Technical Report

SANtricity Drive Security

Feature Details Using SANtricity 11.60

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Abstract

NetApp offers data-at-rest encryption for NetApp® E-Series through the full disk encryption feature. This report provides detailed information about the NetApp SANtricity® full disk encryption feature for E-Series systems, including support for FIPS 140-2 validated drives, and both internal and external key management support.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Solution Overview

A company's data is likely its most valuable asset. With data security attacks on the rise, protecting an organization's data against loss or theft is increasingly important. SANtricity full disk encryption technology provides comprehensive security for data at rest without sacrificing system performance or ease of use.

1.1 SANtricity Full Disk Encryption Use Cases

SANtricity full disk encryption primarily protects your data if a physical security breach occurs. Versions prior to SANtricity 11.40 address the security threats for a disk drive in transit. The goal is to prevent unauthorized access to the data by someone in possession of the physical drives who uses standalone tools to attempt to read the media or moves the drives to a different unauthorized storage array. SANtricity 11.40 and later addresses the threat for a storage array in transit by adding another level of protection to prevent unauthorized access to data by someone in possession of the entire storage array. This is achieved by adding support for a centralized key management implementation. SANtricity 11.40 and later versions do not protect data from unauthorized access if the data center is compromised.

SANtricity 11.60 introduces a brand new EF600, which is a full end-to-end NVMe storage array. The EF600 supports the new NVMe full disk encryption (secure)/FIPS drives. These drives use the TCG Opal standard, not the TCG Enterprise standard that is currently used on the SAS secure/FIPS drives. Although the drives use a different standard, SANtricity 11.60 has been updated so that the difference in standards is not visible when it comes to security features.

SANtricity full disk encryption addresses two main use cases:

- Prevents unauthorized access to data without the proper security credentials either by using the same storage array where the entire system is compromised, by using a different storage array where the secure drive is compromised, or through stand-alone tools
- Enables you to upgrade controllers or legitimately move a set of drives from one array to another while maintaining data security.

With the information in this report, NetApp sales teams and partners can verify that the E-Series solution meets your security requirements. These requirements might vary according to the market, which includes the following sectors:

- U.S. Public Sector
- Financial
- Healthcare
- Retail

1.2 SANtricity Full Disk Encryption

E-Series storage systems provide at-rest data encryption through self-encrypting drives. These drives encrypt data on write operations and decrypt data on read operations regardless of whether the full disk encryption feature is enabled. If the SANtricity feature is not enabled, the data is encrypted at rest on the media, but automatically decrypted on a read request.

When the full disk encryption feature is enabled on the storage array, the drives protect the data at rest by locking the drive from read or write operations unless the storage array provides the correct security or authentication key. This process prevents another array from accessing the data without first importing the appropriate security key file to unlock the drives. It also prevents any third-party utility or operating system from accessing the data.

SANtricity 11.40 and later further enhances the full disk encryption feature by enabling you to manage the full disk encryption security key through a centralized key management system, such as Gemalto SafeNet KeySecure Enterprise Encryption Key Management which adheres to the Key Management

Interoperability Protocol (KMIP) standard. This feature is in addition to the internal security key management solution that exists in versions prior to SANtricity 11.40 and is available with the E2800, E5700, EF570, and EF600.

The encryption and decryption operations performed by the hardware in the drive are invisible to the user and do not affect the performance or user workflow. Each drive has its own unique encryption key that cannot be transferred, copied or read from the drive. The encryption key is a 256-bit key as specified in the National Institute of Standards and Technology (NIST) AES. The entire drive, not just a portion, is encrypted.

Security can be enabled at any time by selecting the `Secure Drives` option in the Volume Group or Disk Pool menus. This selection can be made at either volume group or pool creation or afterward. It does not affect existing data on the drives and can be used to secure the data after creation.

Note: The option cannot be disabled without erasing all the data on the affected volume group or pool.

Figure 1 shows the technical components of the NetApp E-Series full disk encryption feature with an internally managed security key.

Figure 1) E-Series full disk encryption with an internally managed security key.

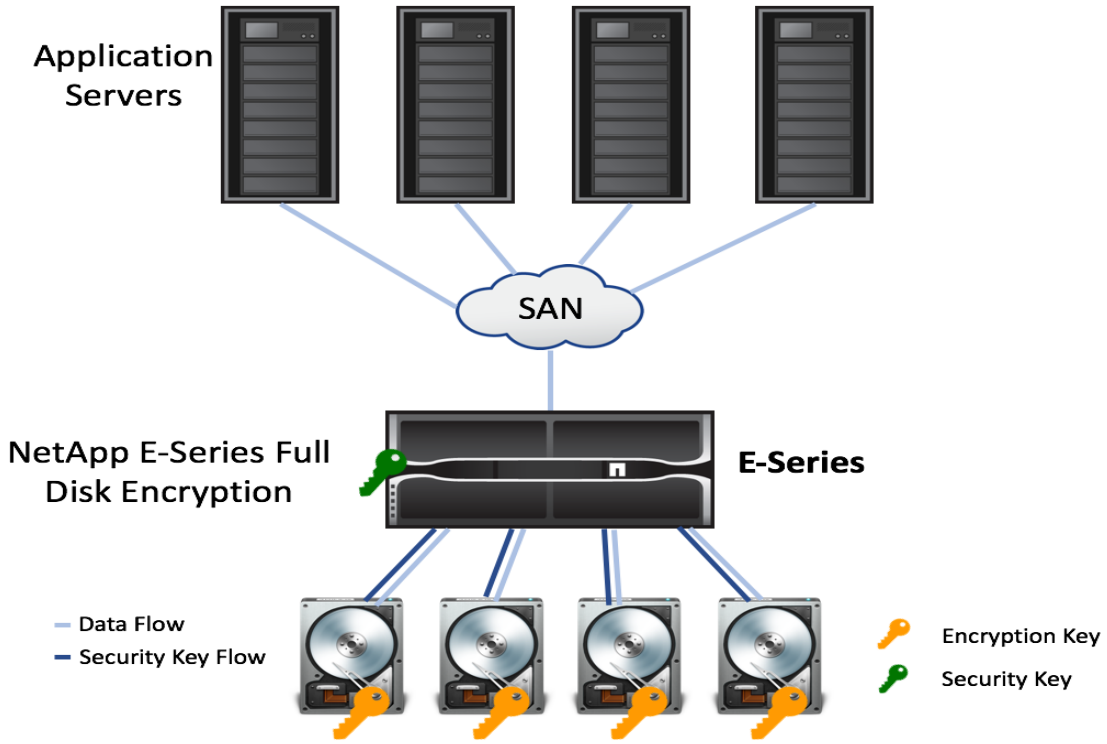
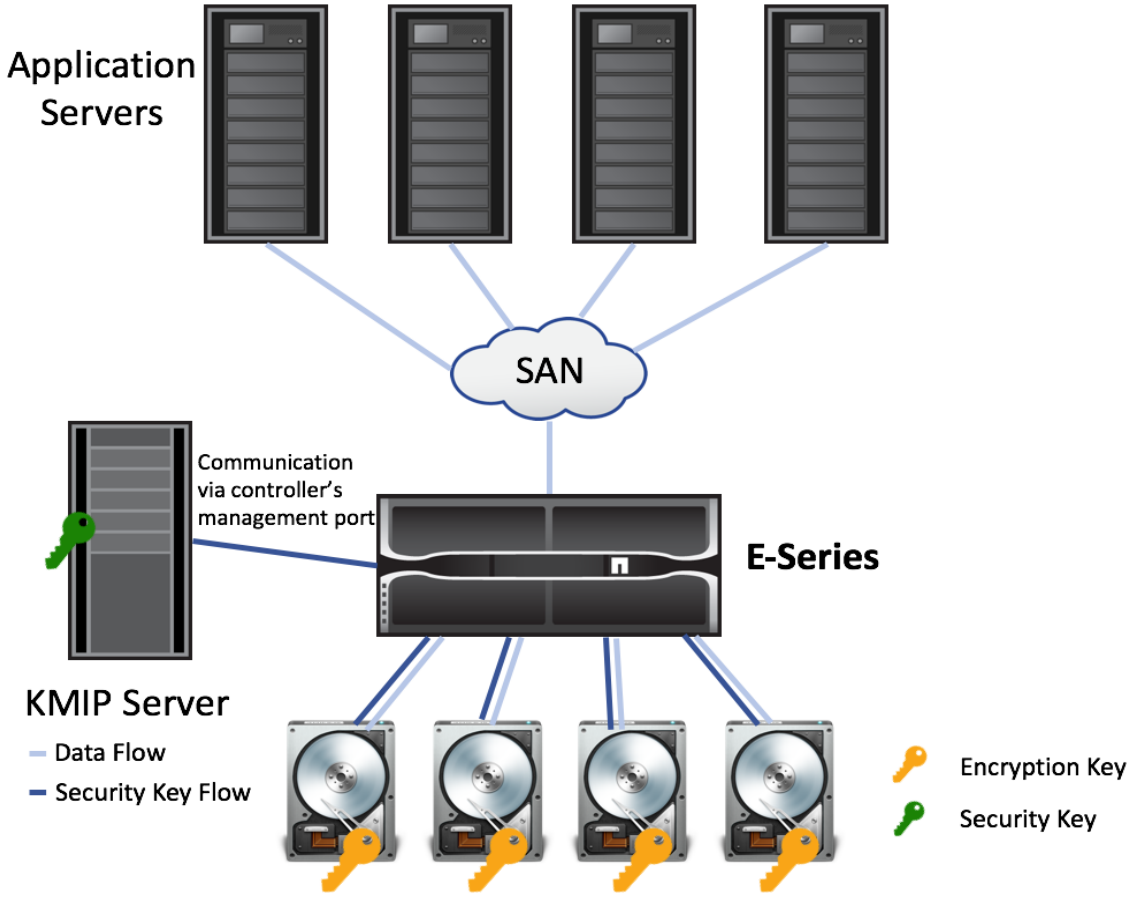


Figure 2 shows the technical components of the NetApp E-Series full disk encryption feature with an externally managed security key.

Figure 2) E-Series full disk encryption with an externally managed security key.



2 Security Key Authentication

When the NetApp E-Series full disk encryption feature is enabled, you must create a security key for the storage array. There is only one security key per storage array, and it is used to secure all volume groups or pools that are defined as secure-enabled. This security key is used to unlock the secure-enabled drives for read and write operations.

There is no partial use of full disk encryption security within a volume group or pool. To use the security feature, all drives in the volume group or pool must be secure-capable. All volumes configured from the secure-enabled volume group or pool are secured.

E-Series manages the security key using either internal or external key management. For the internal key management, the security key is maintained on the array. For the external key management, the security key is maintained on the external KMIP server. For either method, you must also back up the security key. The backup key is wrapped using a user-supplied passphrase and encrypted using AES-128. You can specify where the backup file is stored. The backup file contains two copies of the encrypted security key. You can validate the backup security key through the SANtricity Storage Manager software or the CLI. This validation process verifies that the backup key can be unwrapped and matches the security key stored on the array or on the KMIP server. During the validation process, you must provide the same user-supplied passphrase used to create the backup security key file.

In addition to the security key, a security key identifier is created and changed any time the security key is changed. The purpose of the security key identifier is to identify the security key for a specific storage

array to the user without the user knowing the actual security key. The identifier is a string containing up to 255 bytes and is either set to a user-defined value (for internal key management) or automatically generated (for external key management) by the controller. Unlike the security key, the security key identifier is designed to be read by humans. The security key identifier is stored on the controller and on all drives associated with that security key and is backed up together with the security key.

When importing drives to another E-Series storage array, the new storage array does not allow read or write operations to the drives until the associated security key is imported. During the import of the security key, the new storage array compares the security key ID of the imported key with the security key ID on the imported drives. If both storage arrays use a centralized external key management system (such as the same KMIP server), there is no need for a manual import of the security key. The new storage array automatically obtains the key from the KMIP server to unlock the imported drives. After the imported drives are unlocked, they are rekeyed to the security key of the new storage array.

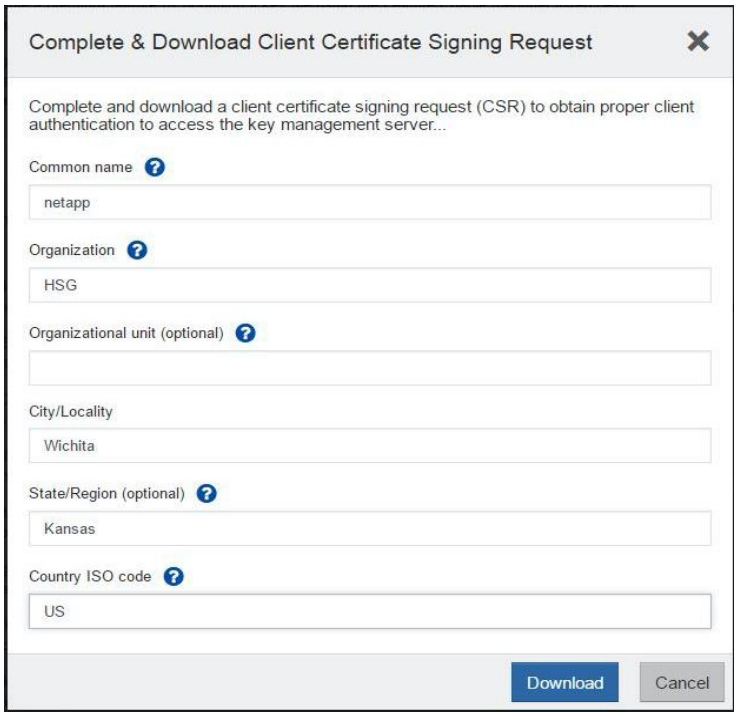
The array security key can be changed at any time without affecting the underlying user data. To protect against disruptions during the rekeying operation using internal key management, the old key is not deleted from the array until the new key is generated and applied to all secured drives. When using an external key management system, the keys (old and new) are always managed by the KMIP server and not persistently stored on the storage array.

3 External KMIP Server Authentication

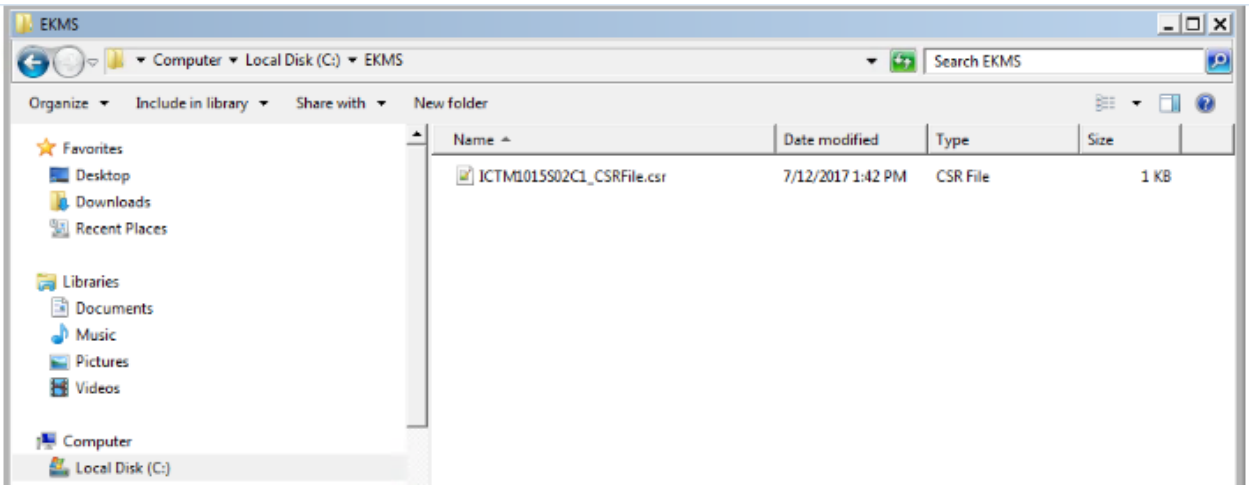
The external key management system provides an increased layer of security by detaching the security key from the storage array on which the data resides. However, this added layer of security comes with the additional cost of procuring the crypto management hardware and/or software. There are also additional steps to configure both the storage array and the KMIP server with the appropriate sets of certificates so that requests can be authenticated and honored by the KMIP server.

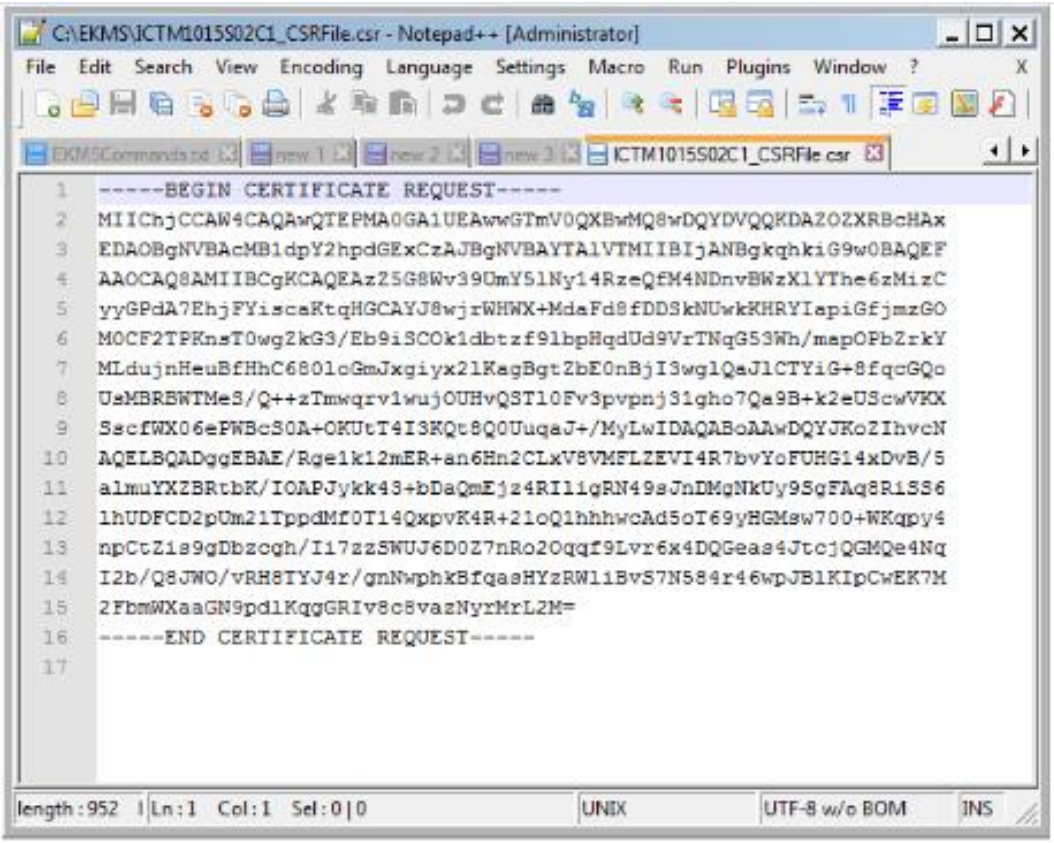
To configure the storage array and KMIP server to authenticate requests, complete the following steps:

1. Open a Certificate Signing Request (CSR) from the CLI or SANtricity System Manager and enter the appropriate Secure Sockets Layer (SSL) Distinguished Name (DN), business name, and location information.

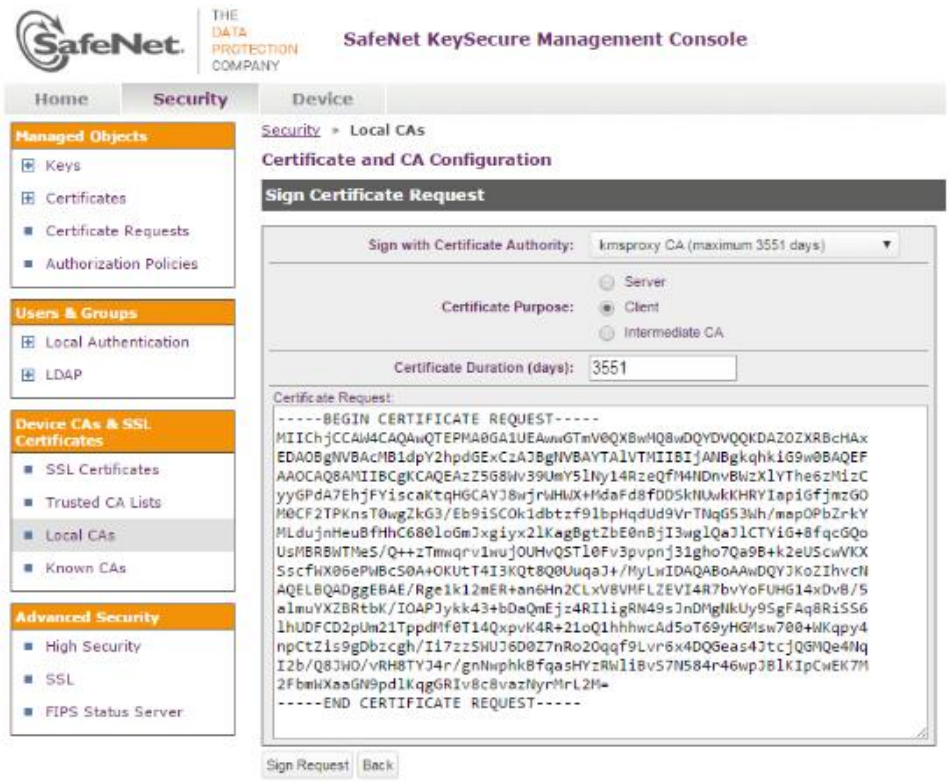


The OpenSSL library on the E-Series Storage Array generates a private key and a public key. A CSR is created by using the generated public key and the user-provided DN.



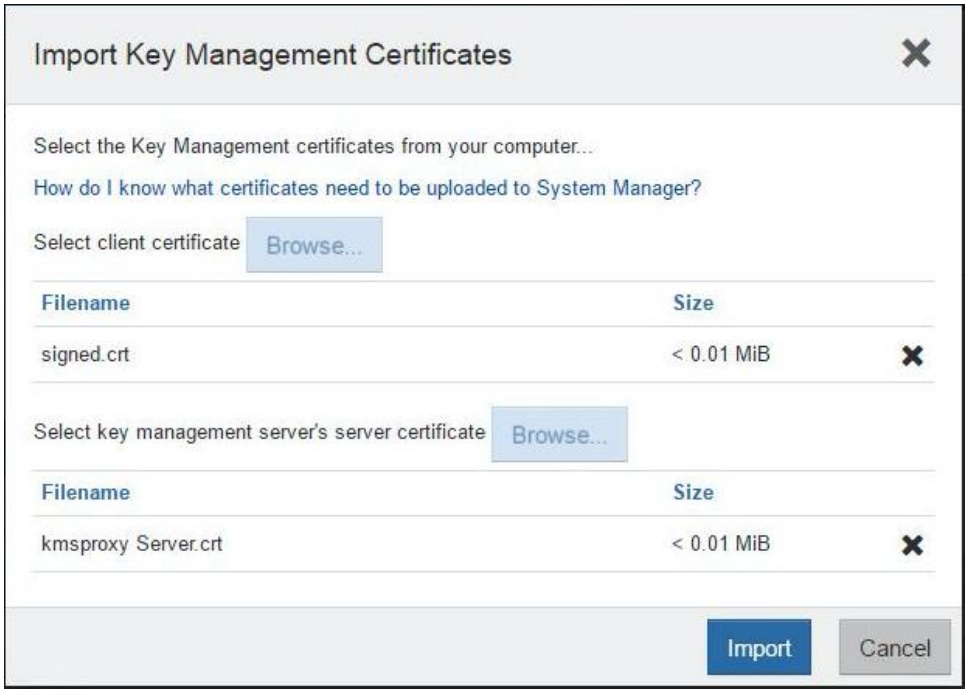


2. Submit the request to the certificate authority (CA).



A signed client certificate file is generated.

3. Install the signed client certificate file.



If there is no signed server certificate available, complete the following steps:

a. Request the KMIP server to create a CSR and generate a signed server certificate file.

b. Download and install the signed server certificate file from the KMIP server on the E-Series storage array.

4. After all the certificates have been installed, enable the external key management through which the E-Series storage array will request a new security key for the secure-enabled drives.

4 FIPS 140-2 Level 2 Compliance

With third-party certification becoming a fundamental business requirement for government and commercial customers, the full disk encryption feature offers a higher level of assurance with drives that have been validated against the FIPS 140-2 developed by the National Institute of Standards and Technology (NIST). FIPS 140-2 validated drives are level 2 compliant, which provides an added layer of security assurance by using tamper-resistant drives and other approved protocols. The process for creating and authenticating the security key does not change with FIPS 140-2 drives. Secure-capable drives in NetApp's Hardware Universe and other tools are now identified as either FIPS Compliant or full disk encryption. For SANtricity 11.40 and later versions, the support for Gemalto SafeNet KeySecure appliances with FIPS 140-2 validated cryptographic modules enables NetApp E-Series storage arrays (such as E2800, E5700, EF570, and EF600) to provide secure external key management of FIPS140-2 validated secure drives.

4.1 Operating in FIPS 140-2 Compliant Mode

With SANtricity 11.25 or later, when a FIPS 140-2 validated drive is installed on an E-Series system, an initialization process is performed in accordance to the specific drive model's FIPS 140-2 security policy. After the initialization process, the SANtricity UI identifies the FIPS drives as FIPS compliant. If you are using an earlier version of SANtricity, the drives function like secure drives and are not initialized in accordance with the FIPS 140-2 security policy or identified as FIPS in the SANtricity Storage Manager GUI. If the storage array is upgraded to SANtricity 11.25 or later, and the volume group or pool is composed solely of FIPS 140-2 validated drives, the drives are initialized to place them into FIPS 140-2 compliant mode.

5 Secure Drive Operations

Standard volume groups (RAID) or pools are a grouped set of drives that must adhere to certain quality of service rules, such as encryption capability. A nonsecure-capable volume group or disk pool can consist of a mix of secure-capable and nonsecure-capable drives, but a secure-capable volume group or disk pool must consist only of secure-capable drives. After enabling the security on a secure-capable volume group or pool, that group of drives are secure-enabled. Any volumes or logical unit numbers (LUNs) created on that secure-enabled volume group or disk pool are secured. An E-Series storage system can consist of a mix of secure-enabled, secure-capable, and nonsecure-capable volume groups or pools at the same time.

To move secure-enabled volume groups with the data intact between arrays, complete the following steps:

1. Export the volume group from the source array.
2. Import the volume group into the destination array.
3. For internal key management or if the security key does not reside on the KMIP server for the destination array, apply a copy of the backed-up security key to unlock the imported drives.

If both storage arrays use a centralized external key management system (such as the same KMIP server), there is no need for a manual import of the backup security key. The new storage array automatically obtains the security key from the KMIP server to unlock the imported drives.

Note: E-Series storage systems do not support movement of drives associated to a pool between storage arrays.

The storage array enforces configuration rules regarding the use of secure and FIPS drives, including how they can be used with the various features. For example, drives can be securely erased by reprovisioning them. This function triggers a rekeying of the individual drive's encryption keys, rendering all previous data unreadable. See the following sections for additional information regarding the rules associated to each topic.

5.1 Volume Group and Disk Pool Configuration

A volume group or pool can consist of any mixture of nonsecure-capable and secure-capable drives on which both full disk encryption and FIPS 140-2 compliant drives are considered secure-capable. If you want to secure the volume group or disk pool, all the drives in that volume group or disk pool must be secure-capable (either full disk encryption or FIPS 140-2 compliant drives). If you require FIPS 140-2 compliant volume groups or pools, all the constituent drives must be FIPS 140-2 compliant. If global hot spares are used, they must be at least as secure as the volume group. Table 1 provides the configuration rules.

Table 1) Volume group and disk pool configuration rules.

Drive Type	FIPS Secure-Enabled or FIPS Secure-Capable Volume Group or Disk Pool	Full Disk Encryption Secure-Enabled Volume Group or Disk Pool	Full Disk Encryption Secure-Capable Volume Group or Disk Pool	Nonsecure-Capable Volume Group or Disk Pool
FIPS	Yes[1]	Yes[2]	Yes	Yes
Full disk encryption	No	Yes	Yes	Yes
Nonsecure capable	No	No	Yes[3]	Yes

[1] A volume group or disk pool can be FIPS enabled or FIPS capable only if all drives are FIPS-compliant.

[2] If an individual FIPS drive is used in a full disk encryption secure-enabled volume group or disk pool, it is placed into the FIPS-compliant mode, but the volume group or pool is not considered FIPS compliant.

[3] If a volume group or pool consists of a mix of secure-capable and nonsecure-capable drives, security cannot be enabled until the nonsecure-capable drives are replaced with secure-capable drives.

5.2 Global Hot Spare Compatibility

Table 2 provides the requirements associated to using global hot spare drives with standard RAID configurations.

Note: Pools do not use hot spare drives.

Table 2) Global hot spare compatibility rules.

Drive Type	FIPS Secure-Enabled or FIPS Secure-Capable Volume Group	Full Disk Encryption Secure-Enabled Volume Group	Full Disk Encryption Secure-Capable Volume Group	Nonsecure-Capable Volume Group
FIPS	Yes	Yes[1]	Yes[1]	Yes[1]
Full disk encryption	No	Yes	Yes	Yes[2]

Drive Type	FIPS Secure-Enabled or FIPS Secure-Capable Volume Group	Full Disk Encryption Secure-Enabled Volume Group	Full Disk Encryption Secure-Capable Volume Group	Nonsecure-Capable Volume Group
Nonsecure-capable	No	No	Yes[3]	Yes

[1.]A FIPS 140-2 compliant drive is only used if there are no other options.

[2.]If both secure-capable and non-secure-capable drives are available, the non-secure-capable drives are chosen.

[3.]If both secure-capable and non-secure-capable drives are available, the secure-capable drives are chosen. If a nonsecure-capable drive is used, the volume group may not be secured until it is replaced with a secure-capable drive. This restores the volume group to a homogeneous secure-capable state.

5.3 Secure Erase and Disk Sanitization

As mentioned, a secure erase (reprovisioning) of the drives can be performed on both secure and FIPS compliant drives. This triggers a rekeying of the individual drive's encryption key and renders all previous data unreadable. To perform a secure erase, the drives should not be part of a configured volume group or pool. Both secure and FIPS drives are reprovisioned using the same process, with one exception: If the drive security key is not available for the FIPS drive, the PSID is required to execute a CLI command to perform the secure erase for the associated FIPS drives. The PSID is a human readable string on the label of the drive and you must enter it manually through the SANtricity management software or the CLI.

Starting with SANtricity OS 11.60 running on the EF600 NVMe storage array, only NVMe SSD drives are supported. For both secure and FIPS drives, any reprovisioning of the drive will require the PSID input if the drive security key is not available. With SANtricity OS 11.60, you can complete this operation through either the CLI command or the SANtricity System Manager GUI.

Figure 3) Drive reset/provisioning procedure on the SANtricity System Manager GUI.

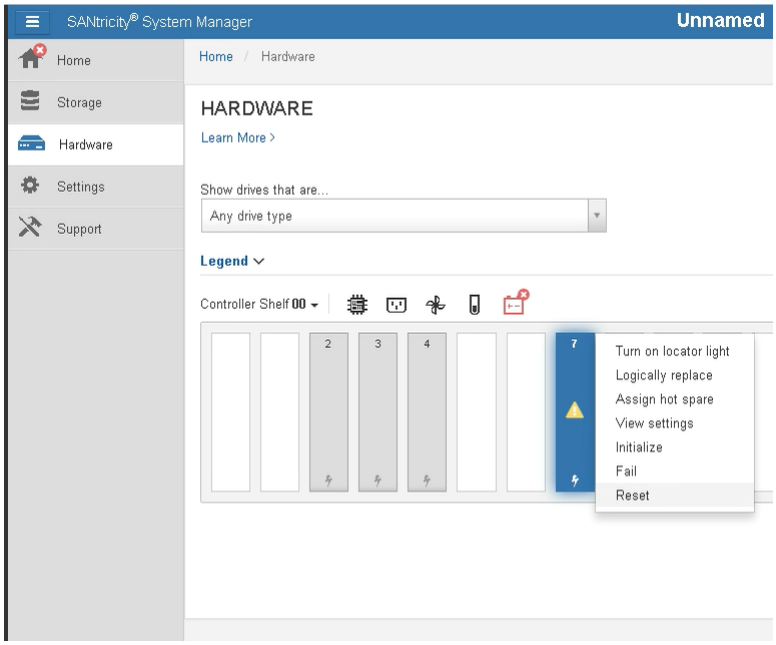
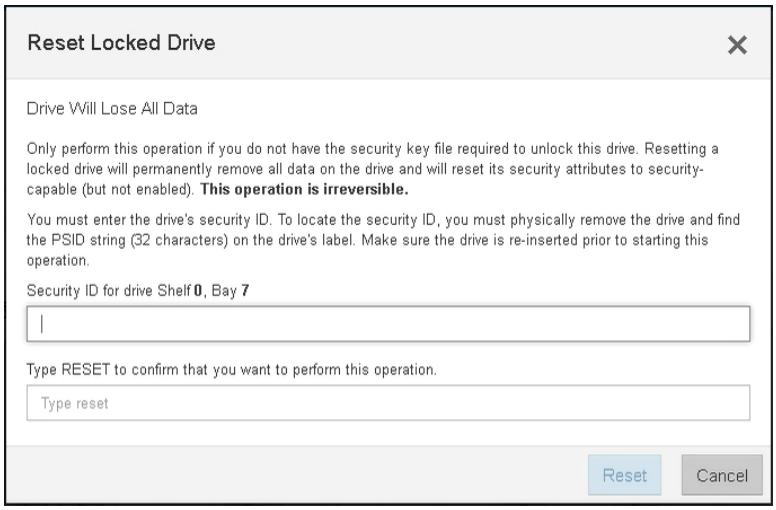


Figure 4) Reset Locked Drive dialog box on the SANtricity System Manager GUI.



6 Feature Interaction

The following sections describe the rules associated with drive security as it relates to the listed features.

6.1 Volume Copy

There are no restrictions on the volume copy feature. You can select any combination of security capabilities for the source and target of the copy operation. However, SANtricity Storage Manager generates a warning if you copy from a higher security volume to a lower security volume.

6.2 Snapshot Images

The reserved NetApp Snapshot™ copy repository must be as secure as the volume from which the Snapshot copy is being created.

6.3 Synchronous Mirroring

There are no restrictions on the synchronous mirroring feature. You can select any combination of security capabilities for the primary and secondary volumes. NetApp recommends that you select matching security capabilities as a best practice.

Note: Synchronous mirroring is not supported on SANtricity OS 11.60 running on the EF600.

6.4 Asynchronous Mirroring

The mirror repository must be as secure as the volume being mirrored. The quality of service limitations on the primary and secondary volumes are outlined in Table 3.

Table 3) Asynchronous mirroring configuration rules.

Primary Mirror Security State	Secondary Mirror Security State
Nonsecure-capable	Non-secure-capable[1]
Full disk encryption secure-capable[4]	Full disk encryption or FIPS secure-capable[2] or full disk encryption or FIPS secure-enabled
Full disk encryption secure-enabled	Full disk encryption or FIPS secure-enabled

Primary Mirror Security State	Secondary Mirror Security State
FIPS secure-capable[4]	Full disk encryption or FIPS secure-capable or secure-enabled
FIPS secure-enabled	Full disk encryption or FIPS secure-enabled[3]

[1.]The secondary volume cannot be secure-capable because a role reversal results in an incompatible configuration that is not correctable (the new secondary volume cannot be made secure).

[2.]A role reversal results in an incompatible configuration. You can correct this by enabling security on the new secondary volume. The system generates an alert to this condition.

[3.]A role reversal results in a primary volume with a lower security level (full disk encryption secure-enabled) than the secondary volume (FIPS secure-enabled). This does not require any action by the user and the system does not generate an alert to the condition. The best practice is to create both the primary and secondary volumes from FIPS secure-capable drives.

[4.]Enabling security on the primary results in an incompatible configuration. You can correct this by enabling security on the secondary volume. The system generates an alert to the condition.

Note: Asynchronous mirroring is not supported on NetApp SANtricity OS 11.60 running on the EF600.

6.5 SSD Read Cache

SSD read cache can only be secure-enabled at the time of creation. The underlying HDD volume can be secure-enabled at any time, but only if the SSD read cache is already enabled. Table 4 provides the configuration rules.

Table 4) SSD read cache configuration rules.

SSD Read Cache	Nonsecure-Capable HDD Volume	Full Disk Encryption Secure-Capable HDD Volume	Full Disk Encryption Secure-Enabled HDD Volume	FIPS Secure-Capable HDD Volume	FIPS Secure-Enabled HDD Volume
Nonsecure-capable SSD cache	Yes	No	No	No	No
Full disk encryption secure-capable SSD cache	Yes	Yes	No	Yes[1]	No
Full disk encryption secure-enabled SSD cache	Yes	Yes	Yes	Yes	Yes [2]
FIPS secure-capable SSD cache	Yes	Yes	No	Yes	No
FIPS secure-enabled SSD cache	Yes	Yes	Yes	Yes	Yes

[1].The system generates a message that the SSD read cache has a lower potential security than the HDD volume.

[2].The system generates a message that the SSD read cache has a lower enabled security than the HDD volume.

Note: The SSD cache is not supported on SANtricity OS 11.60 running on the EF600.

7 Frequently Asked Questions

Following are commonly asked questions regarding the rules and functionality of the SANtricity drive security feature.

Does the feature work with external key management products?

Answer: Yes. In addition to supporting internal key management, SANtricity 11.40 or later running on E2800, E5700, EF570 or EF600, also supports the use of a centralized key management system, such as the Gemalto KeySecure Enterprise Encryption Key Management, which adheres to the KMIP standard.

How does the storage array authenticate with the external key management server?

Answer: When enabling the external key management feature, the administrator must install a set of certificates on the array. These certificates are used to establish a secure connection between the array and the key management server. The SANtricity System Manager provides an interface to walk the administrator through the process of generating a Certificate Signing Request (CSR) and installing the signed client certificate and KMIP server Secure Sockets Layer (SSL) certificate. You can perform this process through the CLI.

When is the backup security key file and passphrase needed?

Answer: The backup security key file is created and securely wrapped using a user-supplied passphrase. The backup security key file is created each time a new lock key is created. The backup security key file and passphrase are needed in the following scenarios to unlock the locked drives:

- The storage array power cycles and cannot access the KMIP server for the key.
- A volume group import where the drives are secured.
- A dual controller replacement where all drives in the storage array are secured.

Is IPv6 addressing supported for communication between the storage array and the KMIP server?

Answer: It is supported by SafeNet KeySecure version k170v v1.2 or later.

Can I mix secured and unsecured drives in a single storage system?

Answer: Yes. A single storage system can consist of a mixture of secured and unsecured volume groups or pools. As mentioned previously, if a volume group or pool has a mix of secure-capable and nonsecure-capable drives, security cannot be enabled for the volume group or pool.

Can I have both secured and unsecured volumes in a single volume group or Dynamic Disk pool?

Answer: No. The entire volume group or pool must be either secured or unsecured.

Which types of drives support encryption?

Answer: Currently shipping HDDs and SSDs support encryption on selected capacities and models.

Which types of drives are FIPS compliant?

Answer: Currently shipping HDDs and SSDs are FIPS compliant on selected capacities and models.

What level of encryption is used by this solution?

Answer: The drives use AES-256 encryption. The backed-up security key that is returned in a key file during key creation, rekeying, or a backup request, is wrapped using AES-128 encryption.

Can I enable or disable security on the drives at any time?

Answer: You can enable security at any time with data in place. The only exception is the SSD read cache feature. You can only enable security on the SSD read cache at the creation time of the cache. You can disable security on a drive through reprovisioning. Reprovisioning requires that the drive is no longer configured for user data. The drive reprovision process is a secure erase operation because the encryption key on the drive is changed and is irreversible.

Is the full disk encryption feature FIPS 140-2 validated?

Answer: FIPS validation can be performed on drives (HDDs and SSDs), software modules (the full disk encryption feature), or storage systems (E-Series arrays). Selected currently shipping drives are validated at FIPS 140-2 Level 2.

Are controller replacements allowed while full disk encryption is in use?

Answer: Yes. The security key and other configuration parameters are automatically synchronized after a single-controller replacement in a dual-controller system. In a simplex controller system or a dual controller replacement in a dual-controller system, you must provide the backed-up security key from the original controller. If a backup of the security key is not available, the data on the drives are not accessible.

Where to Find Additional Information

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

- E-Series and SANtricity 11 Documentation Center
  http://docs.netapp.com/ess-11/index.jsp
- E-Series and SANtricity 11 Resources
  https://mysupport.netapp.com/info/web/ECMP1658252.html
- NetApp SANtricity System Manager Online Help v11.60
  https://mysupport.netapp.com/NOW/public/eseries/sam/index.html
- FIPS Publication
  http://csrc.nist.gov/publications/fips/fips140-2/fips1402.pdf

Version History

Version	Date	Document Version History
Version 1.0	October 2015	Initial version for SANtricity v11.20
Version 2.0	July 2016	Refresh for SANtricity v11.25
Version 3.0	July 2017	Refreshed for SANtricity v11.40. Added External Key Management Support.
Version 4.0	August 2019	Refreshed for SANtricity v11.60. Updated drive provisioning topic for NVMe drives.

Refer to the Interoperability Matrix Tool (IMT) on the NetApp Support site to validate that the exact product and feature versions described in this document are supported for your specific environment. The NetApp IMT defines the product components and versions that can be used to construct configurations that are supported by NetApp. Specific results depend on each customer's installation in accordance with published specifications.

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