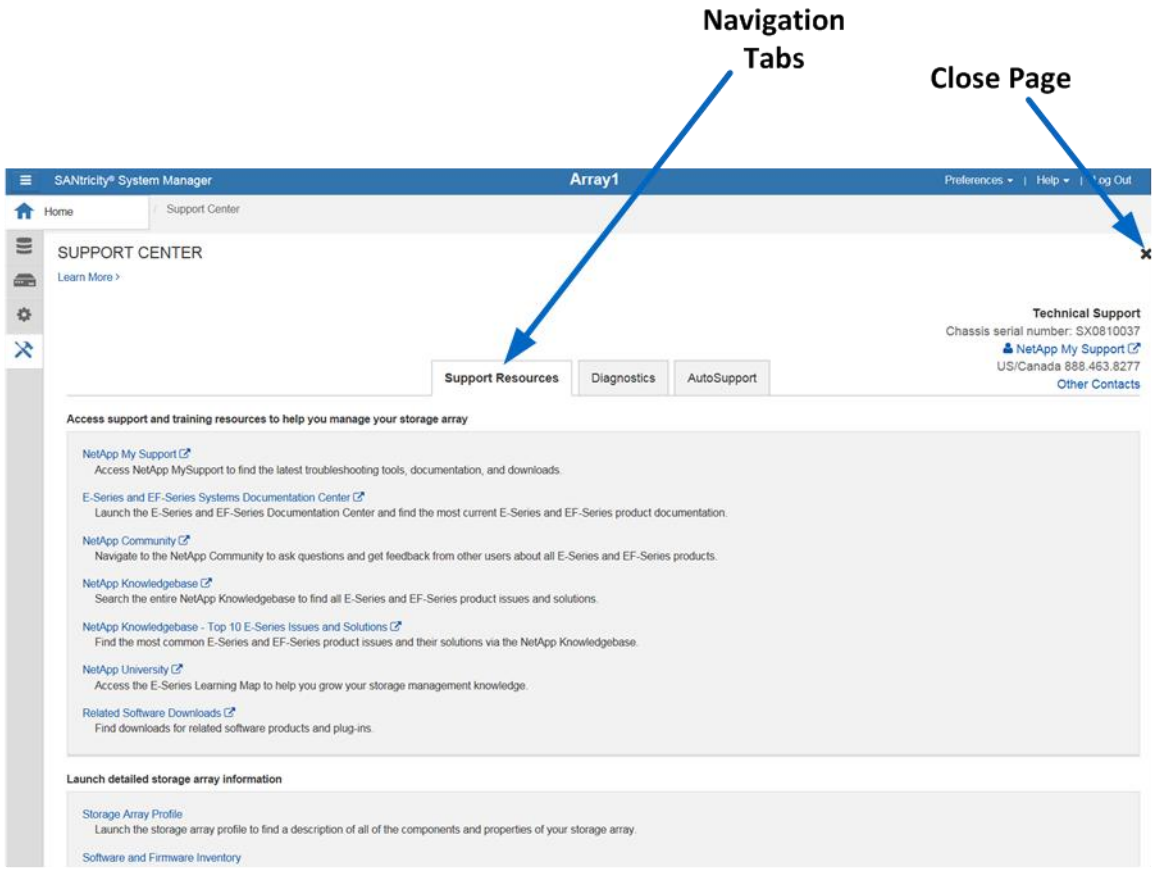


Figure 18 displays the Support Center, which you can reach by selecting the Support Center tile on the Support page (Figure 17). From the Support Center, use navigation tabs to reach support topics.

Figure 18) System Manager 11.90x Support Center.



The EF600C is supported by SANtricity 12.10 or later and that homepage is shown in Figure 19.

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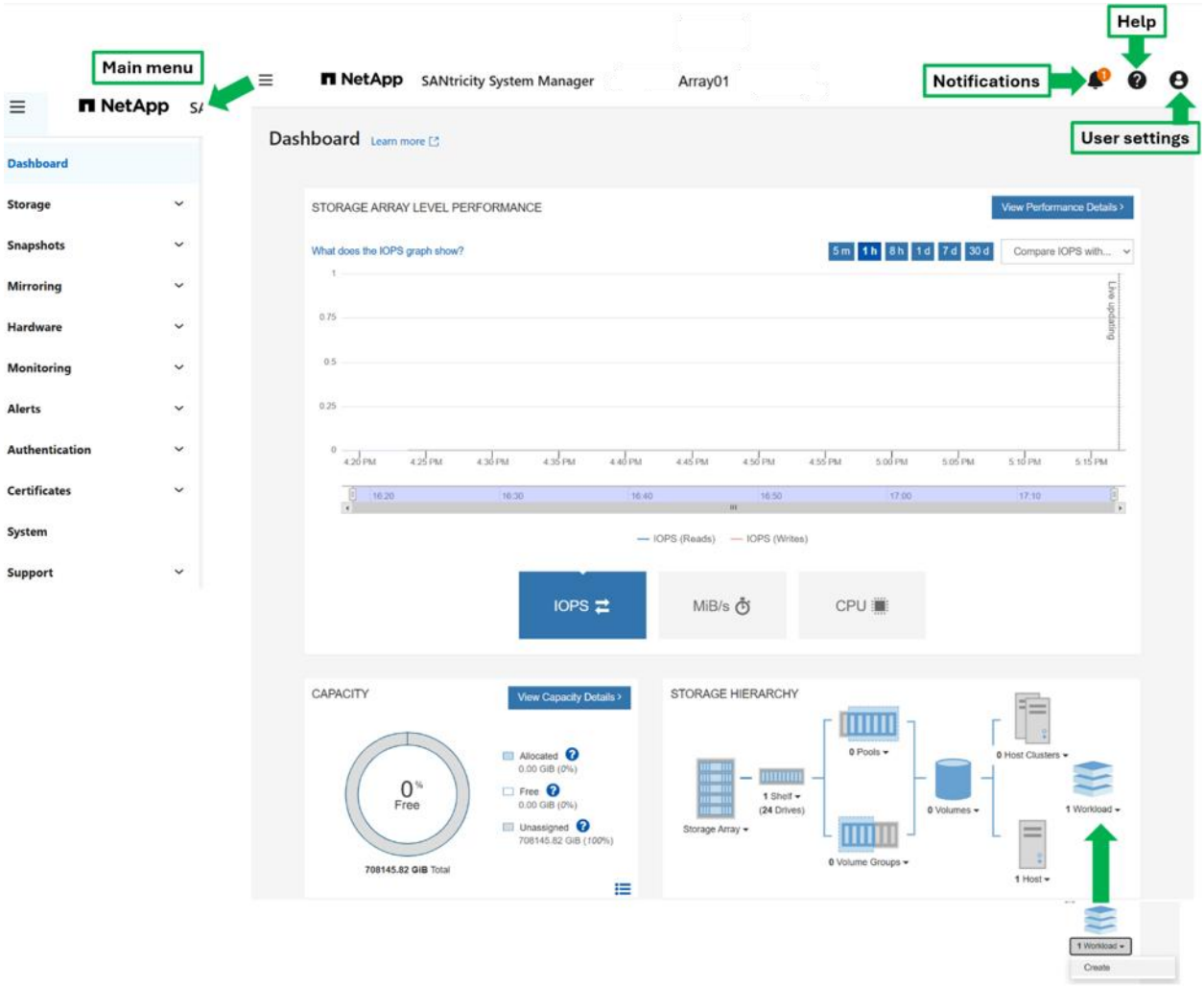
Figure 19) SANtricity 12.10 System Manager home page.



Displaying the main menu allows the user to select one of several menu items used in SANtricity System Manager. Many menu items have an up pointing array to the right of the name, "^", that after clicking on it expands to show what options are available with the menu item. See Figure 20 for the different menu items' options.

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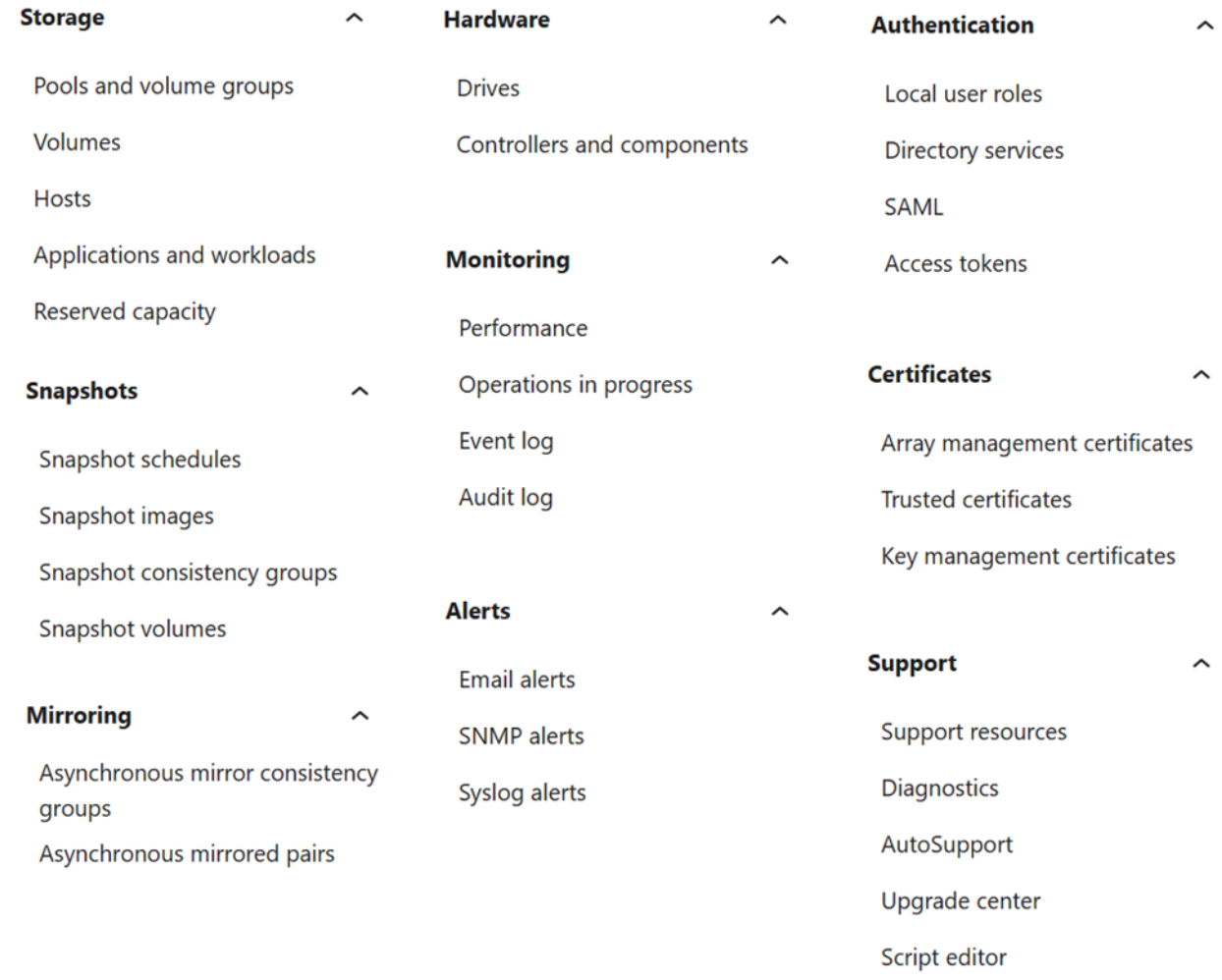
Figure 20) System Manager 12.10 menu items' various options.



Beginning with SANtricity 12.10, the number of characters allowed for a volume's name has been increased from 30 up to 60 characters.

SANtricity System Manager security

SANtricity System Manager supports multiple levels of management interface security including:

- Support for directory services through LDAP.
- Support for RBAC: five standard roles with varying permission levels.
- Support for certification authority (CA) and SSL certificates.
- Implementation of a secure CLI. The CLI is secure when the certificates are installed. Syntax and invocation are the same as in the legacy CLI, but additional security parameters are supplied.
- Security enhancements that extend to the onboard web services API, where user account passwords are now required.

  Note: If you want to run in the previous security mode with a single administrative password and still use symbols to communicate through the legacy API, the new security features can be disabled by the admin or security users.

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LDAP and RBAC

LDAP is a commonly used communication protocol that enables directory servers such as Microsoft Active Directory to provide centralized identity control over user and group definitions. The directory service is used by many devices in a network infrastructure to identify and authenticate users seeking access to devices in the network.

RBAC is software on the E-Series array that defines standard user levels, each with a well-defined set of access permissions. A user is authenticated as a member of a group, and specific permissions are set on the array side to define the type of access that user or group is allowed. This approach enables SANtricity 11.40 and later versions to provide the granularity of access that customers require.

The permission level with each role is defined in Table 1.

Table 1) Built-in roles and associated permissions.

Role name (log in as)	Access permissions
Root Admin (admin)	This role allows you to change the passwords of any local users and execute any command supported by the array. The admin password is set at initial login or any time after.
Security Admin (security)	This role allows you to modify security configuration settings on the array. It allows you to view audit logs; configure secure syslog server, LDAP, or LDAP over SSL (LDAPS) server connections; and manage certificates. This role provides read access but does not provide write access to storage array properties such as pool or volume creation or deletion. This role also has privileges to enable or disable SYMbol access to the array.
Storage Admin (storage)	This role allows full read and write access to the storage array properties and maintenance/diagnostics functions. However, it does not include access to perform any security configuration functions.
Support Admin (support)	This role provides access to all hardware resources on the array, failure data, event log/audit log, and controller firmware (CFW) upgrades. You can view the storage configuration but cannot change it.
Monitor (monitor)	This role provides read-only access to all storage array properties. However, you will not be able view the security configuration.

Setting up the directory server and roles

Directory servers, like most data center devices, are complex and designed to fulfill many use cases. However, the E-Series LDAP/RBAC implementation focuses on authentication and two main elements: users and groups. As with most applications, you must understand a few acronyms and follow a few conventions to set up communication between the E-Series array and the directory server. The most critical acronyms to understand are as follows:

- **CN.** Stands for `commonName`, used to identify group names as defined by the directory server tree structure.
- **DC.** Stands for `domainComponent`, the network in which user and groups exist (for example, netapp.com).
- **DN.** Stands for `distinguishedName`, the fully qualified domain name made up of one or more comma-separated common names, followed by one or more comma-separated DCs (for example, `CN=functional_group_name,CN=Users,DC=netapp,DC=com`).

E-Series systems follow a standard web server implementation on the controllers, and information about the general directory services setup is available on the web. As a result, setting up the service on E-Series systems only requires some fields, which are listed in Table 2.

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Table 2) LDAP/RBAC required fields and definitions.

Field name	Definitions
Domain (for example, netapp.com)	Network domains defined in the directory server of which users accessing the storage array are members.
Server URL	Could be a fully qualified domain name or IP and port number with the format `ldap://<IP:port_number>` (port 389 or port 636 for LDAPS).
Bind account	Format is `CN=binduser,CN=Users,DC=<some_name>,DC=com`.
Bind account password	Password for bind account user.
Search base DN	Format is `CN=Users,DC=<some_name>,DC=com`.
Username attribute	The LDAP attribute that defines the username. Example: `sAMAccountName`: standard entry for legacy Windows-based browsers, including Windows 95, Windows 98, and Windows XP. Linux can have other designations.
Group attributes	The LDAP attributes that define the groups to which a given user belongs. Example: `memberOf` is a standard attribute.

Figure 21 shows an example Active Directory server integration with SANtricity System Manager. The entries are all examples except for username attributes and group attributes in the privileges section. Those items are standard entries for Windows and are not likely to change for most implementations.

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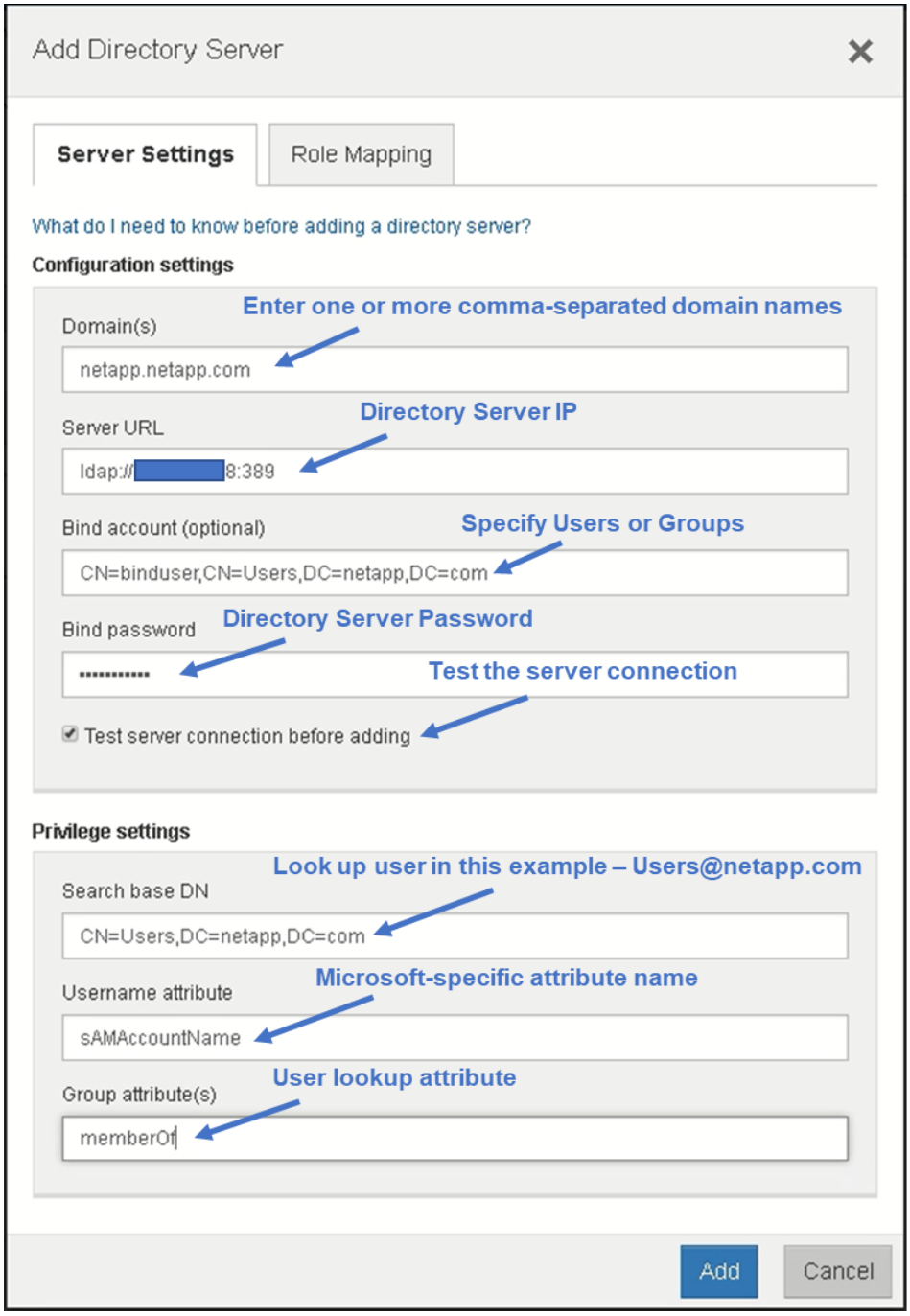
Figure 21) SANtricity System Manager directory server setup wizard.



The array roles for the specified user groups are set in the Role Mapping tab. As shown in Figure 22, users who are members of the StorageAdmin, StorageTechs, and ITSupport groups are authenticated as branches of the Users group `@cre.com`. When users in one of those groups log in to the array, they are allowed access to certain views and functions in the management interface according to the permissions granted.

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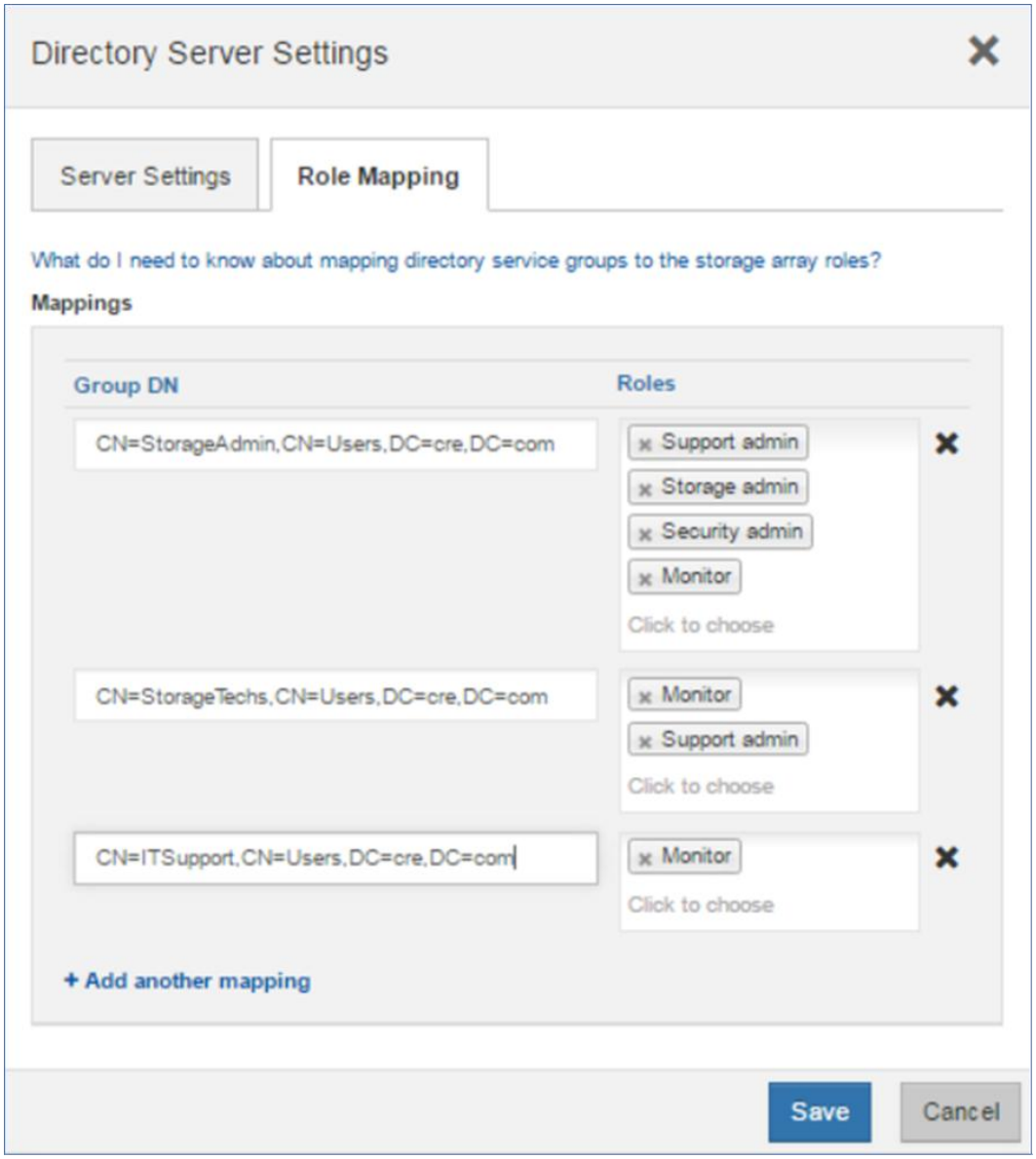
Figure 22) Role Mapping tab in the directory server settings wizard.



Note: The monitor role is automatically added to all group DNs. Without monitor permission, users in the associated mapped group are not able to log in to the array.

Multiple groups can be defined and mapped to specific roles that meet individual business requirements. Figure 23 shows the difference in user views and access to features according to access permission level for SANtricity System Manager 11.90x, Figure 24 shows SANtricity 12.10 permission differences. The login on top provides monitor and support access, but it does not provide security access like the admin login below it.

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Figure 23) SANtricity 11.90x System Manager views change according to user permission level.

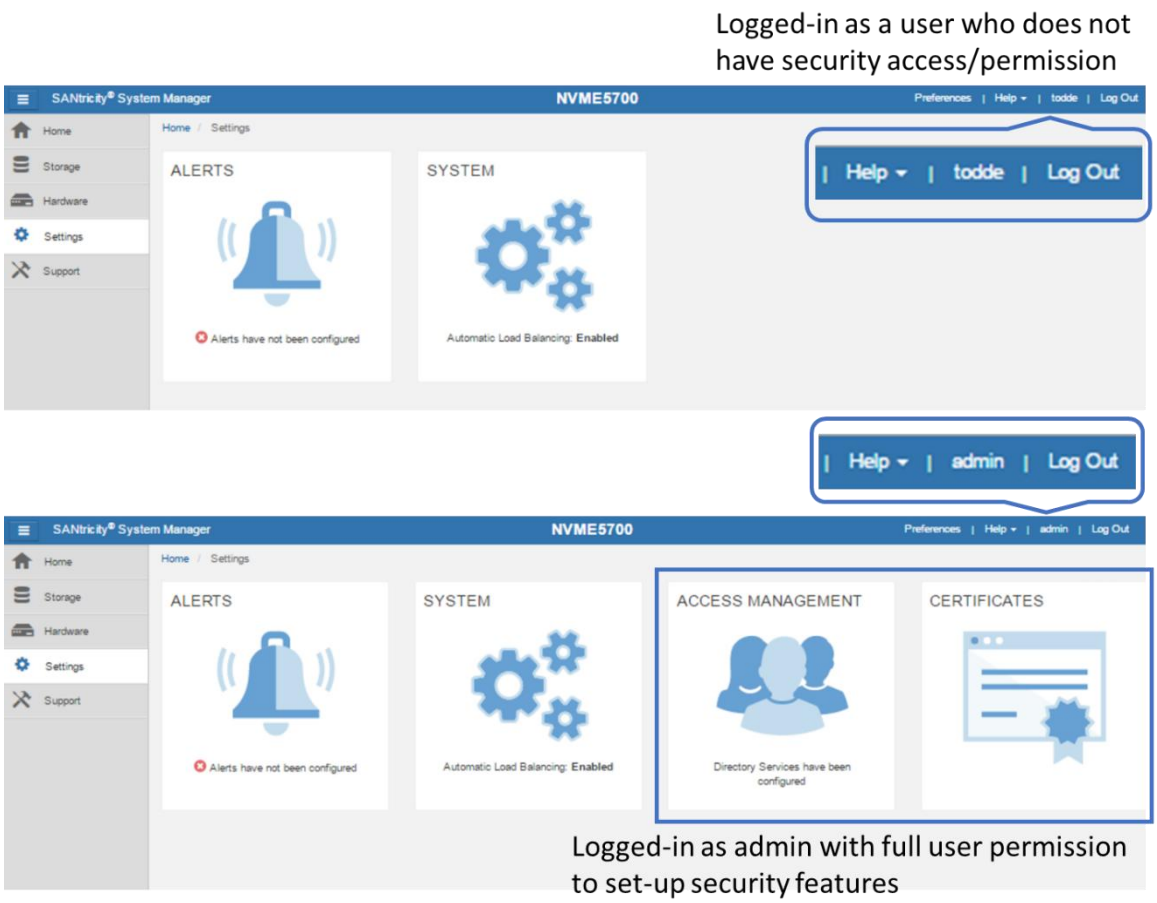

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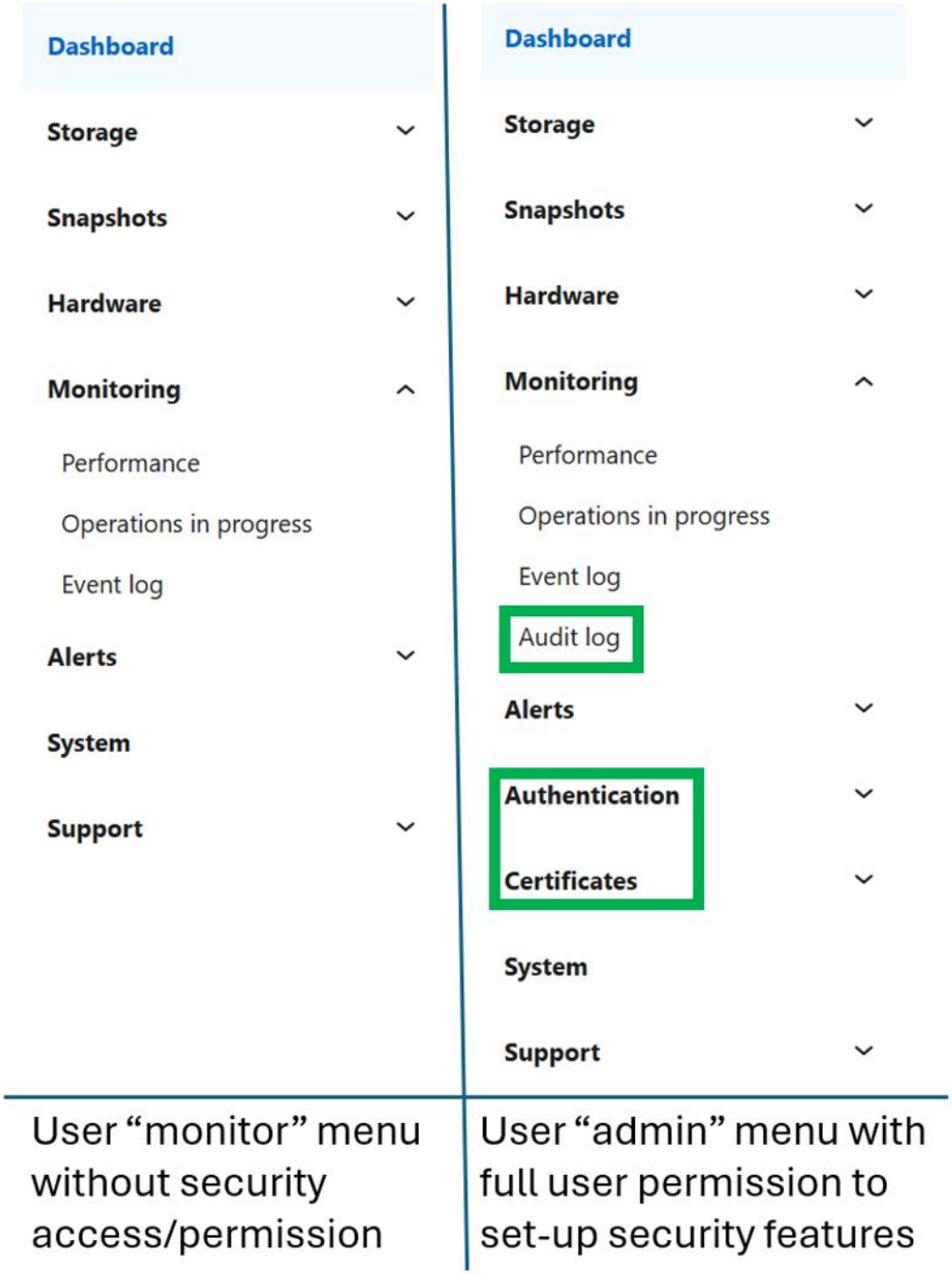
Figure 24) SANtricity 12.10 System Manager views change according to user permission level.



SANtricity web server security certificates

In addition to authentication and access control, SANtricity System Manager supports standard CA certificates. This support enables secure communications (SSL/TLS) between browser clients and the E-Series built-in web servers on the controllers. On EF600C arrays, the SANtricity System Manager UI is accessed through one of the two controllers. (In the legacy SANtricity Storage Manager application, access was through both controllers simultaneously.) As a result, all communication to the other controller in the EF600C array is performed through the midplane in the shelf.

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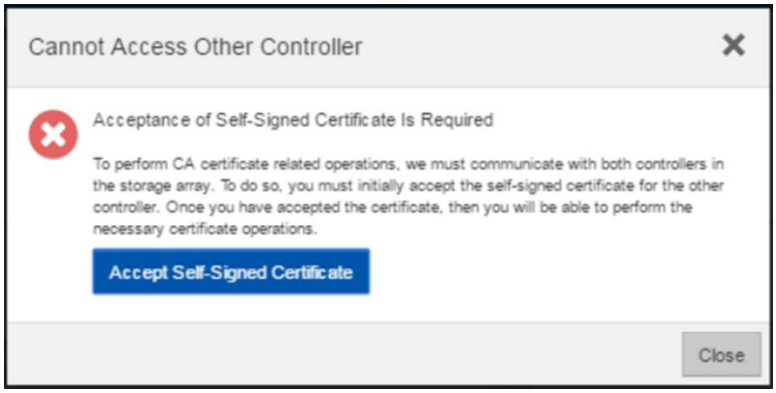
Because you can log in to either of the controllers through the web browser, both controllers must run a web server instance. For proper communication, both controllers must present a self-signed certificate to each other. This process happens automatically when the admin or security user logs in to each controller and opens the Certificates tile. Figure 25 shows the dialog box that is displayed the first time the tile is opened.

Figure 25) Initial step required to set up web server certificates.



You must accept the self-signed certificate to continue setting up certificates. The process takes you to another webpage, where the certificate is created in the background. Follow the prompts to complete the process. When the process is complete, the array requires the admin user or a user with security permissions to log in again. Both controllers are then displayed with valid local host certificates, as shown in Figure 26.

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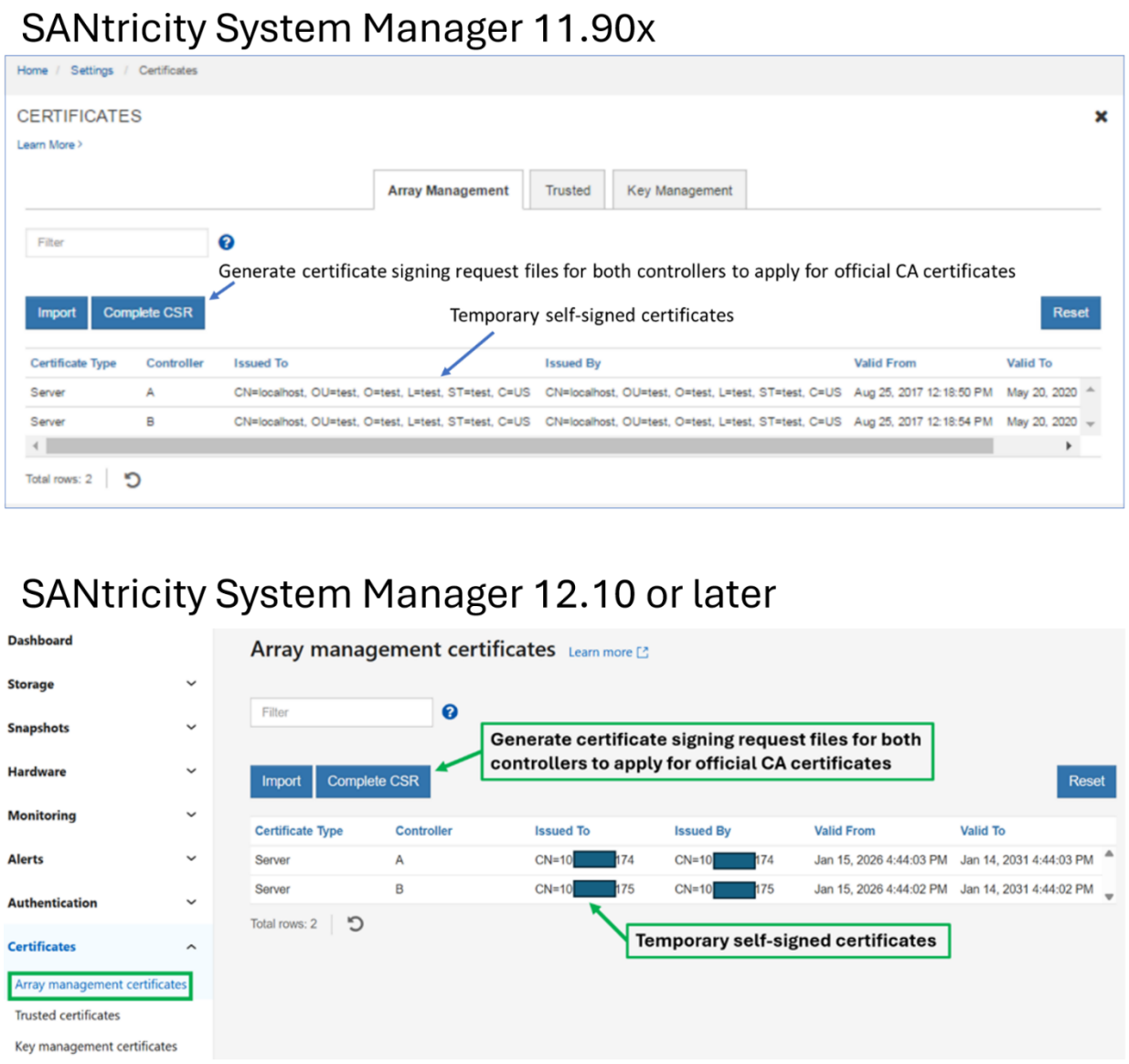
Figure 26) Expanded SANtricity System Manager Certificates.



To enable the E-Series onboard web servers to validate certificates from external client browsers, the controllers are preloaded with industry-standard CA root certificates. To view the standard root certificates, in System Manager 11.90x, select the Trusted tab in the Certificates tile window shown in top image of Figure 26 and then select Show Preinstalled Certificates from the drop-down menu. In System Manager 12.10, select Trusted certificates under Certificates in left pane, then select preinstalled from drop-down menu in right pane, see Figure 27.

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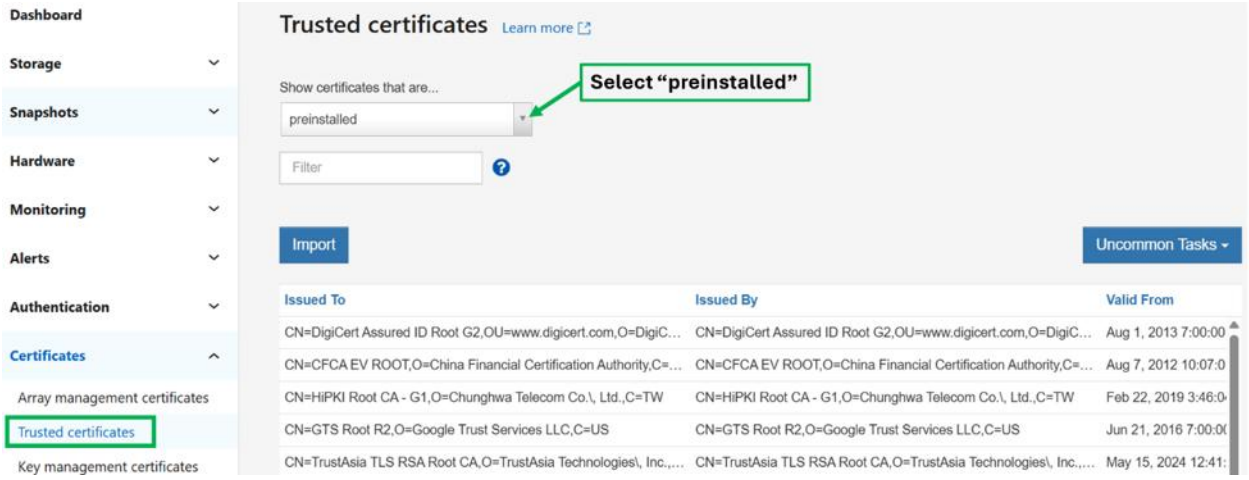
Figure 27) View preinstalled certificates in System Manager 12.10.



Multifactor authentication

Feature overview

Multifactor authentication (MFA) includes several functional areas on EF600C arrays:

- **Authentication with Security Assertion Markup Language (SAML) 2.0 to support MFA.** You can manage authentication through an identity provider (IdP) by using SAML 2.0. An administrator establishes communication between the IdP system and the storage array and then maps IdP users to the local user roles embedded in the storage array. Using IdP allows the administrator to configure MFA.
- **Digitally signed firmware.** The controller firmware verifies the authenticity of any downloadable SANtricity firmware. Digitally signed firmware is required in controller firmware version 8.42 (SANtricity 11.40.2) and later. If you attempt to download unsigned firmware during the controller upgrade process, an error is displayed, and the download is aborted.
- **Certificate revocation checking by using Online Certificate Status Protocol (OCSP).** Certificate management includes certificate revocation checking through an OCSP server. The OCSP server determines whether the CA has revoked any certificates before the scheduled expiration date. The OCSP server then blocks the user from accessing a server if the certificate is revoked. Revocation checking is performed whenever the storage array connects to an AutoSupport server, external key management server, LDAPS server, or syslog server. Configuration tasks are available from Settings > Certificates and require security admin permissions.
- **Syslog server configuration for audit log archiving.** In access management, you can configure a syslog server to archive audit logs. After configuration, all new audit logs are sent to the syslog server; however, previous logs are not transferred. Configuration tasks are available from Settings > Access Management and require security admin permissions.

How MFA works

MFA is provided through the industry standard SAML protocol. SAML does not directly provide the MFA functionality; instead, it allows the web service to send a request to an external system. The external system requests credentials from the user and verifies those credentials. Information about the authenticated user is then returned to the web service to allow the user to be assigned appropriate roles. With the previous E-Series authentication methods, the web service was responsible for requesting the user credentials and authenticating the user. With SAML, an external system provides all authentication activity. The external system can be configured to require any amount and types of user authentication factors.

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SAML identifies two types of systems that cooperate to provide authentication of users:

- **Identity provider.** The identity provider (IdP) is the external system that does the actual authentication of users by requesting the user credentials and verifying their validity. Maintenance and configuration of the IdP is your responsibility.
- **Service provider.** The service provider (SP) is the system that sends a request to the IdP to have a user authenticated. For E-Series storage arrays, the controllers are the service providers; each controller is a separate SP.

Using SAML to provide MFA also enables single sign-on (SSO) capabilities. If multiple applications are configured to use the same IdP, SSO enables them to accept the same user credentials without requiring users to reenter them. The SSO feature is available only if the user is accessing these applications with the same browser.

Note: When SAML is enabled, SANtricity System Manager is the only management access point. There is therefore no access through the SANtricity CLI, the SANtricity Web Services REST API, in-band management (I/O path that uses a host agent), or native SYMbol interface. The lack of SYMbol access means that you cannot use the Storage Manager EMW or other SYMbol-based tools such as the NetApp Storage Management Initiative Specification (SMI-S) provider.

For more information about MFA, see the E-Series online help center and the E-Series Documentation Center. For detailed explanations about the full set of SANtricity management security features and settings, see TR-4712: NetApp SANtricity Management Security Feature Details and Configuration Guide.

SANtricity storage features

SANtricity offers several layers of storage features, including security for data at rest, features that manage host paths, features to manage large-capacity drives that ensure data integrity and efficiently manage drive faults, and features that provide data protection. The following sections describe many of the features and provide links to additional information resources.

Drive encryption

When external key management is enabled from the Settings tile, use the Key Management tab to generate a certificate signing request (CSR) file. Use the CSR file on the key management server to generate a client certificate. Import the client certificate from the Key Management tab to enable secure communication between the E-Series controllers and the external key management server. For more information about the SANtricity drive security feature, see the E-Series online help center and TR-4474: SANtricity Drive Security.

SANtricity host and path management features

When considering the elements of E-Series multipath functionality, you must understand two concepts. The first is controller-to-volume ownership and how path failover between controllers is managed through asymmetrical logical unit access (ALUA) for SCSI hosts or asymmetric namespace access (ANA) for NVMe-oF hosts. This scenario occurs when the primary paths to an E-Series volume (I/O paths through the owning controller) are lost. The second concept concerns how the multipath driver on the host interacts with multiple ports on each E-Series controller (target port group support, or TPGS for SCSI hosts, or ANA for NVMe-oF hosts) to spread I/O across the interfaces and maximize performance. For steps on configuring NVMe specific multipath settings, see the Linux Express Guide or VMWare Express Guide, depending on which operating system is being used.

The design of the E-Series multipath behavior has evolved from a host multipath driver–managed scenario (explicit failover) to the new E-Series–led path management model (implicit failover). However,

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the E-Series fundamentals have not changed. For example, E-Series systems have asymmetric dual active controllers with the following characteristics:

- Volume ownership alternates as volumes are provisioned.
- Write I/O is mirrored to the peer controller.
- Both controllers have access to every volume on the array.
- Both controllers have multiple host ports.
- If one E-Series controller fails, the other controller takes control of all the volumes and continues to process I/O.

These attributes allow host multipath drivers to spread I/O across each controller's ports that are associated to the volumes owned by that controller. The drivers use path policies such as least queue depth and round robin. Depending on the host operating system, the default path policy is one of these two methods.

When all the paths from a host to one E-Series controller are lost, I/O from that host to the volumes owned by that controller is routed to ports on the other E-Series controller, which performs I/O shipping across the shelf midplane to the controller that owns the volumes. In parallel, a volume-ownership timer is set, and changes in controller-to-volume ownership are delayed until the timer expires. This delay time is long enough for links to reset and return to service (the default is 5 minutes). After the timer expires, the array decides whether to initiate a change of volume ownership to the peer controller. The decision is based on whether the non-owning controller is still receiving more than 75% of the I/O.

Table 3 provides a list of SANtricity host types and the associated support for implicit failover/failback.

Table 3) SANtricity host types and associated failover behavior.

Host type	ALUA/AVT status	Implicit failover	Implicit failback	Automatic load balance
Linux DM-Multipath (kernel 3.10 or later)	Enabled	Supported	Supported	Supported
VMware	Enabled	Supported	Supported	Supported
Windows	Enabled	Supported	Supported	Supported
Windows cluster	Enabled	Supported	Supported	Supported
ATTO cluster (all operating systems)	Enabled	Supported	Not supported	Not supported

Note: Several uncommon host types also exist as well as host types that are only to be used if instructed to by support. Appearance on the host type list does not imply the option is fully supported; for more information, see the NetApp Interoperability Matrix Tool (IMT) as well as the SANtricity online help.

SANtricity reliability features

Table 4 provides a list of SANtricity reliability features and a brief explanation of each with references to additional information.

Table 4) SANtricity features for long-term reliability.

Reliability features with SANtricity
Media scan with redundancy check. A background scan of media is run on a set schedule and detects data integrity issues. This feature is critically important to turn on by default when you provision new volumes. **Note:** If you have been running I/O to an array with media scan turned off, consult with NetApp Technical Support before you turn it on.

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Data assurance (T10 PI). This feature confirms data integrity from the HIC to the drive (end-to-end in the storage array). This data integrity is especially important with large-capacity drives.

Cache mirroring. Each E-Series controller owns a set of volumes and is responsible for processing I/O to and from those volumes. Both controllers have access to all volumes, and by default, all incoming writes are cached in memory on the peer controller. This mechanism enables a second level of data integrity checking and enables E-Series and EF-Series arrays to handle controller failover scenarios gracefully.

Nondisruptive controller firmware upgrade. Using the ALUA or ANA host types with multiple paths to hosts and an upgrade wizard that activates one controller at a time, this feature prevents upgrades from affecting host-to-volume access.

Note: Not all host operating systems support the ALUA or ANA host type.

Proactive drive monitor and data evacuator. Nonresponsive drives are automatically power-cycled to see if the fault condition can be cleared. If the condition cannot be cleared, the drive is flagged as failed. For predictive failure events, the evacuator feature starts to remove data from the affected drive to move the data before the drive fails. If the drive fails, rebuild resumes where the evacuator was disrupted, reducing the rebuild time.

Automatic drive fault detection, failover, and rebuild. You can perform these tasks by using global hot spare drives for standard RAID and spare pool capacity for DDP.

SSD wear-life tracking and reporting. This metric is found in the Hardware tab's Drive Settings dialog box. It indicates the wear life of SSDs and replaces two SSD wear-life metrics (average erase count and spare blocks remaining) that were in previous versions of SANtricity. The metric is Percent Endurance Used; to access it, select a drive from the hardware view and then select Settings.

Online drive firmware upgrade. This feature upgrades one drive at a time and tracks writes to the affected drives during the upgrade window; it should be used only during low write I/O periods.

Note: Parallel drive firmware upgrades are supported offline to upgrade multiple drives more quickly during a maintenance window.

Automatic load balancing. This feature provides automated I/O workload balancing and confirms that incoming I/O traffic from hosts is dynamically managed and balanced across both controllers. The workload of each controller is continually monitored and analyzed in the background. When I/O on one controller significantly exceeds the I/O on the other controller for a prolonged, predictable period, SANtricity can change volume ownership from the busy controller to the less busy controller. The feature does not react to short-term changes in I/O patterns. However, when a change of ownership is needed, SANtricity interacts with the affected host multipath driver to initiate an implicit path failover. Most current server operating systems and associated multipath drivers support implicit failover. For more information, search for "What is automatic load balancing?" in the System Manager online help.

Embedded SNMP agent. For the EF600C controller, SNMP is supported natively. The embedded SNMP agent complies with the SNMP V2C standard and RFC 1213 (MIB-II). For more information, search for "manage SNMP alerts" in the System Manager online help.

Automatic alerts. This feature sends email alerts to notify data center support staff about events on the storage array.

Event Monitor and system log. The SANtricity Storage Manager Event Monitor automatically records events that occur on the storage array. Syslog enables a second level of activity tracking that allows you to connect events with associated changes recorded in the system log.

AutoSupport. E-Series products have supported AutoSupport for several releases.

Ability to enable or disable AutoSupport maintenance window. AutoSupport includes an option for enabling or suppressing automatic ticket creation on error events. Under normal operation mode, the storage array uses AutoSupport to open a support case if there is an issue. To enable or disable the AutoSupport maintenance window, select Support > Access Management > AutoSupport.

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SANtricity storage management features

E-Series EF600C systems ship with significant storage management features that can be activated from SANtricity System Manager. Table 5 lists standard features included with SANtricity OS.

Table 5) Standard features that are included with SANtricity.

Standard features with SANtricity
SANtricity System Manager (embedded single-array management). The browser-based, on-box SANtricity System Manager is used to manage individual new-generation storage arrays. • Access all array setup, storage provisioning, and array monitoring features from one UI. • System Manager includes an embedded RESTful API that can be used for management.
Volume workload tags. SANtricity System Manager provides a built-in volume tagging feature that allows administrators to organize the volumes in their arrays by workload type. Usually, the tag is only for organization purposes. In some cases, the Volume Creation wizard provides suggested configuration or volume segment size settings associated with the workload type. You do not have to accept the recommendations. The configurations are suggestions for saving time when you provision volumes for common applications.
Storage partitions. Partitions can consist of an individual host without shared volumes, host groups with shared volumes, or a combination of both. This concept has been abstracted in the new System Manager, but you can view the partitions by using a CLI.
Changing host protocol. This capability is supported through new feature pack keys. To obtain free activation codes and detailed instructions for each starting and ending protocol, go to the Change the host protocol - EF300 and EF600 page.

DDP changes with capacity NVMe SSDs

If running SANtricity 12.10 OS, there are some changes on how DDP works when using the high-density 30TB/60TB drives.

In an array populated with 30TB/60TB drives, a single pool using all available drives will be created automatically at boot-up, no legacy RAID options available. If 20 or more drives are in a pool, then the system will use 16+2 stripes instead of the traditional 8+2 stripes to lower RAID 6 parity overhead (11.1% vs. 20%).

If needed, two smaller pools of 12 drives each can be created. The default pool can be deleted using either System Manager, SMcli or RESTapi, but only SMcli or RESTapi can be used to create the two smaller pools. Creating a pool in System Manager will only allow one pool using all available drives to be created.

The 30TB/60TB drives have lower write bandwidth, so don’t assume same write throughput using 30TB/60TB drives that can be achieved using the lower capacity NVMe SSDs.

SANtricity Remote Storage Volumes

The Remote Storage Volumes feature enables customers to import data through iSCSI from an existing remote storage device onto an E-Series volume with minimal downtime. It can be used to help streamline the process for equipment upgrades and/or provide data migration capabilities to move data from non-E-Series devices to E-Series systems.

The base function for this feature is to support importing data from a remote storage device directly to a local E-Series volume. To use this feature, an iSCSI connection must first be manually established between the remote storage device and the E-Series system. The remote storage then needs to be configured to have one or more IP addresses where the iSCSI IQNs of the remote storage devices can be discovered.

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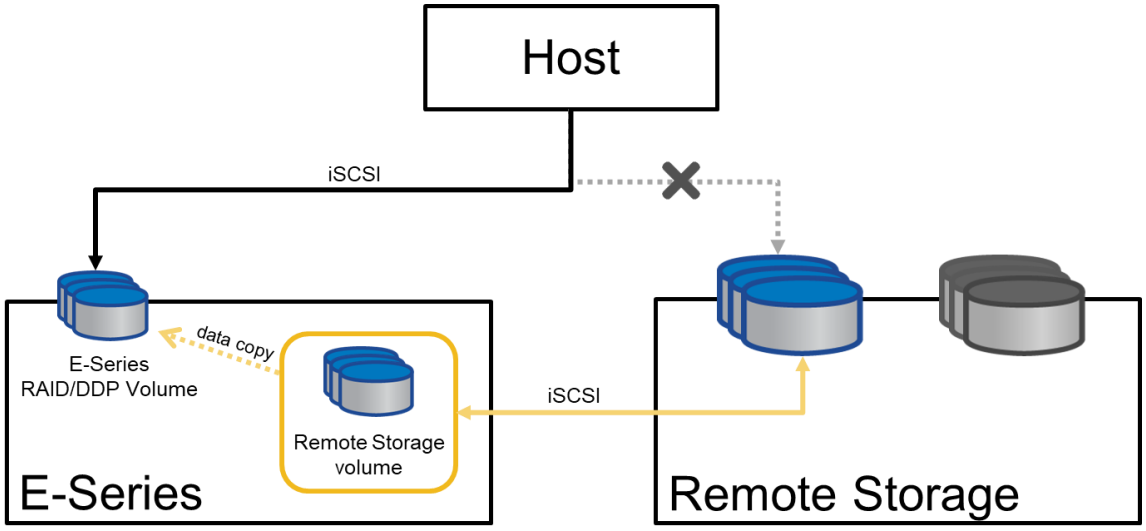
With the iSCSI connection in place, the remote storage device can then be mapped to the E-Series system. After the mapping is in place, you can then use SANtricity System Manager or REST API commands for the E-Series system to initiate and manage the import operation.

During the import operation, the target volume can be set up to process the I/O operations that the remote storage device was originally processing. Any I/O operations going to the target volume are then propagated back to the remote storage device until the import operation has completed and the import has been disconnected.

Figure 28 shows the technical components of the solution.

Figure 28) Remote Storage Volumes solution architecture overview.



Information that you must provide to initiate the import operation includes:

- Remote storage iSCSI IQN
- Remote storage iSCSI IP addresses
- LUN number where the remote device is mapped

The provided information must persist on the E-Series system so that it can remain accessible after reboots, power cycles, and so on.

After it is configured, you can update the remote storage iSCSI IQN and/or iSCSI IP addresses, if needed, through either SANtricity System Manager or REST API commands.

For more information about remote storage volumes, see TR-4893-DEPLOY: SANtricity Remote Storage Volumes.

SANtricity copy services features

Table 6 lists standard copy services features with EF600C storage arrays.

Table 6) SANtricity copy services features.

Standard SANtricity copy services features
SANtricity Snapshot copies. Point-in-time NetApp Snapshot™ copies.
Asynchronous mirroring. Mirroring to a remote site where RPO = 0 is not a requirement.
Volume copy. Used to clone volumes for testing/development or analytics purposes.

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For additional details and use case information about SANtricity copy services features, see TR-4458: Deploying NetApp E-Series and EF-Series Copy Services with Oracle and SQL Server Databases.

For details on using SANtricity Snapshots see TR-4747: SANtricity Snapshot Feature Overview and Deployment Guide.

Starting with SANtricity 11.62 the Unified Manager is used to create mirror relationships. See TR-4839: SANtricity Synchronous and Asynchronous Mirroring Feature Descriptions and Deployment Guide (11.62 and Later) or the Online Help in SANtricity Unified Manager for a complete description. SANtricity Unified Manager must be version 4.2 or later and SANtricity System Manager must be OS version 11.62 or later.

Prior to SANtricity 11.62, for a description of mirroring between two new generation E-Series arrays or between a new generation E-Series array and a legacy E-Series array, see TR-4656: SANtricity Synchronous and Asynchronous Mirroring Feature Descriptions and Deployment Guide (11.61 and Earlier).

SANtricity management integration

To support today's modernized data center operations and partner appliances, NetApp is deemphasizing legacy plug-ins and emphasizing API integration.

Table 7 shows the SANtricity APIs and toolkits that can be used for scripting and custom integration into other management tools and appliance architectures. To download the latest version of the E-Series SANtricity Web Services (REST API) visit NetApp Support at http://mysupport.netapp.com/. Information for how to use Ansible with E-Series for managing your storage can be in TR-4574: Deploying NetApp E-Series with Ansible (Automating E-Series).

Table 7) SANtricity APIs and toolkits.

APIs and toolkits	Description
SANtricity Web Services Proxy **Note:** You can use either the proxy or the embedded REST API for new-generation systems.	These web APIs provide a collection of REST interfaces to configure, manage, and monitor E-Series systems.
NetApp E-Series and Ansible	Ansible is a simple yet powerful orchestration tool. NetApp E-Series has joined the Ansible community to provide you with a high-quality solution for managing your E-Series storage systems, regardless of scale.
SANtricity Secure CLI	New in SANtricity 11.60.2 is the ability to download the SANtricity Secure CLI (SMcli) from System Manager.

Table 8 provides a list of third platform plug-ins that use E-Series storage systems as building blocks. Usually, the plug-ins listed are available on the various provider websites. For more information about third platform integration with EF-Series storage systems, contact your NetApp sales representative.

Table 8) Third platform plug-ins that use the SANtricity Web Services Proxy.

Software package	Use
NetApp SANtricity Performance App for Splunk Enterprise https://splunkbase.splunk.com/app/1932/ Technology Add-On for NetApp SANtricity https://splunkbase.splunk.com/app/1933/	A display and monitor tool to report configuration and performance details of multiple E-Series systems in one interface. Requires both application and technology add-on.

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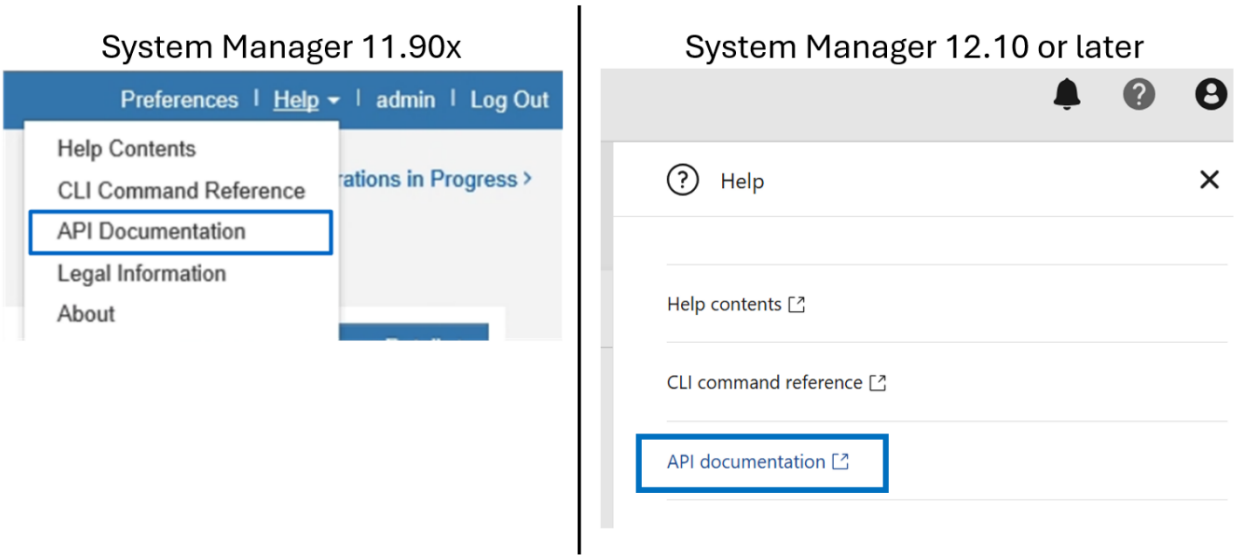
NetApp E-Series + Grafana: Performance Monitoring https://github.com/netapp/eseries-perf-analyzer	The E-Series Performance Analyzer is a powerful and easy-to-use tool to monitor the performance of your E-Series storage system.

SANtricity Web Services native REST API

The SANtricity Web Services REST API is an embedded API for experienced developers. Actions performed through the REST API are applied on execution and without user prompts or confirmation dialog boxes. The REST API is URL based, and the accompanying API documentation is completely interactive. Each URL contains a description of the corresponding operation and enables you to perform the action directly through the API documentation. To access the documentation, select API Documentation in the Help drop-down menu from any page in System Manager, as shown in Figure 29.

Figure 29) Opening the API documentation.



Each URL endpoint presented in the API documentation has a corresponding POST, DELETE, or GET option. These URL endpoint options, known as HTTP verbs, are the actions available through the API documentation. A sample from the REST API documentation is shown in Figure 30. You can expand or hide operations by selecting the drop-down beside the topic name or clicking the individual endpoints. Click Try It Out to execute the endpoint. You must click Execute to run an endpoint (Figure 31).

Note: To execute successfully, some endpoints require additional input parameters in the Try It Out dialog box. No additional input is required for this example.

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Figure 30) Example of expanding the Device-ASUP endpoint.

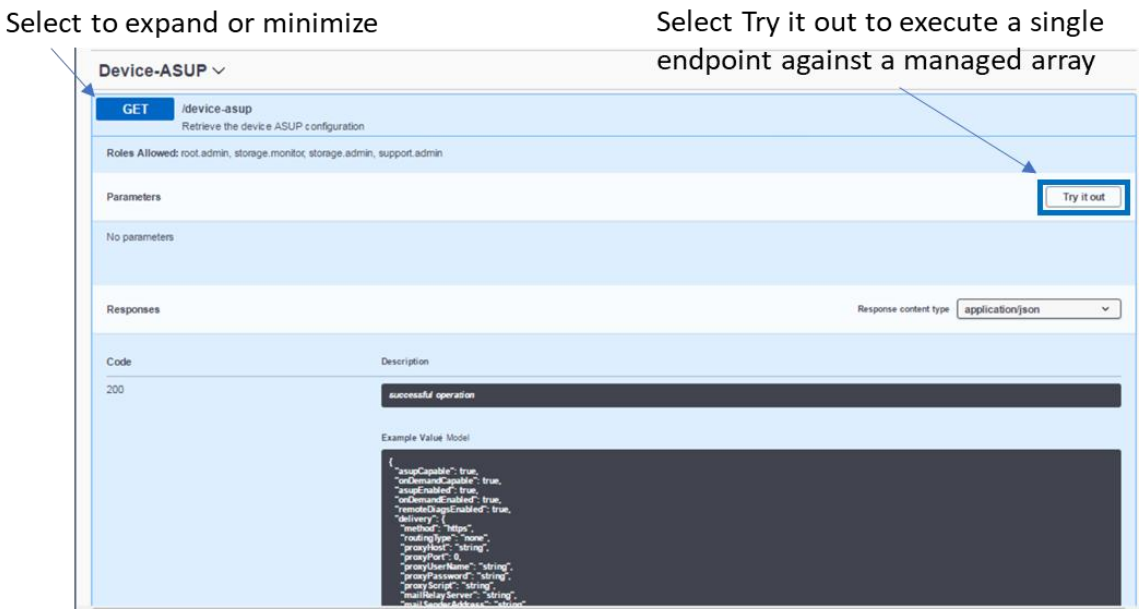
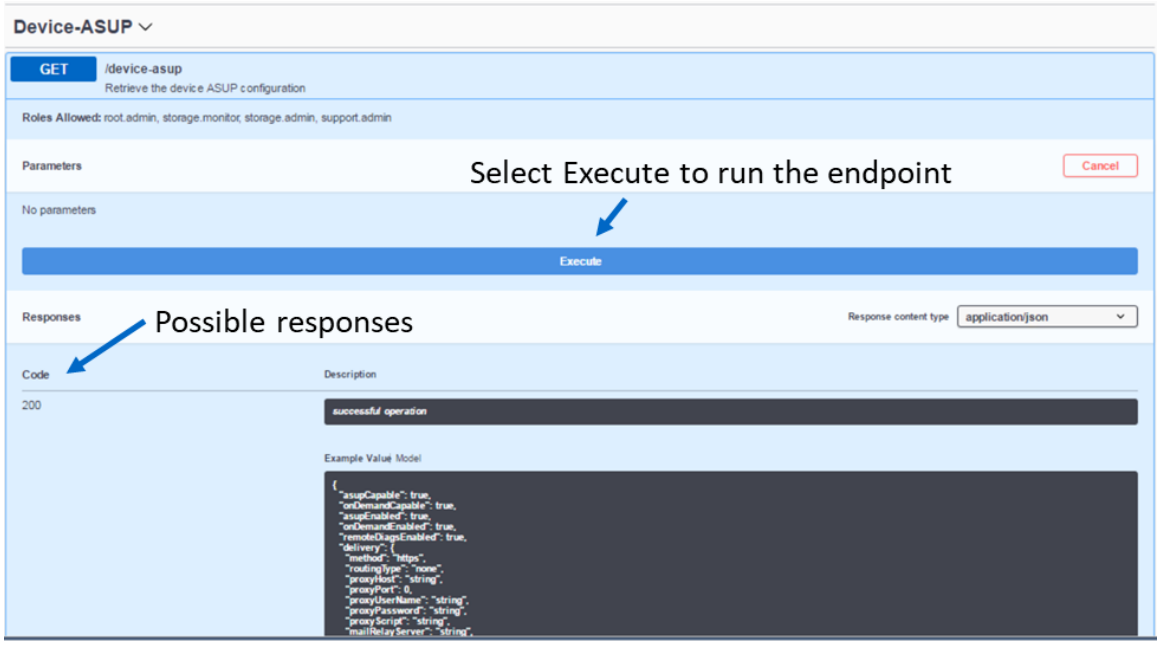


Figure 31) REST API documentation sample.



The corresponding output for the GET device-asup verb is shown in Figure 32 and Figure 33.

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Figure 32) Sample output from the Try It Out button.

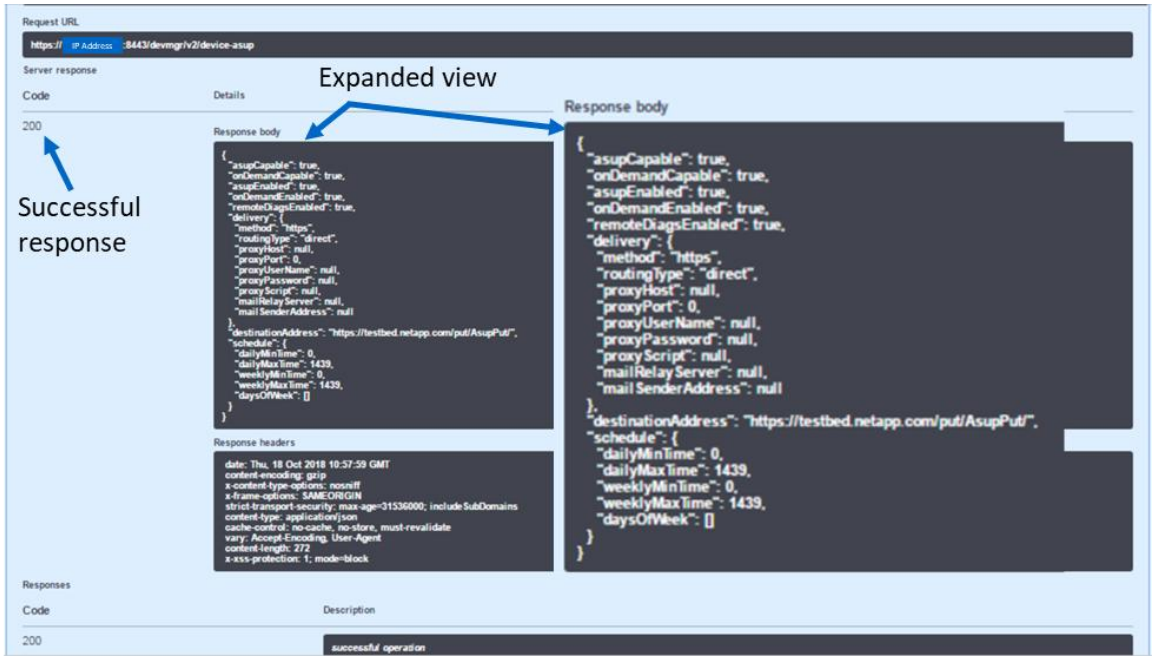
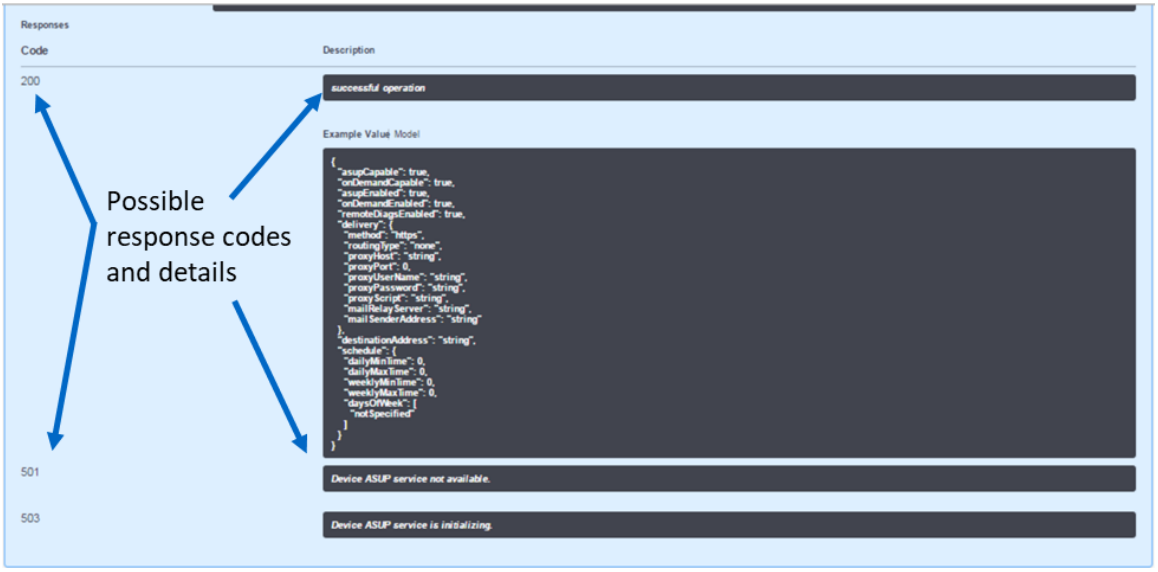


Figure 33) Device-asup endpoint possible response codes and details.



Data in the REST API is encoded through JSON. The structured JSON data from the REST API can be easily parsed by programming languages (C, C++, cURL, Java, Python, Perl, and so on). JSON is simple encoding based on key-value pairs with support for list and subject objects. Objects start and end with curly braces (that is, { }), whereas lists start and end with brackets (that is, [ ]). JSON understands values that are strings, numbers, and Booleans. Numbers are floating-point values. The API documentation provides a JSON template for each applicable URL operation, allowing the developer to simply enter parameters under a properly formatted JSON command.

For more information, see the E-Series Documentation Center.

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SANtricity Secure CLI

The SANtricity Secure CLI is an embedded API for experienced developers. From System Manager you can download the CLI package. The CLI provides a text-based method for configuring and monitoring storage arrays. It communicates via HTTPS and uses the same syntax as the CLI available in the externally installed management software package. No key is required to download the CLI.

A Java Runtime Environment (JRE), version 8 and above, must be available on the management system where you plan to run the CLI commands.

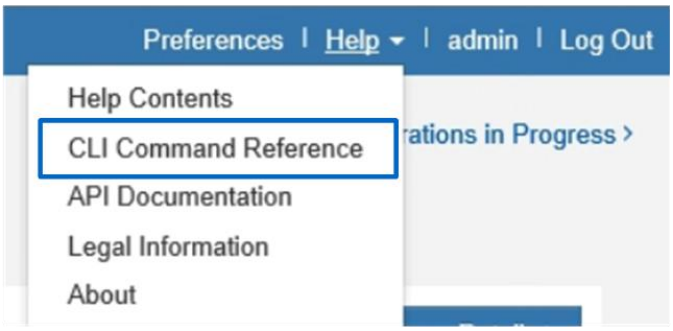
Downloading the CLI

- Select the Settings view > System.
- Under Add-ons, select Command Line Interface. The ZIP package downloads to the browser.
- Save the ZIP file to the management system where you plan to run CLI commands for the storage array, and then extract the file.

You can now run CLI commands from an operating system prompt, such as the DOS C: prompt.

To access the documentation, select CLI Command Reference in the Help drop-down menu from any page in System Manager A CLI, as shown in Figure 34.

Figure 34) Opening the CLI Command Reference.



SANtricity OS 12.10 Script editor

In SANtricity OS 12.10 there is the Script editor that allows CLI scripts to be run from within System Manager. To open the Script editor in SANtricity 12.10, expand Support in left-pane menu and click on Script editor, see Figure 35.

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Figure 35) Opening the Script editor in SANtricity 12.10.

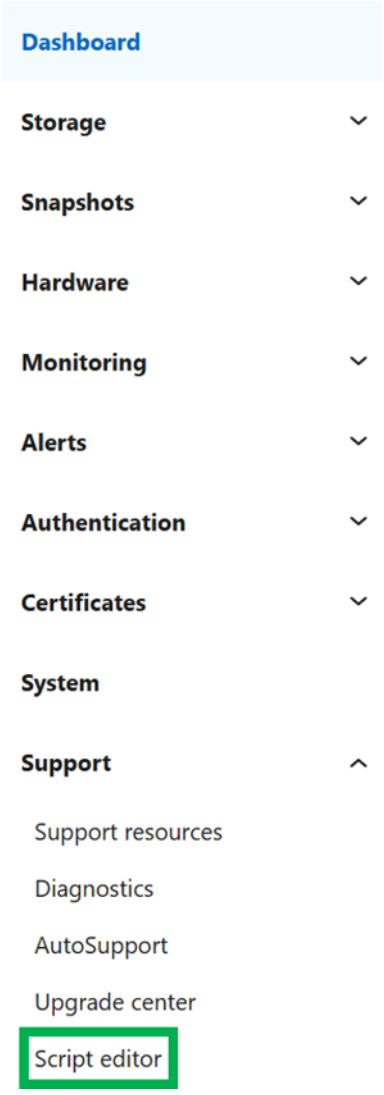

Figure 36 shows the Script editor start page.

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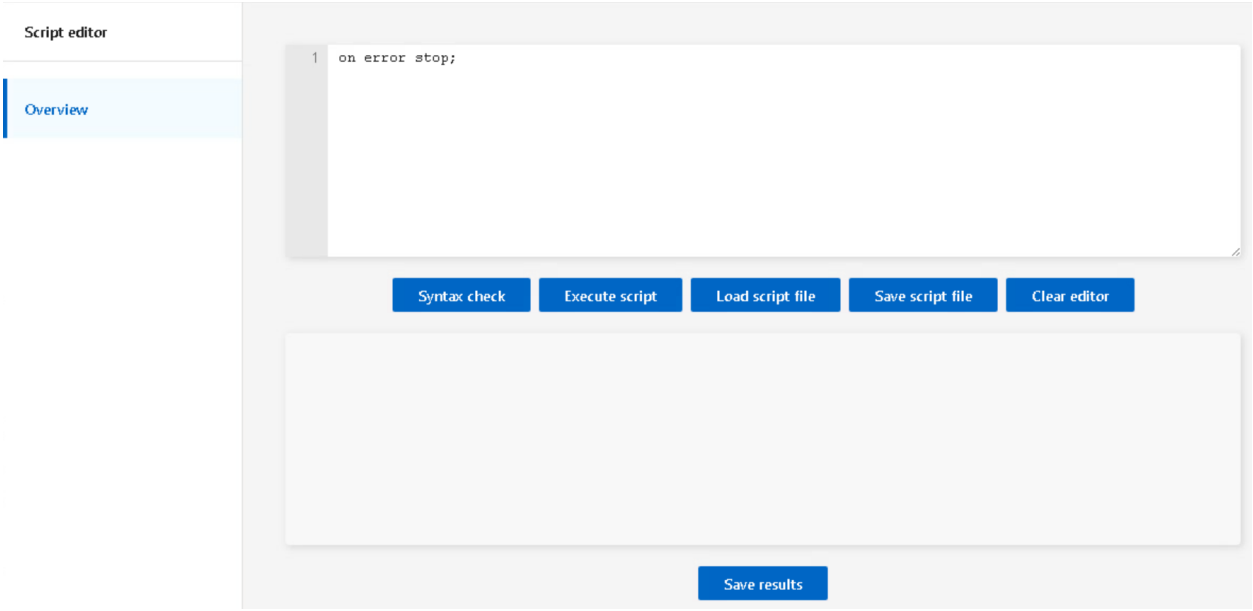
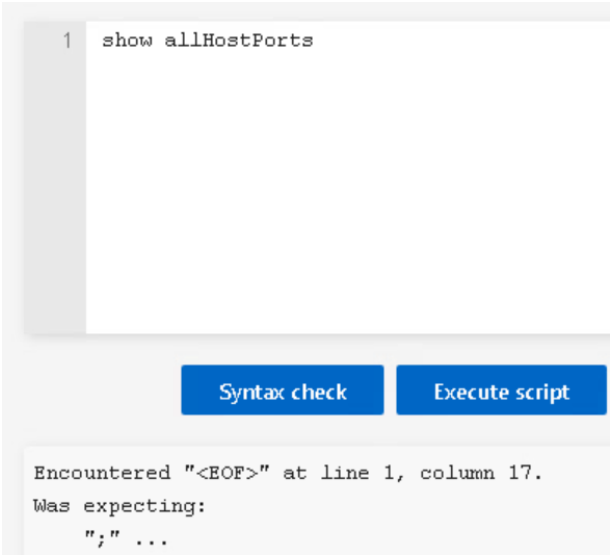
Figure 36) Script editor start page.



Multiple CLI commands can be entered in the top box, each command must end with a semicolon or a syntax error will be reported. To verify syntax prior to executing the script, click on Syntax check button, any errors will be reported in lower box, see Figure 37.

Figure 37) Script editor syntax check.



To execute a script click on Execute script button. First a syntax check will be performed, if any syntax errors are found the errors will be reported in the lower box and execution will fail. If no syntax errors are found the script will then execute automatically and the lower box will report the results, see Figure 38.

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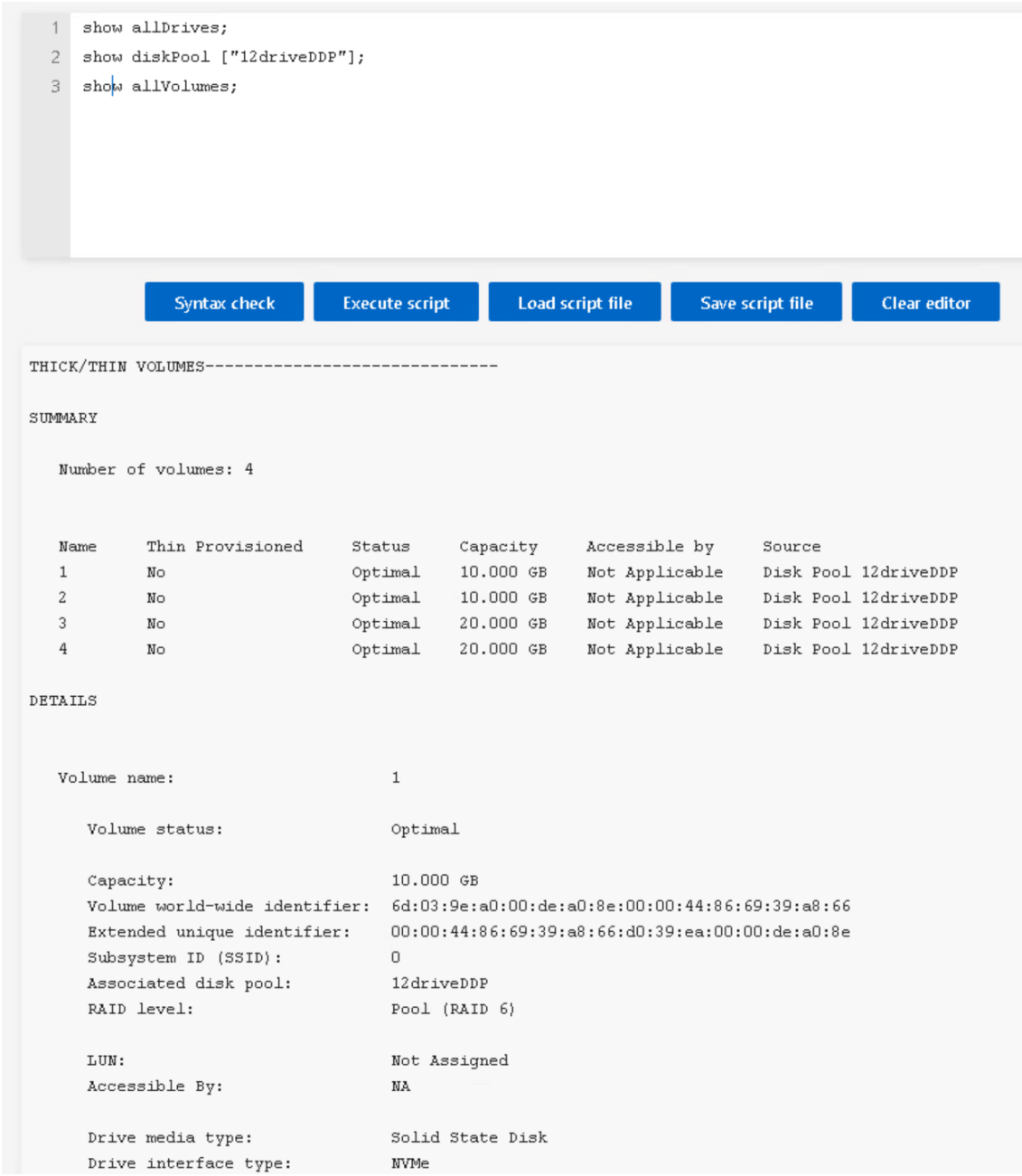
Figure 38) Script editor execution output.



E-Series SANtricity Storage Plugin for vCenter

The vSphere Client is a single management interface that you can use to manage the VMware infrastructure and all your day-to-day storage needs. The following functions are available in the NetApp SANtricity Storage Plugin for vCenter:

- View and manage discovered storage arrays in the network.
- Perform batch operations on groups of multiple storage arrays.
- Perform upgrades on the software operating system.
- Import settings from one storage array to another.

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- Configure volumes, SSD cache, hosts, host clusters, pools, and volume groups.
- Launch the System Manager interface for additional management tasks on an array.

Note: The plugin is not a direct replacement for the System Manager software. System Manager is still required for performing certain storage administration tasks on a single array.

The plugin requires a VMware vCenter Server Appliance deployed in the VMware environment and an application host to install and run the plugin web server.

You can download the plugin from the NetApp Support Site, NetApp Support Site > Downloads > All Downloads.

You can find installation and configuration documentation on the NetApp Documentation site, E-Series Documentation Center.

SANtricity OS specifications for EF600C hardware

Table 9 lists the NetApp SANtricity OS specifications for NetApp EF600-based storage systems.

Table 9) SANtricity OS boundaries for EF600C-based storage systems.

Components	Maximum
Storage hardware components	
Shelves	Only a single controller shelf is supported
Drives—drive slot count	24 QLC NVMe SSDs
Logical components	
Host partitions	256
Volumes per partition	256
Volumes per system	2,048
Disk pools per system	1
Volumes per disk pool	2,048
Total DDP capacity in an array (maximum capacity includes RAID overhead, DDP reserve capacity, and a small DDP-specific overhead based on the number of drives in the pool and other factors)	• SANtricity 11.90R6 or earlier: 12PiB maximum DDP capacity • SANtricity 12.10 or later: 16PiB maximum DDP capacity **Note:** NVMe SSDs max DDP capacity is not achievable with current drive capacities
Maximum DDP single volume capacity	4PiB
Consistency groups	
Volumes per consistency groups	64
Consistency groups per system	32
Snapshot copies	
Per Snapshot group	32
Per volume	128
Per storage system	2,048
Snapshot volumes	
Per Snapshot copy	4
Per system	1,024

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Snapshot groups	
Per volume	4
Per system	1,024
Asynchronous mirrors	
Mirrors per system	256
Mirrors per volume	1
Mirrors per asynchronous mirror group	64
Asynchronous mirror groups per system	4

For additional software limits and specifications, see the Hardware Universe.

Note: EF600C does not support thin provisioning.

Note: EF600C does not support synchronous mirroring.

EF600C hardware configurations

NetApp EF600C storage systems, like all NetApp E-Series arrays, use a modular approach to hardware configuration. This approach can meet most customer SAN storage requirements for flexible host interfaces and versatile drive choices without sacrificing supportability, ease of implementation, and long-term stability. The E-Series has a proven record of accomplishment for reliability and scalability to satisfy requirements in remote dedicated environments or primary data centers that provide mission-critical infrastructure.

Controller shelf configurations

The following sections provide detailed information about the EF600C shelf configuration.

EF600C controller shelf

The EF600C is a two-rack-unit-high (2U) shelf that holds up to 24 2.5" NVMe SSDs. It features two RAID controllers, and two ENERGY STAR Platinum certified high-efficiency power supplies (1600W) with integrated fans.

Figure 39, Figure 40, Figure 41 show the front and rear views of the EF600C controller shelf.

Figure 39) EF600C front view with bezel.

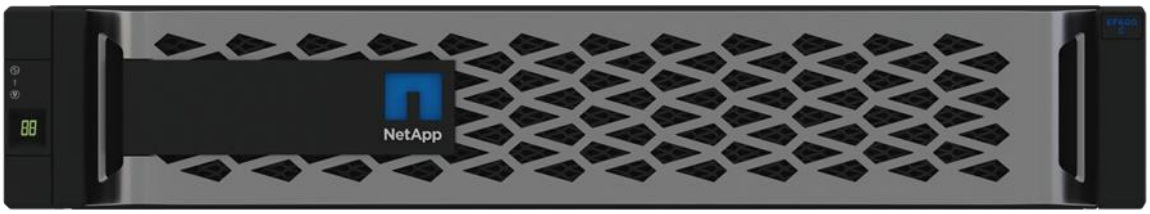

Figure 40) EF600C front view (open).

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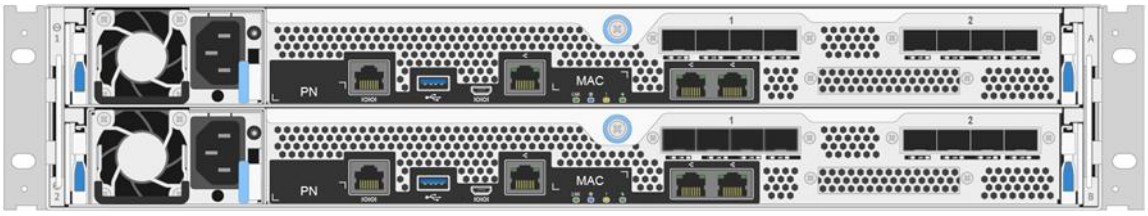
Figure 41) EF600C rear view with HICs in slots 1 and 2 shown.



EF600C hardware specifications

The EF600C controller has the following base hardware features:

- Ethernet port for management-related activities
- Dual 10GbE ports not used for E-Series
- Type-A USB port for factory use only is disabled

Table 10 lists the technical specifications for the EF600C-based storage systems.

Table 10) EF600C technical specifications.

Specification	EF600C
Maximum raw system capacity	1.474PB (24 x 61.4TB SSDs)
Maximum number of NVMe drives per system	24 NVMe SSDs
NE224 shelf form factor	2U, 24 drives
Memory	32GB or 128GB per controller
	64GB or 256GB per duplex system
• Single HIC per controller • Controllers must match. • A software feature pack* can be applied to convert between host protocols. • Cannot mix protocols.	2-port 200Gb IB (2 ports per controller) – supports NVMe/IB, NVMe/RoCE, or iSER/IB
• Two HICs per controller • Controllers must match. • A software feature pack* can be applied to convert between the various protocols available on each HIC. • Cannot mix protocols.	• 2x 2-port 100Gb IB (4 ports per controller) – supports NVMe/IB, NVMe/RoCE, SRP/IB, or iSER/IB according to feature pack installed* • 2x 4-port 32Gb FC (8 ports per controller) – supports traditional FC as well as NVMe/FC according to feature pack installed*; see the Hardware Universe for SFP details • 2x 4-port 25Gb iSCSI (8 ports per controller); see Hardware Universe for SFP details
High-availability (HA) features	Dual active controllers with automated I/O path failover
	Support for DDP only
	Redundant, hot-swappable storage controllers, disks, and power supplies. Fans require that you remove the controller to do a replacement.
	Mirrored data cache with battery-backed destage to flash

*For details about the available feature pack submodel IDs (SMIDs) for the EF600C storage controllers, see the section, “Controller host interface features“.

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Note: For current supported drive availability information and encryption capability by drive capacity (full disk encryption [FDE] and FIPS), see the Hardware Universe.

Controller host interface features

By default, the EF600C controller includes an Ethernet management port that provides out-of-band system management access.

The management port defaults to the Dynamic Host Configuration Protocol (DHCP). If you want to use static addresses to manage the EF600C, simply leave the management ports disconnected for approximately 5 minutes after powering on, to allow the DHCP feature to time out. Then, you can connect with a local PC to the default IP addresses:

- Controller A Management Port = 169.254.128.101
- Controller B Management Port = 169.254.128.102

Host interface ports can be added, as indicated in Table 11. Other than the 25Gb iSCSI HIC, each HIC supports multiple protocols.

Table 11) Available feature pack submodel IDs (FP-SMIDs) for EF600C controllers.

FP-SMID	HIC protocol
564	NVMe/FC or NVMe/IB
565	NVMe/FC, NVMe/RoCE, or iSCSI
566	FC (not NVMe)
567	FC PTL (not NVMe)
568	iSER/IB
569	SRP/IB (100Gb HIC only)

For instructions on how to obtain and apply a software feature, see Change the host protocol - EF300 and EF600.

Table 12 provides port speed detail options.

Table 12) Host interface protocols and supported speeds.

HIC protocol	Supported speeds
25Gbps iSCSI	25Gbps, 10Gbps
32Gbps FC	32Gbps, 16Gbps, 8Gbps
32Gbps NVMe/FC	32Gbps, 16Gbps, 8Gbps
200Gbps NVMe/IB	200Gbps, 100Gbps, 56Gbps
200Gbps NVMe/RoCE	200Gbps, 100Gbps, 50Gbps, 40Gbps, 25Gbps, 10Gbps
200Gbps iSER/IB	200Gbps, 100Gbps, 56Gbps
100Gbps NVMe/IB	100Gbps, 56Gbps, 40Gbps
100Gbps NVMe/RoCE	100Gbps, 50Gbps, 40Gbps, 25Gbps, 10Gbps
100Gbps SRP/IB or iSER/IB	100Gbps, 56Gbps, 40Gbps

Note: NetApp does not sell IB cables for either port speed; however, cables are readily available from suppliers such as NVIDIA Mellanox and QLogic.

Note: For optical connections, the appropriate SFPs must be ordered for the specific implementation. Consult the Hardware Universe for a full listing of available host interface equipment. All EF600C optical connections use OM4 optical cable.

Note: Both controllers in a duplex configuration must be configured identically.

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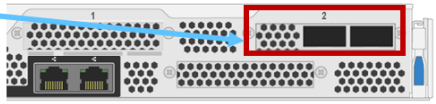
The HIC options are shown in Figure 42.

Figure 42) EF600C controller HIC options.

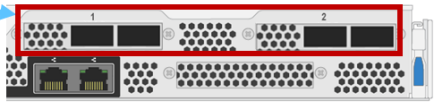
200 Gb IB HIC

- Single 2-port 200Gb IB (use for NVMe/IB, NVMe/RoCE, or iSER/IB)



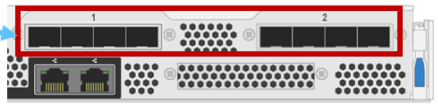
100Gb IB HIC

- Two 2-port 100Gb IB (use for NVMe/IB, NVMe/RoCE, SRP/IB, iSER/IB)



FC or iSCSI HIC

- Two 4-port 25Gb iSCSI
- Two 4-port 32Gb FC (use for NVMe/FC and traditional FC)



Hardware LED definitions

EF600C controller shelf LEDs

The EF600C controller shelf has LED status indicators on the front of the shelf, the operator display panel (ODP), the rear of the shelf, the power supply, and the controller canisters. The LEDs on the ODP indicate systemwide conditions, and the LEDs on the power-fan canisters and controller canisters indicate the status of the individual units.

Figure 43 shows the ODP of the EF600C controller shelf.

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Figure 43) ODP on front panel of EF600C controller shelf.

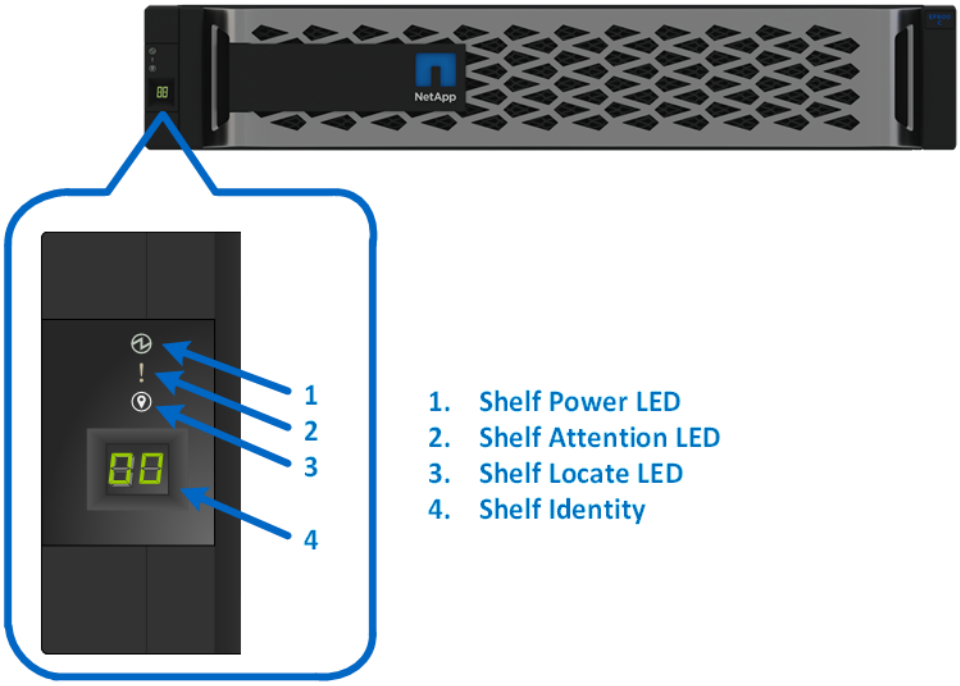

Table 13 defines the ODP LEDs on the EF600C controller shelf.

Table 13) EF600C controller shelf LED definitions (front panel).

LED name	Color	LED on	LED off
Power	Green	Power is present	Power is not present
Attention	Amber	A component in the controller shelf requires attention	Normal status
Locate	Blue	There is an active request to physically locate the shelf	Normal status

The shelf-identity feature displays a numerical value to identify the shelf. The dual seven-segment display indicates values from 00 to 99 that can be set from the NetApp SANtricity System Manager Hardware tab shown in Figure 44 or after selecting Hardware, Controllers and components from left-pane menu then selecting Change ID from 3-dot drop-down menu in right pane of System Manager 12.10, see Figure 45.

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Figure 44) Setting the shelf ID by using SANtricity System Manager 11.90x.

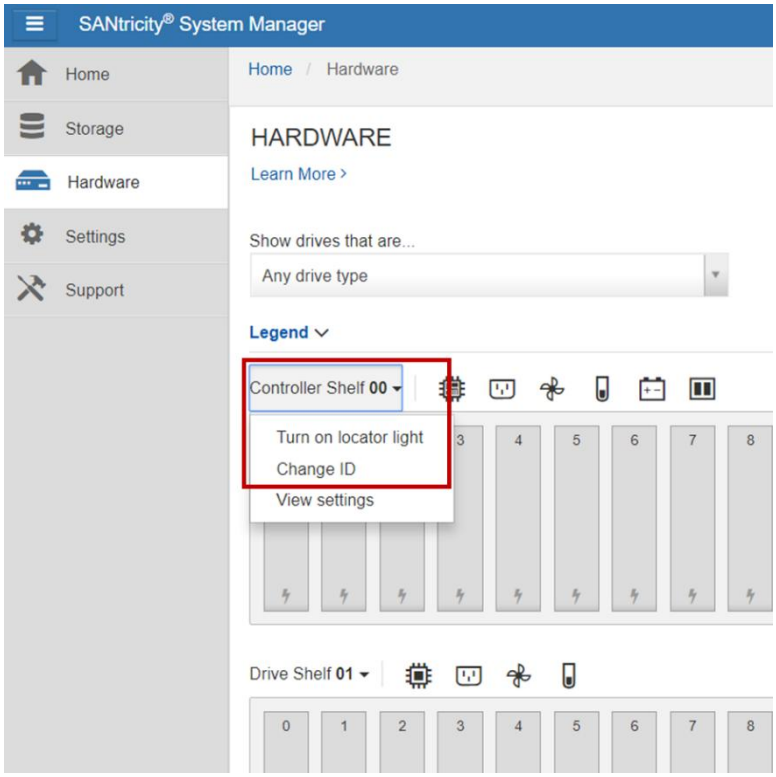
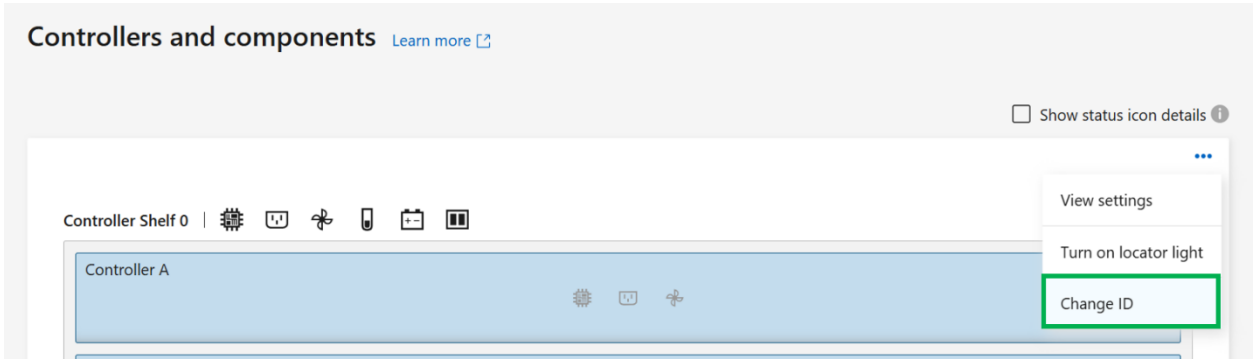


Figure 45) Setting the shelf ID by using SANtricity System Manager in SANtricity 12.10 or later.



EF600C controller canister LEDs

The EF600C controller canister has several LED status indicators. You can verify host port status and other system-level status information by directly checking the port LEDs or by using the SANtricity System Manager UI. For example, systemwide status information is displayed on the View Settings page, as shown in Figure 46 and Figure 47.

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Figure 46) Viewing system status information by using SANtricity 11.90x System Manager.

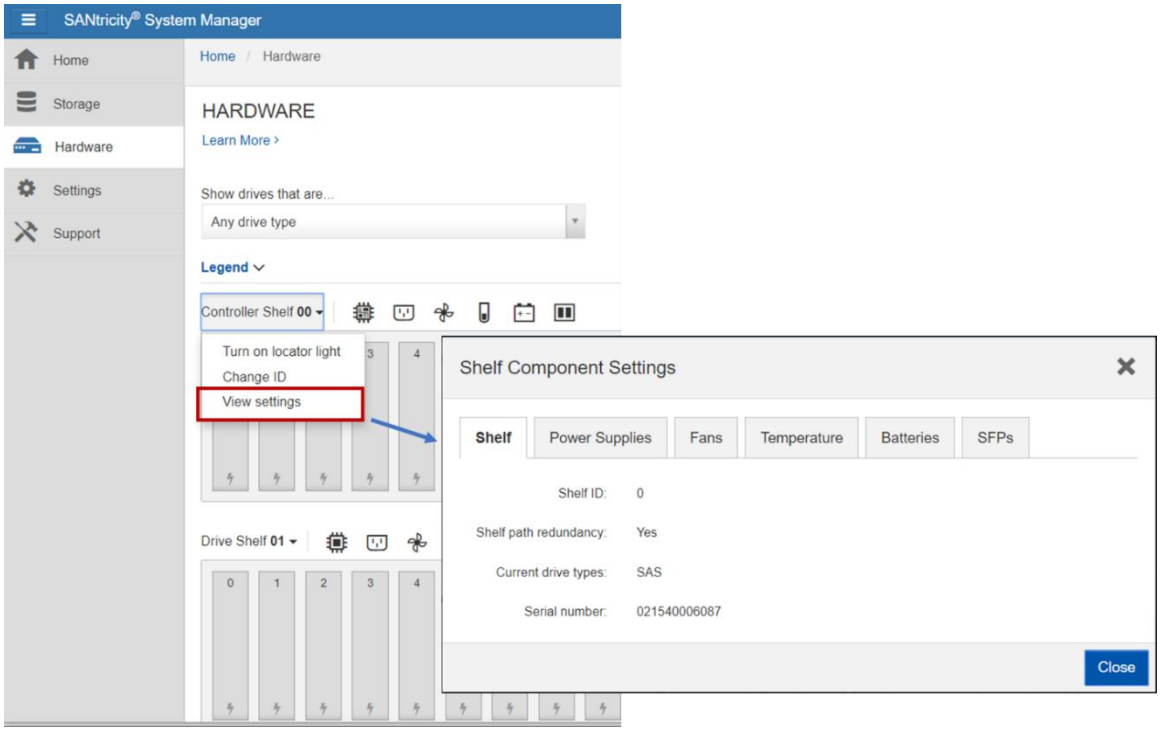
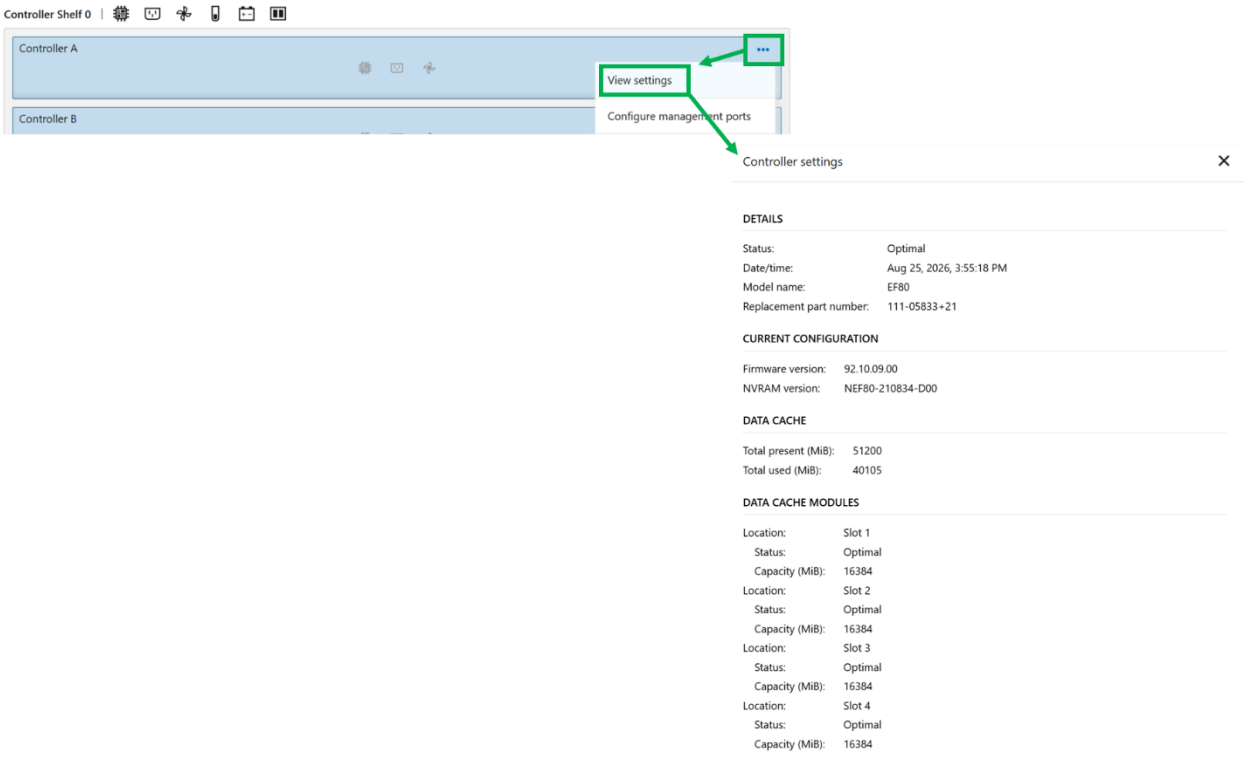


Figure 47) Viewing system status information by using SANtricity 12.10 System Manager.



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LED definitions with 4-Port 32Gb FC HICs installed

The EF600C controller supports two 4-port 32Gbps FC HICs that offer the ability to auto negotiate down to 16Gbps with the 32Gbps SFP and down to 8Gbps with the 16Gbps SFP. The new 32Gbps FC HIC does require OM4 fiber cable to connect to switches or directly to hosts. Figure 48 shows the LEDs for the 4-port 32Gbps FC HICs.

Figure 48) LEDs on the EF600C with 4-port 32Gb FC HICs.

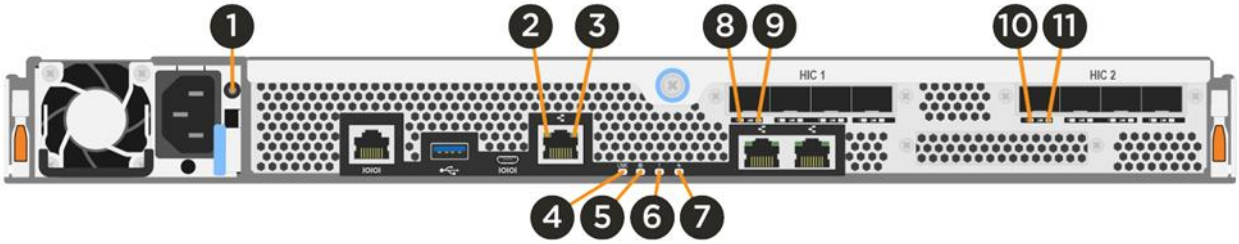

Table 14 defines the LEDs on the 4-port 32Gbps optical HIC.

Table 14) EF600C with 4-port 32Gb FC HIC LED definitions.

Call-out	LED Name	Color	LED description
1	PSU	Green/Red	• LED off: no AC power • Green: AC present and DC output OK • Red: AC cord unplugged or power supply failure
2	Link	Green	• LED on: link is up • LED off: link is down
3	Activity	Green	• Blinking: indicates activity for the Ethernet port
4	NV LED	Green	Defaults to on at power on. Software turns off this LED during boot. On indicates that battery backup has been enabled to support caching activity.
5	Locate LED	Blue	• On: identifies enclosure • Off: not locating enclosure **Note:** During power on, this LED is on initially, but it will turn off after boot process is complete.
6	Attention LED	Amber	• On: direct attention to the controller for service event • Off: no issues on controller **Note:** During power on, this LED is on initially, but it will turn off after boot process is complete (if no issues are indicated).
7	Activity LED	Green	• Blinking: activity on controller
8	Attention LED	Amber	• On: a condition that requires attention • Off: no special conditions
9	Link LED	Green	• On: link up • Off: no link
10	Attention LED	Amber	• On: a condition that requires attention • Off: no special conditions

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11	Link LED	Green	• On: link up • Off: no link

Note: LED definitions with alternate HIC options are similar.

For more information about the EF600C storage systems and related hardware, see the E-Series and SANtricity 11 Resources page.

Drive LED definitions

Figure 49 shows the LEDs on the drive carriers for the EF600C SSDs. The NE224C shelf in the EF600C architecture supports only 2.5-inch form-factor SSDs.

Figure 49) NVMe drive carrier LEDs.

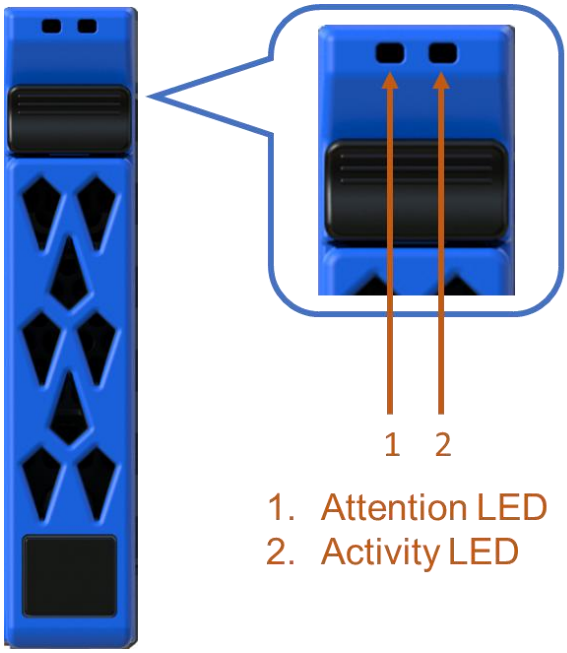

Table 15 defines the LEDs for the drives.

Table 15) NVMe drive LED definitions.

LED Name	Color	LED On	LED Off
Activity	Green	Drive has power	Drive does not have power
	Blinking green	The drive has power, and I/O is in process	No I/O is in process
Attention	Amber	An error occurred with the functioning of the drive	Normal status
	Blinking amber	Drive locate turned on	Normal status

Drive loading for maximum performance

With the release of the NE224 shelf, the process by which drive slots are assigned to the PCIe bus has changed. In previous versions of EF-Series, alternate drive slots were assigned to a different PCIe bus. With the EF300C and EF600C arrays, the first PCIe bus is connected to the drive slots 0 through 11, the

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first 12 drive slots; and the second PCIe bus is connected to drive slots 12 through 23, the second 12 drive slots.

When inserting fewer than 24 drives into an NE224 shelf, you must alternate between the two halves of the drive shelf. You must evenly load drives either from the middle drive slots (11,12) outward, Figure 50, or from the outside drive slots (0, 23) inward, Figure 51.

Note: Storage system performance can be significantly reduced if drives are not loaded such that both PCIe buses are employed.

Figure 50) Loading drives from the inside drive slots outward.

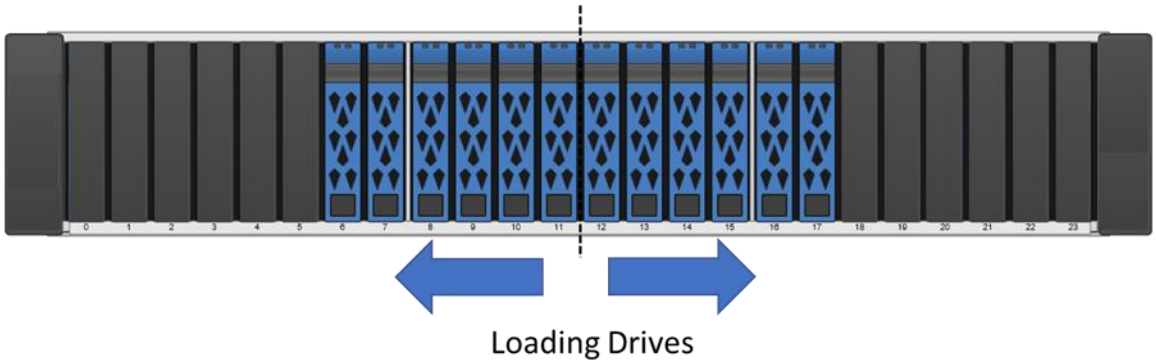
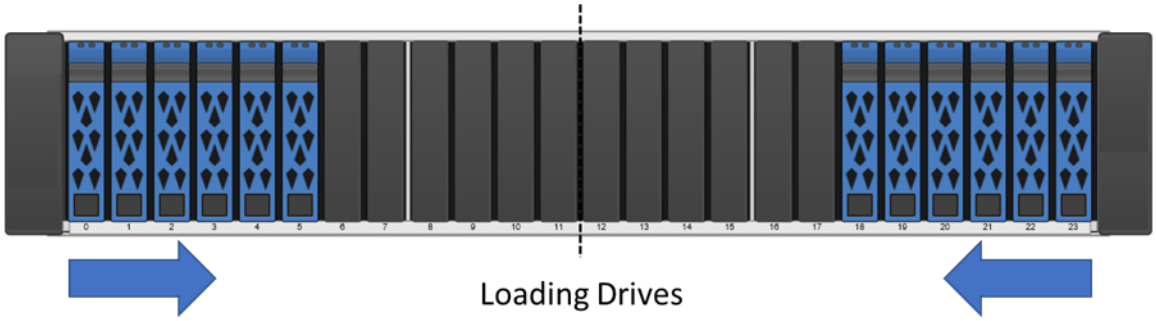


Figure 51) Loading drives from the outside drive slots inward.



When configuring the storage array, each controller should have access to an equal number of drives in the first 12 slots and from the last 12 slots to use both drive-side PCIe buses effectively. After you create a pool, create an even number of volumes split equally across the two controllers. Figure 52 shows an example of creating a pool from the middle drives. For DDP creation, NetApp recommends using all drives in the storage array.

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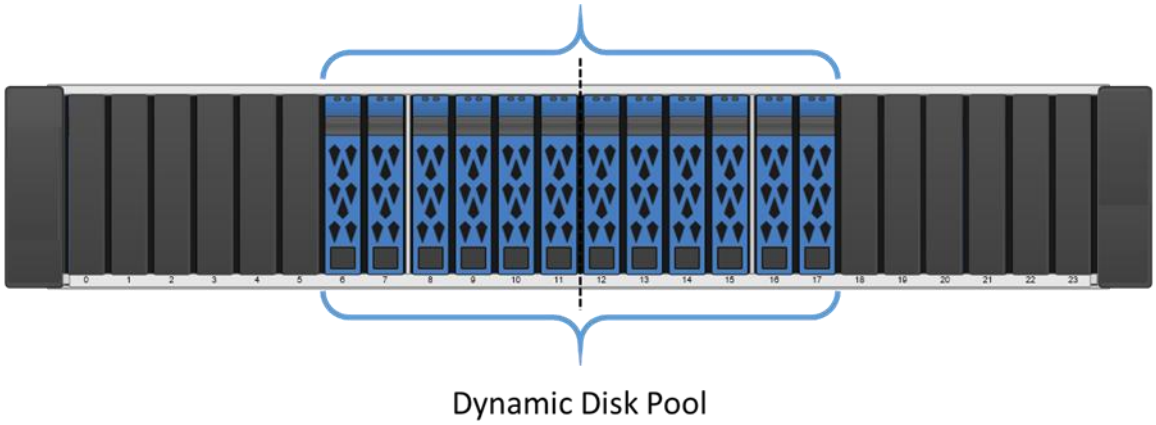
Figure 52) Example DDP using 12 drives.



E-Series product support

NetApp E-Series storage systems are identified by the chassis serial number (SN) of the E-Series system shelf, not the SNs of the individual controllers in the system shelf. You must register the E-Series system shelf SN, because only that SN can be used to log a support case with NetApp.

Controller shelf serial number

NetApp EF600C storage systems are shipped preconfigured from the factory (controllers have HICs and batteries installed, and controllers are installed in the controller shelf). The chassis serial number is printed on a white label that is affixed to the controller shelf behind the right end cap on the front of the chassis. The SN is circled in red on Figure 53.

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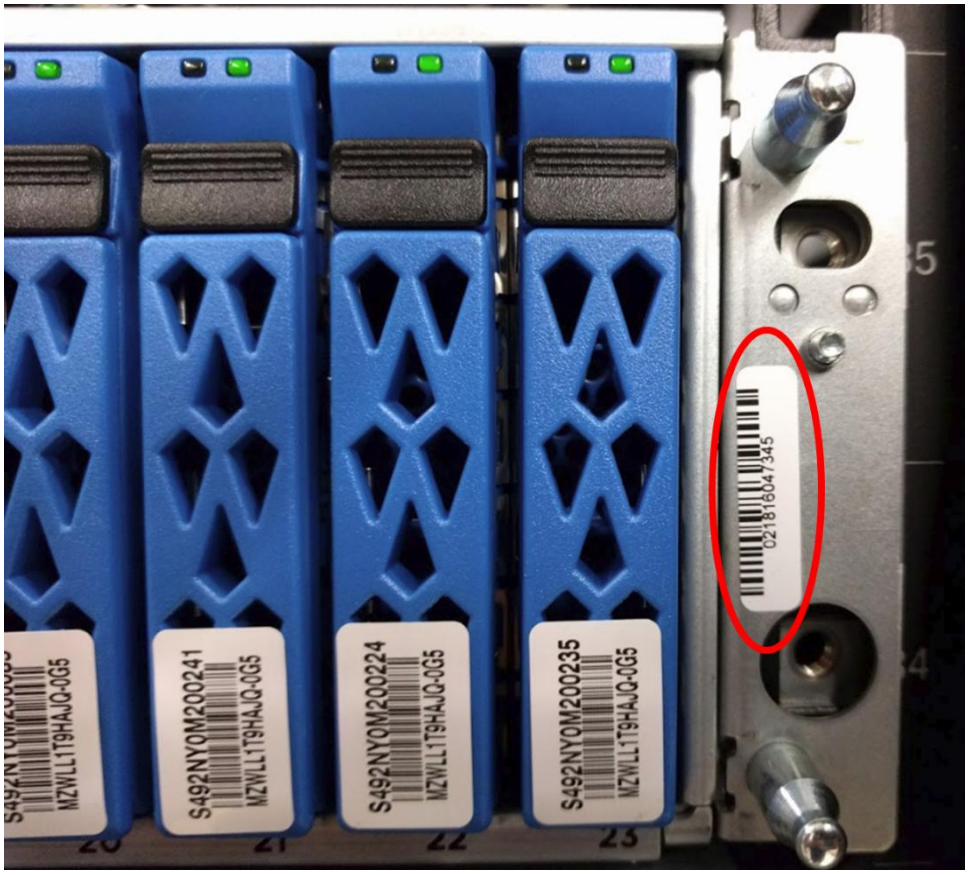
Figure 53) Controller shelf SN.



The SN is also included on the shelf UL sticker. However, this sticker is often not visible after the shelves are installed in a rack.

On a running storage system, you can also find the chassis serial number through NetApp SANtricity System Manager by selecting the Support tab and positioning your cursor over the Support Center tile in SANtricity 11.90x System Manager, as shown in Figure 54, or under Support Center in SANtricity 12.10 System Manager, see Figure 55.

Figure 54) SANtricity 11.90x System Manager Support Center tile showing chassis serial number.

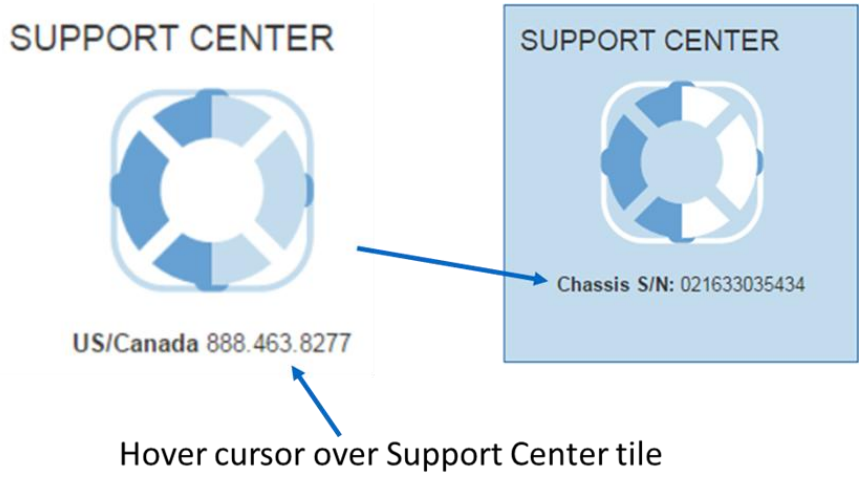


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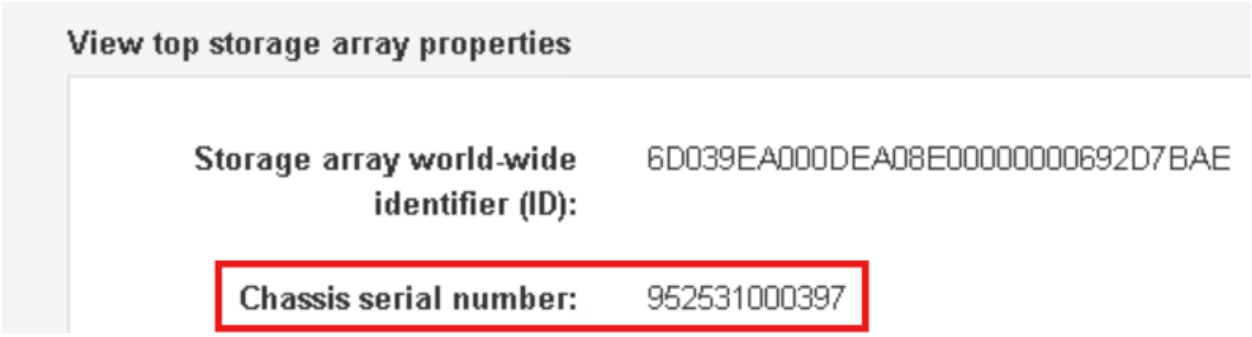
Figure 55) SANtricity 12.10 System Manager Support Center showing chassis serial number.



License keys

E-Series storage arrays use two types of license keys. One type of key file is for premium features, and the other type of key file is used to change the storage system feature pack (which changes the host interface protocol).

For the EF600C system, there are currently no premium features. All features are enabled out of the box.

Note: The encryption feature is disabled for systems sold in export-limited countries.

The feature pack keys are used to change the protocol on IB HICs between NVMe/IB and NVMe/RoCE and between FC and NVMe/FC on FC HICs. The process to generate a new feature pack key for your storage array is almost the same as the process to generate a premium feature key. The difference is that the 11-digit key activation code for each package is available at no additional cost and is listed in the hardware upgrade instructions per controller type, available on the Change the host protocol - EF300 and EF600.

The following information is required to generate a feature pack key file:

- 11-digit key activation code
- Array serial number shown in System Manager by selecting Support, then Support Center in SANtricity 11.90x System Manager, or by selecting Support, then Support Resources in SANtricity 12.10 or later System Manager

Select the feature enable identifier shown in System Manager by selecting Settings > System, then reference the identifier in the Add-Ons section in SANtricity 11.90x System Manager, or by selecting System then reference the identifier in the Add-Ons section in SANtricity 12.10 or later System Manager.

After the feature pack file is downloaded to the host server, click Change Feature Pack, as shown in Figure 56. Follow the prompts, beginning with browsing to the feature pack file, as shown in Figure 57 for SANtricity 11.90x System Manager. For SANtricity 12.10 System Manager or later, click on Choose a file to browse for the feature pack file, as shown in Figure 58.

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Figure 56) Changing the feature pack from Settings > System view.

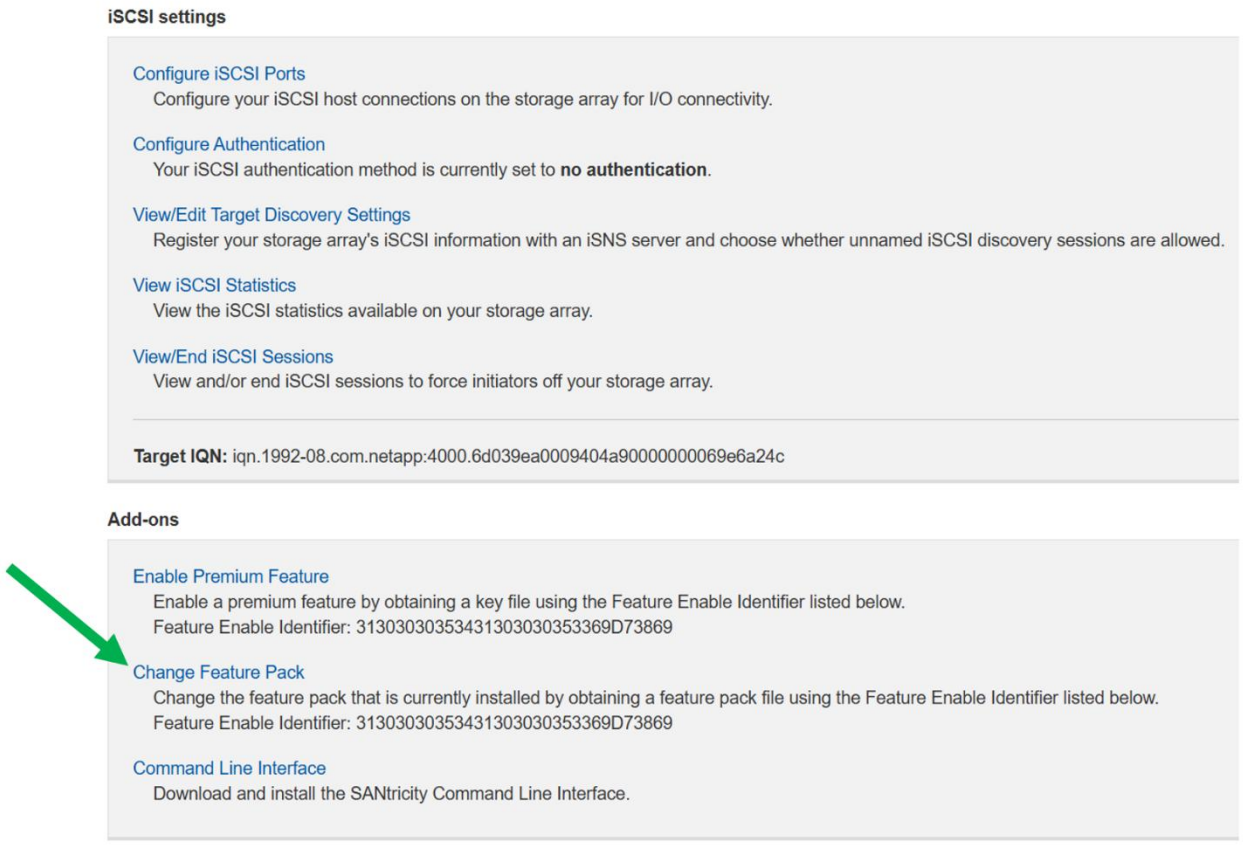

Figure 57) Change Feature Pack option for SANtricity 11.90x System Manager.

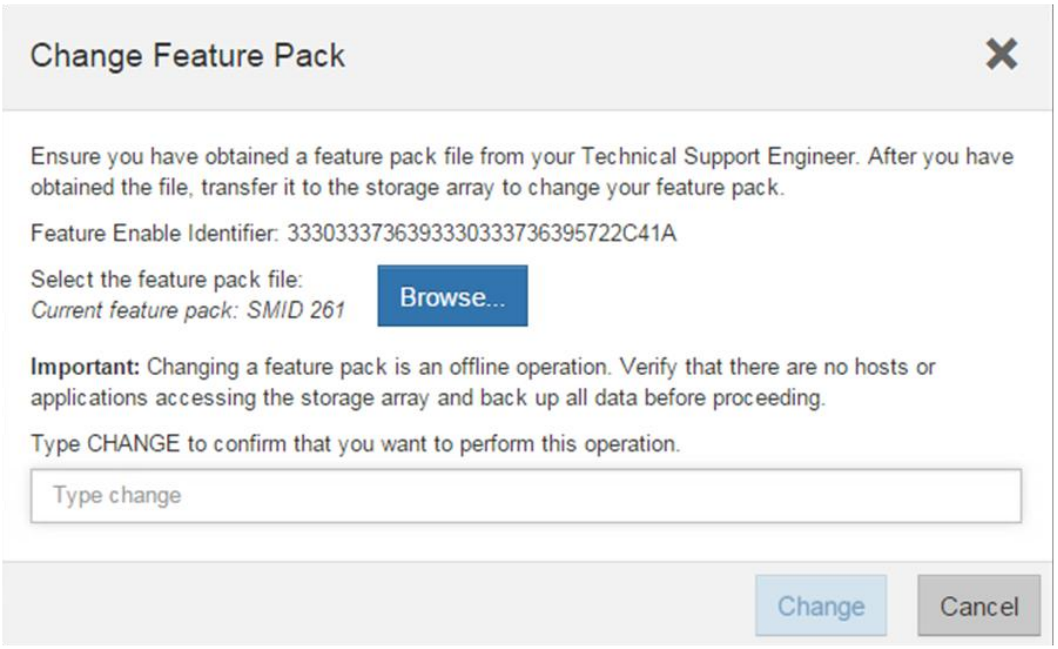

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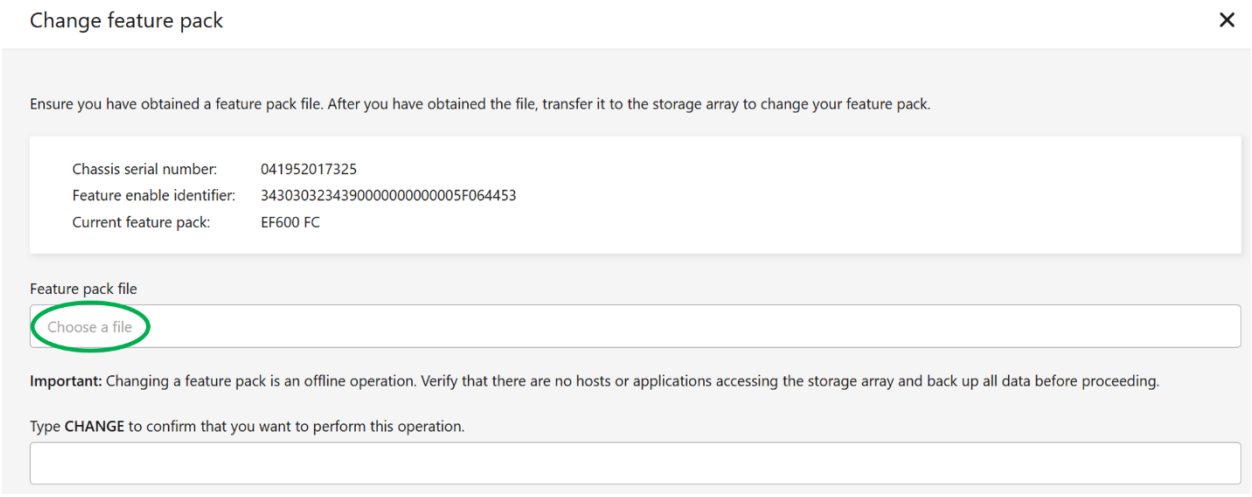
Figure 58) Change Feature Pack option for SANtricity 12.10 or later System Manager.



Note: Changing the feature pack causes the storage array to reboot. The new protocol will be active after the system is back online.

For issues with accessing license key files, open a support ticket with NetApp Support by using the serial number of the registered controller shelf for the associated storage system. This process requires a NetApp Support login.

Conclusion

NetApp EF-Series with high-capacity flash drives broadens the abilities of the array to manage more use cases. The additional capacity enables the EF600C array to store an application backup or provide a cold tier for an application such as Splunk.

This core block storage system provides the fast, affordable high-performance and high-density options required for demanding block workloads such as media and entertainment, HPC/AI, and high-performance databases.

With high-capacity NVMe SSD drives, the newest EF-Series systems will improve operational efficiency, help accelerate the transition from E-Series HDD-based systems to high-capacity flash and meet increasing capacity needs without compromising performance or reliability.

The EF600C storage systems provide high throughput performance with fast host interfaces and can offer up to 1.5PB of raw NVMe SSD capacity in only 2U with 24 60TB drives to support fast, large-capacity applications. The EF600C is also available with 30TB NVMe drives.

For high-random IOPS environments, the EF600C supports up to one million 4KB read IOPS. For high-bandwidth workloads, the EF600C supports approximately 12.5GBps cache-mirrored sequential writes and up to 44GBps sequential reads.

With its extreme versatility—including multiple host interface choices—the EF600C is a modern, ready-to-work, NVMe all-flash storage system. The addition of NVMe/IB, NVMe/RoCE, and NVMe/FC makes the EF600C a truly new-generation NVMe all-flash array. The EF600C system delivers industry-leading price/performance, excellent interface and configuration flexibility, and the extended RAS value that enterprise customers can trust with their highest-value workloads.

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Where to find additional information

To learn more about the information that is described in this document, review the following documents and websites:

- EF-Series All-Flash Arrays
  https://www.netapp.com/data-storage/ef-series/
- E-Series and SANtricity Documentation Center
  https://docs.netapp.com/us-en/e-series-family/index.html
- SANtricity software documentation
  https://mysupport.netapp.com/info/web/ECMP1658252.html

Version history

Version	Date	Document version history
Version 1.0	February 2025	Initial release of EF600C array.
Version 1.5	September 2026	Update for support of SANtricity OS 12.10 release. Updated max DDP capacity in Table 9.

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