Configure NetApp hardware-based encryption

ONTAP 9

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Learn about ONTAP hardware-based encryption

NetApp hardware-based encryption supports full-disk encryption (FDE) of data as it is written. The data cannot be read without an encryption key stored on the firmware. The encryption key, in turn, is accessible only to an authenticated node.

Understanding NetApp hardware-based encryption

A node authenticates itself to a self-encrypting drive using an authentication key retrieved from an external key management server or Onboard Key Manager:

- The external key management server is a third-party system in your storage environment that serves keys to nodes using the Key Management Interoperability Protocol (KMIP). It is a best practice to configure external key management servers on a different storage system from your data.
- The Onboard Key Manager is a built-in tool that serves authentication keys to nodes from the same storage system as your data.

You can use NetApp Volume Encryption with hardware-based encryption to “double encrypt” data on self-encrypting drives.

When self-encrypting drives are enabled, the core dump is also encrypted.

If an HA pair is using encrypting SAS or NVMe drives (SED, NSE, FIPS), you must follow the instructions in the topic Returning a FIPS drive or SED to unprotected mode for all drives within the HA pair prior to initializing the system (boot options 4 or 9). Failure to do this may result in future data loss if the drives are repurposed.

Supported self-encrypting drive types

Two types of self-encrypting drives are supported:

- Self-encrypting FIPS-certified SAS or NVMe drives are supported on all FAS and AFF systems. These drives, called *FIPS drives,* conform to the requirements of Federal Information Processing Standard Publication 140-2, level 2. The certified capabilities enable protections in addition to encryption, such as preventing denial-of-service attacks on the drive. FIPS drives cannot be mixed with other types of drives on the same node or HA pair.
- Beginning with ONTAP 9.6, self-encrypting NVMe drives that have not undergone FIPS testing are supported on AFF A800, A320, and later systems. These drives, called *SEDs*, offer the same encryption capabilities as FIPS drives, but can be mixed with non-encrypting drives on the same node or HA pair.
- All FIPS validated drives use a firmware cryptographic module that has been through FIPS validation. The FIPS drive cryptographic module does not use any keys that are generated outside of the drive (the authentication passphrase that is input to the drive is used by the drive’s firmware cryptographic module to obtain a key encryption key).

Non-encrypting drives are drives that are not SEDs or FIPS drives.

If you are using NSE on a system with a Flash Cache module, you should also enable NVE or NAE. NSE does not encrypt data that resides on the Flash Cache module.

When to use external key management

Although it is less expensive and typically more convenient to use the onboard key manager, you should use external key management if any of the following are true:

- Your organization's policy requires a key management solution that uses a FIPS 140-2 Level 2 (or higher) cryptographic module.
- You need a multi-cluster solution, with centralized management of encryption keys.
- Your business requires the added security of storing authentication keys on a system or in a location different from the data.

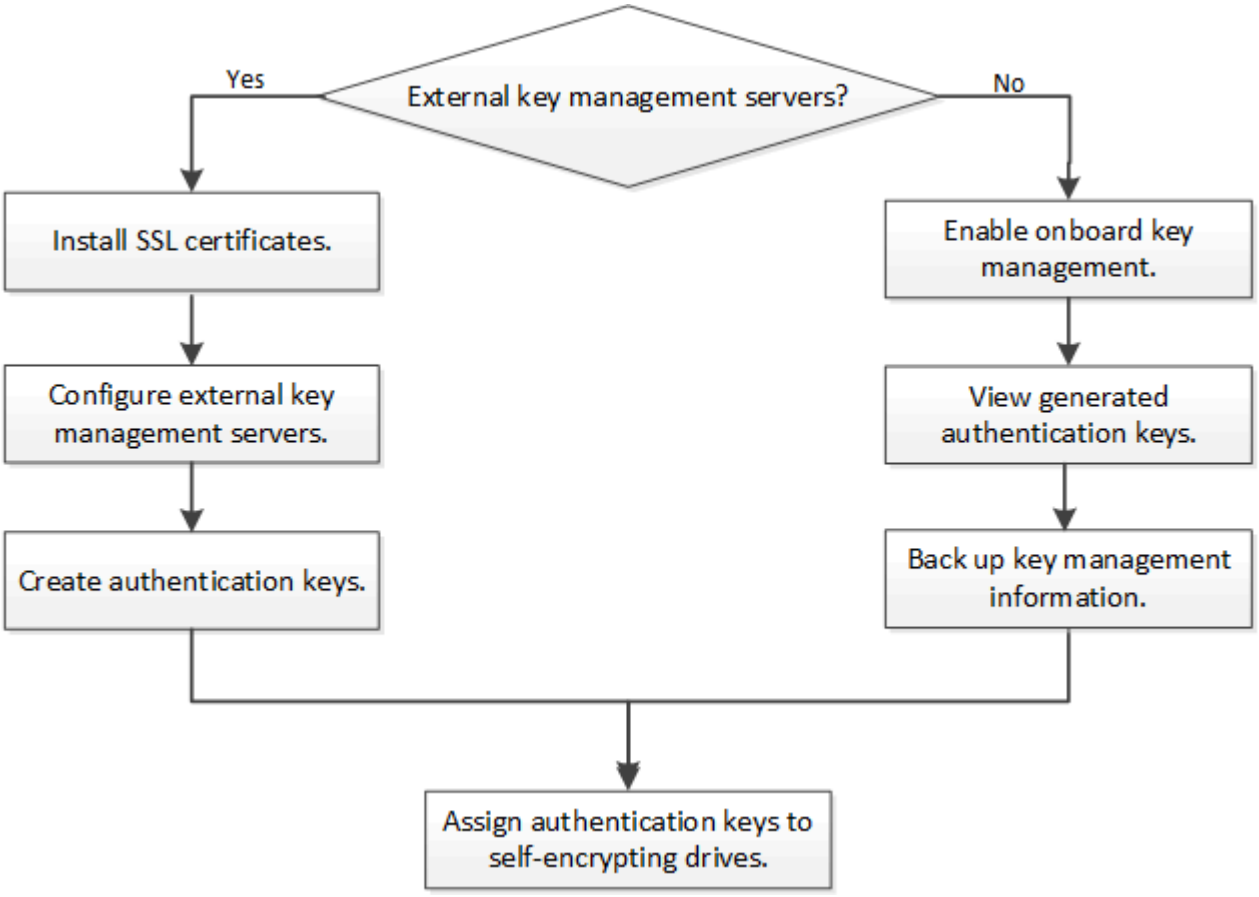
Support details

The following table shows important hardware encryption support details. See the Interoperability Matrix for the latest information about supported KMIP servers, storage systems, and disk shelves.

Resource or feature	Support details
Non-homogeneous disk sets	• FIPS drives cannot be mixed with other types of drives on the same node or HA pair. Conforming HA pairs can coexist with non-conforming HA pairs in the same cluster. • SEDs can be mixed with non-encrypting drives on the same node or HA pair.
Drive type	• FIPS drives can be SAS or NVMe drives. • SEDs must be NVMe drives.
10 Gb network interfaces	Beginning with ONTAP 9.3, KMIP key management configurations support 10 Gb network interfaces for communications with external key management servers.
Ports for communication with the key management server	Beginning with ONTAP 9.3, you can use any storage controller port for communication with the key management server. Otherwise, you should use port e0M for communication with key management servers. Depending on the storage controller model, certain network interfaces might not be available during the boot process for communication with key management servers.
MetroCluster (MCC)	• NVMe drives support MCC. • SAS drives do not support MCC.

Hardware-based encryption workflow

You must configure key management services before the cluster can authenticate itself to the self-encrypting drive. You can use an external key management server or an onboard key manager.



Related information

- NetApp Hardware Universe
- NetApp Volume Encryption and NetApp Aggregate Encryption

Configure external key management

Learn about configuring ONTAP external key management

You can use one or more external key management servers to secure the keys that the cluster uses to access encrypted data. An external key management server is a third-party system in your storage environment that serves keys to nodes using the Key Management Interoperability Protocol (KMIP).

NetApp Volume Encryption (NVE) can be implemented with Onboard Key Manager. In ONTAP 9.3 and later, NVE can be implemented with external key management (KMIP) and Onboard Key Manager. Beginning with ONTAP 9.11.1, you can configure multiple external key managers in a cluster. See Configure clustered key servers.

Install SSL certificates on the ONTAP cluster

The cluster and KMIP server use KMIP SSL certificates to verify each other's identity and establish an SSL connection. Before configuring the SSL connection with the KMIP server, you must install the KMIP client SSL certificates for the cluster, and the SSL public certificate for the root certificate authority (CA) of the KMIP server.

About this task

In an HA pair, both nodes must use the same public and private KMIP SSL certificates. If you connect multiple HA pairs to the same KMIP server, all nodes in the HA pairs must use the same public and private KMIP SSL certificates.

Before you begin

- The time must be synchronized on the server creating the certificates, the KMIP server, and the cluster.
- You must have obtained the public SSL KMIP client certificate for the cluster.
- You must have obtained the private key associated with the SSL KMIP client certificate for the cluster.
- The SSL KMIP client certificate must not be password-protected.
- You must have obtained the SSL public certificate for the root certificate authority (CA) of the KMIP server.
- In a MetroCluster environment, you must install the same KMIP SSL certificates on both clusters.

You can install the client and server certificates on the KMIP server before or after installing the certificates on the cluster.

Steps

1. Install the SSL KMIP client certificates for the cluster:

   ```
   security certificate install -vserver admin_svm_name -type client
   ```

   You are prompted to enter the SSL KMIP public and private certificates.

   ```
   cluster1::> security certificate install -vserver cluster1 -type client
   ```

2. Install the SSL public certificate for the root certificate authority (CA) of the KMIP server:

   ```
   security certificate install -vserver admin_svm_name -type server-ca
   ```

   ```
   cluster1::> security certificate install -vserver cluster1 -type server-ca
   ```

Related information

- security certificate install

Enable external key management for hardware-based encryption in ONTAP 9.6 and later

You can use one or more KMIP servers to secure the keys the cluster uses to access encrypted data. You can connect up to four KMIP servers to a node. A minimum of two servers is recommended for redundancy and disaster recovery.

Beginning with ONTAP 9.11.1, you can add up to 3 secondary key servers per primary key server to create a clustered key server. For more information, see Configure clustered external key servers.

Before you begin

- The KMIP SSL client and server certificates must have been installed.
- You must be a cluster administrator to perform this task.
- In a MetroCluster environment:

- You must configure the MetroCluster environment before you configure an external key manager.
- You must install the same KMIP SSL certificate on both clusters.

Steps

1. Configure key manager connectivity for the cluster:

   ```
   security key-manager external enable -vserver admin_SVM -key-servers
   host_name|IP_address:port,... -client-cert client_certificate -server-ca-cert
   server_CA_certificates
   ```

   - The `security key-manager external enable` command replaces the `security key-manager setup` command. You can run the `security key-manager external modify` command to change the external key management configuration. Learn more about `security key-manager external enable` in the ONTAP command reference.
   - In a MetroCluster environment, if you are configuring external key management for the admin SVM, you must repeat the `security key-manager external enable` command on the partner cluster.

   The following command enables external key management for `cluster1` with three external key servers. The first key server is specified using its hostname and port, the second is specified using an IP address and the default port, and the third is specified using an IPv6 address and port:

   ```
   cluster1::> security key-manager external enable -key-servers
   ks1.local:15696,10.0.0.10,[fd20:8b1e:b255:814e:32bd:f35c:832c:5a09]:1234
   -client-cert AdminVserverClientCert -server-ca-certs
   AdminVserverServerCaCert
   ```

2. Verify that all configured KMIP servers are connected:

   ```
   security key-manager external show-status -node node_name -vserver SVM -key
   -server host_name|IP_address:port -key-server-status available|not-
   responding|unknown
   ```

   The `security key-manager external show-status` command replaces the `security key-manager show -status` command. Learn more about `security key-manager external show-status` in the ONTAP command reference.

```
cluster1::> security key-manager external show-status

Node  Vserver  Key Server                                       Status
----  -------  ------------------------------------
-------------
node1
      cluster1
               10.0.0.10:5696                                   available
               fd20:8b1e:b255:814e:32bd:f35c:832c:5a09:1234   available
               ks1.local:15696                                  available
node2
      cluster1
               10.0.0.10:5696                                   available
               fd20:8b1e:b255:814e:32bd:f35c:832c:5a09:1234   available
               ks1.local:15696                                  available

6 entries were displayed.
```

Related information

- Configure clustered external key servers
- security-key-manager-external-enable
- security-key-manager-external-show-status

Enable external key management for hardware-based encryption in ONTAP 9.5 and earlier

You can use one or more KMIP servers to secure the keys the cluster uses to access encrypted data. You can connect up to four KMIP servers to a node. A minimum of two servers is recommended for redundancy and disaster recovery.

About this task

ONTAP configures KMIP server connectivity for all nodes in the cluster.

Before you begin

- The KMIP SSL client and server certificates must have been installed.
- You must be a cluster administrator to perform this task.
- You must configure the MetroCluster environment before you configure an external key manager.
- In a MetroCluster environment, you must install the same KMIP SSL certificate on both clusters.

Steps

1. Configure key manager connectivity for cluster nodes:

   ```
   security key-manager setup
   ```

   The key manager setup starts.

In a MetroCluster environment, you must run this command on both clusters. Learn more about `security key-manager setup` in the ONTAP command reference.

2. Enter the appropriate response at each prompt.
3. Add a KMIP server:

   `security key-manager add -address key_management_server_ipaddress`

   ```
   cluster1::> security key-manager add -address 20.1.1.1
   ```

   In a MetroCluster environment, you must run this command on both clusters.

4. Add an additional KMIP server for redundancy:

   `security key-manager add -address key_management_server_ipaddress`

   ```
   cluster1::> security key-manager add -address 20.1.1.2
   ```

   In a MetroCluster environment, you must run this command on both clusters.

5. Verify that all configured KMIP servers are connected:

   `security key-manager show -status`

   Learn more about the commands described in this procedure in the ONTAP command reference.

   ```
   cluster1::> security key-manager show -status

   Node            Port      Registered Key Manager  Status
   --------------  ----      ----------------------  ---------------
   cluster1-01     5696      20.1.1.1                available
   cluster1-01     5696      20.1.1.2                available
   cluster1-02     5696      20.1.1.1                available
   cluster1-02     5696      20.1.1.2                available
   ```

6. Optionally, convert plain text volumes to encrypted volumes.

   `volume encryption conversion start`

   An external key manager must be fully configured before you convert the volumes. In a MetroCluster environment, an external key manager must be configured on both sites.

Configure clustered external key servers in ONTAP

Beginning with ONTAP 9.11.1, you can configure connectivity to clustered external key management servers on an SVM. With clustered key servers, you can designate primary and secondary key servers on an SVM. When registering or retrieving keys, ONTAP first attempts to access the primary key server before sequentially attempting to access secondary servers until the operation completes successfully.

You can use external key servers for NetApp Storage Encryption (NSE), NetApp Volume Encryption (NVE), and NetApp Aggregate Encryption (NAE) keys. An SVM can support up to four primary external KMIP servers. Each primary server can support up to three secondary key servers.

About this task

- This process only supports key servers that use KMIP. For a list of supported key servers, check the NetApp Interoperability Matrix Tool.

Before you begin

- KMIP key management must be enabled for the SVM.
- All nodes in the cluster must be running ONTAP 9.11.1 or later.
- The order of servers listed in the `-secondary-key-servers` parameter reflects the access order of the external key management (KMIP) servers.

Create a clustered key server

The configuration procedure depends on whether or not you have configured a primary key server.

Add primary and secondary key servers to an SVM

Steps

1. Confirm that no key management has been enabled for the cluster (admin SVM):

   ```
   security key-manager external show -vserver <svm_name>
   ```

   If the SVM already has the maximum of four primary key servers enabled, you must remove one of the existing primary key servers before adding a new one.

2. Enable the primary key manager:

   ```
   security key-manager external enable -vserver <svm_name> -key-servers
   <primary_key_server_ip> -client-cert <client_cert_name> -server-ca-certs
   <server_ca_cert_names>
   ```

   - If you don't specify a port in the `-key-servers` parameter, the default port 5696 is used.

   > If you are running the `security key-manager external enable` command for the admin SVM in a MetroCluster configuration, you must run the command on both clusters. If you are running the command for an individual data SVM, you don't need to run the command on both clusters. NetApp strongly recommends using the same key servers on both clusters.

3. Modify the primary key server to add secondary key servers. The `-secondary-key-servers` parameter accepts a comma-separated list of up to three key servers:

   ```
   security key-manager external modify-server -vserver <svm_name> -key
   -servers <primary_key_server> -secondary-key-servers <list_of_key_servers>
   ```

   - Do not include a port number for secondary key servers in the `-secondary-key-servers` parameter. It uses the same port number as the primary key server.

   > If you are running the `security key-manager external` command for the admin SVM in a MetroCluster configuration, you must run the command on both clusters. If you are running the command for an individual data SVM, you don't need to run the command on both clusters. NetApp strongly recommends using the same key servers on both clusters.

Add secondary key servers to an existing primary key server

Steps

1. Modify the primary key server to add secondary key servers. The `-secondary-key-servers` parameter accepts a comma-separated list of up to three key servers:

   ```
   security key-manager external modify-server -vserver <svm_name> -key
   -servers <primary_key_server> -secondary-key-servers <list_of_key_servers>
   ```

   - Do not include a port number for secondary key servers in the `-secondary-key-servers` parameter. It uses the same port number as the primary key servers.

If you are running the `security key-manager external modify-server` command for the admin SVM in a MetroCluster configuration, you must run the command on both clusters. If you are running the command for an individual data SVM, you don't need to run the command on both clusters. NetApp strongly recommends using the same key servers on both clusters.

For more information about secondary key servers, see Modify secondary key servers.

Modify clustered key servers

You can modify clustered external key servers by adding and removing secondary key servers, changing the access order of secondary key servers, or by changing the designation (primary or secondary) of particular key servers. If you modify clustered external key servers in a MetroCluster configuration, NetApp strongly recommends using the same key servers on both clusters.

Modify secondary key servers

Use the `-secondary-key-servers` parameter of the `security key-manager external modify-server` command to manage secondary key servers . The `-secondary-key-servers` parameter accepts a comma-separated list. The specified order of the secondary key servers in the list determines the access sequence for the secondary key servers. You can modify the access order by running the command `security key-manager external modify-server` with the secondary key servers entered in a different sequence. Do not include a port number for secondary key servers.

If you are running the `security key-manager external modify-server` command for the admin SVM in a MetroCluster configuration, you must run the command on both clusters. If you are running the command for an individual data SVM, you don't need to run the command on both clusters.

To remove a secondary key server, include the key servers you want to keep in the `-secondary-key -servers` parameter and omit the one you want to remove. To remove all secondary key servers, use the argument `-`, signifying none.

Convert primary and secondary key servers

You can use the following steps to change the designation (primary or secondary) of particular key servers.

Convert a primary key server into a secondary key server

Steps

1. Remove the primary key server from the SVM:

   `security key-manager external remove-servers`

   > If you are running the `security key-manager external remove-servers` command for the admin SVM in a MetroCluster configuration, you must run the command on both clusters. If you are running the command for an individual data SVM, you don't need to run the command on both clusters.

2. Perform the Create a clustered key server procedure using the former primary key server as a secondary key server.

Convert a secondary key server into a primary key server

Steps

1. Remove the secondary key server from its existing primary key server:

   `security key-manager external modify-server -secondary-key-servers`

   > - If you are running the `security key-manager external modify-server -secondary-key-servers` command for the admin SVM in a MetroCluster configuration, you must run the command on both clusters. If you are running the command for an individual data SVM, you don't need to run the command on both clusters.
   > - If you convert a secondary key server to a primary key server while removing an existing key server, attempting to add a new key server before completing the removal and conversion can result in the the duplication of keys.

2. Perform the Create a clustered key server procedure using the former secondary key server as the primary key server of the new clustered key server.

Refer to Modify secondary key servers for more information.

Related information

- Learn more about `security key-manager external` in the ONTAP command reference

Create authentication keys in ONTAP 9.6 and later

You can use the `security key-manager key create` command to create the authentication keys for a node and store them on the configured KMIP servers.

About this task

If your security setup requires you to use different keys for data authentication and FIPS 140-2 authentication, you should create a separate key for each. If that's not the case, you can use the same authentication key for FIPS compliance that you use for data access.

ONTAP creates authentication keys for all nodes in the cluster.

- This command is not supported when Onboard Key Manager is enabled. However, two authentication keys are created automatically when Onboard Key Manager is enabled. The keys can be viewed with the following command:

```
security key-manager key query -key-type NSE-AK
```

- You receive a warning if the configured key management servers are already storing more than 128 authentication keys.
- You can use the `security key-manager key delete` command to delete any unused keys. The `security key-manager key delete` command fails if the given key is currently in use by ONTAP. (You must have privileges greater than `admin` to use this command.)

In a MetroCluster environment, before you delete a key, you must make sure that the key is not in use on the partner cluster. You can use the following commands on the partner cluster to check that the key is not in use:

  - `storage encryption disk show -data-key-id <key-id>`
  - `storage encryption disk show -fips-key-id <key-id>`

Before you begin

You must be a cluster administrator to perform this task.

Steps

1. Create the authentication keys for cluster nodes:

```
security key-manager key create -key-tag <passphrase_label> -prompt-for
-key true|false
```

Setting `prompt-for-key=true` causes the system to prompt the cluster administrator for the passphrase to use when authenticating encrypted drives. Otherwise, the system automatically generates a 32-byte passphrase. The `security key-manager key create` command replaces the `security key-manager create-key` command. Learn more about `security key-manager key create` in the ONTAP command reference.

   The following example creates the authentication keys for `cluster1`, automatically generating a 32-byte passphrase:

```
cluster1::> security key-manager key create
Key ID: <id_value>
```

2. Verify that the authentication keys have been created:

```
security key-manager key query -node node
```

> The `security key-manager key query` command replaces the `security key-manager query key` command.
>
> The key ID displayed in the output is an identifier used to refer to the authentication key. It is not the actual authentication key or the data encryption key.

The following example verifies that authentication keys have been created for `cluster1`:

```
cluster1::> security key-manager key query
       Vserver: cluster1
   Key Manager: external
          Node: node1

Key Tag                                  Key Type  Restored
---------------------------------------  --------  --------
node1                                    NSE-AK    yes
    Key ID: <id_value>
node1                                    NSE-AK    yes
    Key ID: <id_value>

       Vserver: cluster1
   Key Manager: external
          Node: node2

Key Tag                                  Key Type  Restored
---------------------------------------  --------  --------
node2                                    NSE-AK    yes
    Key ID: <id_value>
node2                                    NSE-AK    yes
    Key ID: <id_value>
```

Learn more about `security key-manager key query` in the ONTAP command reference.

Related information

- storage encryption disk show

Create authentication keys in ONTAP 9.5 and earlier

You can use the `security key-manager create-key` command to create the authentication keys for a node and store them on the configured KMIP servers.

About this task

If your security setup requires you to use different keys for data authentication and FIPS 140-2 authentication,

you should create a separate key for each. If that is not the case, you can use the same authentication key for FIPS compliance that you use for data access.

ONTAP creates authentication keys for all nodes in the cluster.

- This command is not supported when onboard key management is enabled.
- You receive a warning if the configured key management servers are already storing more than 128 authentication keys.

  You can use the key management server software to delete any unused keys, then run the command again.

Before you begin

You must be a cluster administrator to perform this task.

Steps

1. Create the authentication keys for cluster nodes:

   `security key-manager create-key`

   Learn more about `security key-manager create-key` in the ONTAP command reference.

   > The key ID displayed in the output is an identifier used to refer to the authentication key. It is not the actual authentication key or the data encryption key.

   The following example creates the authentication keys for `cluster1`:

   ```
   cluster1::> security key-manager create-key
      (security key-manager create-key)
   Verifying requirements...

   Node: cluster1-01
   Creating authentication key...
   Authentication key creation successful.
   Key ID: <id_value>

   Node: cluster1-01
   Key manager restore operation initialized.
   Successfully restored key information.

   Node: cluster1-02
   Key manager restore operation initialized.
   Successfully restored key information.
   ```

2. Verify that the authentication keys have been created:

   `security key-manager query`

Learn more about `security key-manager query` in the ONTAP command reference.

The following example verifies that authentication keys have been created for `cluster1`:

```
cluster1::> security key-manager query

  (security key-manager query)

          Node: cluster1-01
   Key Manager: 20.1.1.1
 Server Status: available

Key Tag         Key Type  Restored
--------------  --------  --------
cluster1-01     NSE-AK    yes
       Key ID: <id_value>


          Node: cluster1-02
   Key Manager: 20.1.1.1
 Server Status: available

Key Tag         Key Type  Restored
--------------  --------  --------
cluster1-02     NSE-AK    yes
       Key ID: <id_value>
```

Assign a data authentication key to a FIPS drive or SED with ONTAP external key management

You can use the `storage encryption disk modify` command to assign a data authentication key to a FIPS drive or SED. Cluster nodes use this key to lock or unlock encrypted data on the drive.

About this task

A self-encrypting drive is protected from unauthorized access only if its authentication key ID is set to a non-default value. The manufacturer secure ID (MSID), which has key ID 0x0, is the standard default value for SAS drives. For NVMe drives, the standard default value is a null key, represented as a blank key ID. When you assign the key ID to a self-encrypting drive, the system changes its authentication key ID to a non-default value.

This procedure is not disruptive.

Before you begin

You must be a cluster administrator to perform this task.

Steps

1. Assign a data authentication key to a FIPS drive or SED:

   `storage encryption disk modify -disk disk_ID -data-key-id key_ID`

   Learn more about `storage encryption disk modify` in the ONTAP command reference.

   > You can use the `security key-manager query -key-type NSE-AK` command to view key IDs.

   ```
   cluster1::> storage encryption disk modify -disk 0.10.* -data-key-id
   <id_value>

   Info: Starting modify on 14 disks.
         View the status of the operation by using the
         storage encryption disk show-status command.
   ```

2. Verify that the authentication keys have been assigned:

   `storage encryption disk show`

   Learn more about `storage encryption disk show` in the ONTAP command reference.

   ```
   cluster1::> storage encryption disk show
   Disk    Mode Data Key ID
   -----   ----
   ------------------------------------------------------------------
   0.0.0   data <id_value>
   0.0.1   data <id_value>
   [...]
   ```

Related information

- storage encryption disk show
- storage encryption disk show-status

Configure onboard key management

Enable onboard key management in ONTAP 9.6 and later

You can use the Onboard Key Manager to authenticate cluster nodes to a FIPS drive or SED. The Onboard Key Manager is a built-in tool that serves authentication keys to nodes from the same storage system as your data. The Onboard Key Manager is FIPS-140-2 level 1 compliant.

You can use the Onboard Key Manager to secure the keys that the cluster uses to access encrypted data. You must enable Onboard Key Manager on each cluster that accesses an encrypted volume or a self-encrypting

disk.

About this task

You must run the `security key-manager onboard enable` command each time you add a node to the cluster. In MetroCluster configurations, you must run `security key-manager onboard enable` on the local cluster first, then run `security key-manager onboard sync` on the remote cluster, using the same passphrase on each.

Learn more about `security key-manager onboard enable` and `security key-manager onboard sync` in the ONTAP command reference.

By default, you are not required to enter the key manager passphrase when a node is rebooted. Except in MetroCluster, you can use the `cc-mode-enabled=yes` option to require that users enter the passphrase after a reboot.

When the Onboard Key Manager is enabled in Common Criteria mode (`cc-mode-enabled=yes`), system behavior is changed in the following ways:

- The system monitors for consecutive failed cluster passphrase attempts when operating in Common Criteria mode.

  If NetApp Storage Encryption (NSE) is enabled and you fail to enter the correct cluster passphrase at boot, the system cannot authenticate to its drives and automatically reboots. To correct this, you must enter the correct cluster passphrase at the boot prompt. Once booted, the system allows up to 5 consecutive attempts to correctly enter the cluster passphrase in a 24-hour period for any command that requires the cluster passphrase as a parameter. If the limit is reached (for example, you have failed to correctly enter the cluster passphrase 5 times in a row) then you must either wait for the 24-hour timeout period to elapse, or you must reboot the node, in order to reset the limit.

- System image updates use the NetApp RSA-3072 code signing certificate together with SHA-384 code signed digests to check the image integrity instead of the usual NetApp RSA-2048 code signing certificate and SHA-256 code signed digests.

  The upgrade command verifies that the image contents have not been altered or corrupted by checking various digital signatures. If validation works, the image update goes to the next step. If validation does not work, the image update fails. Learn more about `cluster image` in the ONTAP command reference.

The Onboard Key Manager stores keys in volatile memory. Volatile memory contents are cleared when the system is rebooted or halted. Under normal operating conditions, volatile memory contents will be cleared within 30s when a system is halted.

Before you begin

- If you are using NSE with an external key management (KMIP) server, you must have deleted the external key manager database.

  Transitioning to onboard key management from external key management

- You must be a cluster administrator to perform this task.
- You must configure the MetroCluster environment before you configure the Onboard Key Manager.

Steps

1. Start the key manager setup command:

   `security key-manager onboard enable -cc-mode-enabled yes|no`

   > Set `cc-mode-enabled=yes` to require that users enter the key manager passphrase after a reboot. The `- cc-mode-enabled` option is not supported in MetroCluster configurations. The `security key-manager onboard enable` command replaces the `security key-manager setup` command.

   The following example starts the key manager setup command on cluster1 without requiring that the passphrase be entered after every reboot:

2. Enter a passphrase between 32 and 256 characters, or for “cc-mode”, a passphrase between 64 and 256 characters.

   > If the specified “cc-mode” passphrase is less than 64 characters, there is a five-second delay before the key manager setup operation displays the passphrase prompt again.

3. At the passphrase confirmation prompt, reenter the passphrase.
4. Verify that the system creates the authentication keys:

   `security key-manager key query -node node`

   > The `security key-manager key query` command replaces the `security key-manager query key` command.

   Learn more about `security key-manager key query` in the ONTAP command reference.

After you finish

Copy the passphrase to a secure location outside the storage system for future use.

The system automatically backs up key management information to the replicated database (RDB) for the cluster. You should also back up this information manually for disaster recovery.

Related information

- cluster image commands
- security key-manager external enable
- security key-manager key query
- security key-manager onboard enable
- Transitioning to onboard key management from external key management

Enable onboard key management in ONTAP 9.5 and earlier

You can use the Onboard Key Manager to authenticate cluster nodes to a FIPS drive or SED. The Onboard Key Manager is a built-in tool that serves authentication keys to nodes from the same storage system as your data. The Onboard Key Manager is FIPS-140-2 level 1 compliant.

You can use the Onboard Key Manager to secure the keys that the cluster uses to access encrypted data. Enable Onboard Key Manager on each cluster that accesses encrypted volumes or self-encrypting disks.

About this task

You must run the `security key-manager setup` command each time you add a node to the cluster.

If you have a MetroCluster configuration, review these guidelines:

- In ONTAP 9.5, you must run `security key-manager setup` on the local cluster and `security key-manager setup -sync-metrocluster-config yes` on the remote cluster, using the same passphrase on each.
- Prior to ONTAP 9.5, you must run `security key-manager setup` on the local cluster, wait approximately 20 seconds, and then run `security key-manager setup` on the remote cluster, using the same passphrase on each.

By default, you are not required to enter the key manager passphrase when a node is rebooted. Beginning with ONTAP 9.4, you can use the `-enable-cc-mode yes` option to require that users enter the passphrase after a reboot.

For NVE, if you set `-enable-cc-mode yes`, volumes you create with the `volume create` and `volume move start` commands are automatically encrypted. For `volume create`, you need not specify `-encrypt true`. For `volume move start`, you need not specify `-encrypt-destination true`.

After a failed passphrase attempt, you must reboot the node again.

Before you begin

- If you are using NSE with an external key management (KMIP) server, delete the external key manager database.

  Transitioning to onboard key management from external key management

- You must be a cluster administrator to perform this task.
- Configure the MetroCluster environment before you configure the Onboard Key Manager.

Steps

1. Start the key manager setup:

   ```
   security key-manager setup -enable-cc-mode yes|no
   ```

   Beginning with ONTAP 9.4, you can use the `-enable-cc-mode yes` option to require that users enter the key manager passphrase after a reboot. For NVE, if you set `-enable-cc-mode yes`, volumes you create with the `volume create` and `volume move start` commands are automatically encrypted.

   The following example starts setting up the key manager on cluster1 without requiring that the passphrase be entered after every reboot:

```
cluster1::> security key-manager setup
Welcome to the key manager setup wizard, which will lead you through
the steps to add boot information.

...

Would you like to use onboard key-management? {yes, no} [yes]:
Enter the cluster-wide passphrase:    <32..256 ASCII characters long
text>
Reenter the cluster-wide passphrase:    <32..256 ASCII characters long
text>
```

2. Enter `yes` at the prompt to configure onboard key management.
3. At the passphrase prompt, enter a passphrase between 32 and 256 characters, or for “cc-mode”, a passphrase between 64 and 256 characters.

> If the specified “cc-mode” passphrase is less than 64 characters, there is a five-second delay before the key manager setup operation displays the passphrase prompt again.

4. At the passphrase confirmation prompt, reenter the passphrase.
5. Verify that keys are configured for all nodes:

   `security key-manager show-key-store`

   Learn more about `security key-manager show-key-store` in the ONTAP command reference.

```
cluster1::> security key-manager show-key-store

Node: node1
Key Store: onboard
Key ID                                                               Used By
-----------------------------------------------------------------------
--------
<id_value> NSE-AK
<id_value> NSE-AK

Node: node2
Key Store: onboard
Key ID                                                               Used By
-----------------------------------------------------------------------
--------
<id_value> NSE-AK
<id_value> NSE-AK
```

After you finish

ONTAP automatically backs up key management information to the replicated database (RDB) for the cluster.

After you configure the Onboard Key Manager passphrase, manually back up the information to a secure location outside the storage system. See Back up onboard key management information manually.

Related information

- Back up onboard key management information manually
- security key-manager setup
- security key-manager show-key-store
- Transitioning to onboard key management from external key management

Assign a data authentication key to a FIPS drive or SED with ONTAP onboard key management

You can use the `storage encryption disk modify` command to assign a data authentication key to a FIPS drive or SED. Cluster nodes use this key to access data on the drive.

About this task

A self-encrypting drive is protected from unauthorized access only if its authentication key ID is set to a non-default value. The manufacturer secure ID (MSID), which has key ID 0x0, is the standard default value for SAS drives. For NVMe drives, the standard default value is a null key, represented as a blank key ID. When you assign the key ID to a self-encrypting drive, the system changes its authentication key ID to a non-default value.

Before you begin

You must be a cluster administrator to perform this task.

Steps

1. Assign a data authentication key to a FIPS drive or SED:

   `storage encryption disk modify -disk` *`disk_ID`* `-data-key-id` *`key_ID`*

   Learn more about `storage encryption disk modify` in the ONTAP command reference.

   > You can use the `security key-manager key query -key-type NSE-AK` command to view key IDs.

   ```
   cluster1::> storage encryption disk modify -disk 0.10.* -data-key-id
   <id_value>

   Info: Starting modify on 14 disks.
         View the status of the operation by using the
         storage encryption disk show-status command.
   ```

   Learn more about `security key-manager key query` in the ONTAP command reference.

2. Verify that the authentication keys have been assigned:

   `storage encryption disk show`

   Learn more about `storage encryption disk show` in the ONTAP command reference.

```
cluster1::> storage encryption disk show
Disk    Mode Data Key ID
-----   ----
------------------------------------------------------------------
0.0.0   data <id_value>
0.0.1   data <id_value>
[...]
```

Related information

- storage encryption disk show
- storage encryption disk show-status

Assign a FIPS 140-2 authentication key to an ONTAP FIPS drive

You can use the `storage encryption disk modify` command with the `-fips-key-id` option to assign a FIPS 140-2 authentication key to a FIPS drive. Cluster nodes use this key for drive operations other than data access, such as preventing denial-of-service attacks on the drive.

About this task

Your security setup may require you to use different keys for data authentication and FIPS 140-2 authentication. If that is not the case, you can use the same authentication key for FIPS compliance that you use for data access.

This procedure is not disruptive.

Before you begin

The drive firmware must support FIPS 140-2 compliance. The NetApp Interoperability Matrix Tool contains information about supported drive firmware versions.

Steps

1. You must first ensure you have assigned a data authentication key. This can be done with using an external key manager or an onboard key manager. Verify the key is assigned with the command `storage encryption disk show`.
2. Assign a FIPS 140-2 authentication key to SEDs:

   `storage encryption disk modify -disk` *`disk_id`* `-fips-key-id` *`fips_authentication_key_id`*

   You can use the `security key-manager query` command to view key IDs.

```
cluster1::> storage encryption disk modify -disk 2.10.* -fips-key-id
<id_value>

Info: Starting modify on 14 disks.
      View the status of the operation by using the
      storage encryption disk show-status command.
```

3. Verify that the authentication key has been assigned:

   `storage encryption disk show -fips`

   Learn more about `storage encryption disk show` in the ONTAP command reference.

```
cluster1::> storage encryption disk show -fips
Disk    Mode FIPS-Compliance Key ID
------  ----
--------------------------------------------------------------------
2.10.0  full <id_value>
2.10.1  full <id_value>
[...]
```

Related information

- storage encryption disk modify
- storage encryption disk show
- storage encryption disk show-status

Enable cluster-wide FIPS-compliant mode for KMIP server connections in ONTAP

You can use the `security config modify` command with the `-is-fips-enabled` option to enable cluster-wide FIPS-compliant mode for data in flight. Doing so forces the cluster to use OpenSSL in FIPS mode when connecting to KMIP servers.

About this task

When you enable cluster-wide FIPS-compliant mode, the cluster will automatically use only TLS1.2 and FIPS-validated cipher suites. Cluster-wide FIPS-compliant mode is disabled by default.

You must reboot cluster nodes manually after modifying the cluster-wide security configuration.

Before you begin

- The storage controller must be configured in FIPS-compliant mode.
- All KMIP servers must support TLSv1.2. The system requires TLSv1.2 to complete the connection to the KMIP server when cluster-wide FIPS-compliant mode is enabled.

Steps

1. Set the privilege level to advanced:

   ```
   set -privilege advanced
   ```

2. Verify that TLSv1.2 is supported:

   ```
   security config show -supported-protocols
   ```

   Learn more about `security config show` in the ONTAP command reference.

   ```
   cluster1::> security config show
             Cluster                                                 Cluster
   Security
   Interface FIPS Mode  Supported Protocols     Supported Ciphers Config
   Ready
   --------- ---------- ----------------------- -----------------
   ----------------
   SSL       false      TLSv1.2, TLSv1.1, TLSv1 ALL:!LOW:         yes
                                                !aNULL:!EXP:
                                                !eNULL
   ```

3. Enable cluster-wide FIPS-compliant mode:

   ```
   security config modify -is-fips-enabled true -interface SSL
   ```

   Learn more about `security config modify` in the ONTAP command reference.

4. Reboot cluster nodes manually.
5. Verify that cluster-wide FIPS-compliant mode is enabled:

   ```
   security config show
   ```

   ```
   cluster1::> security config show
             Cluster                                                 Cluster
   Security
   Interface FIPS Mode  Supported Protocols     Supported Ciphers Config
   Ready
   --------- ---------- ----------------------- -----------------
   ----------------
   SSL       true       TLSv1.2, TLSv1.1        ALL:!LOW:         yes
                                                !aNULL:!EXP:
                                                !eNULL:!RC4
   ```

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