Configure NetApp Volume Encryption

ONTAP 9

NetApp
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Configure NetApp Volume Encryption overview

NetApp Volume Encryption (NVE) is a software-based technology for encrypting data at rest one volume at a time. An encryption key accessible only to the storage system ensures that volume data cannot be read if the underlying device is repurposed, returned, misplaced, or stolen.

Understanding NVE

Both data, including Snapshot copies, and metadata are encrypted. Access to the data is given by a unique XTS-AES-256 key, one per volume. An external key management server or Onboard Key Manager serves keys to nodes:

- 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 keys to nodes from the same storage system as your data.

Beginning with ONTAP 9.7, aggregate and volume encryption is enabled by default if you have a volume encryption (VE) license and use an onboard or external key manager. Whenever an external or onboard key manager is configured there is a change in how the encryption of data at rest is configured for brand new aggregates and brand new volumes. Brand new aggregates will have NetApp Aggregate Encryption (NAE) enabled by default. Brand new volumes that are not part of an NAE aggregate will have NetApp Volume Encryption (NVE) enabled by default. If a data storage virtual machine (SVM) is configured with its own key-manager using multi-tenant key management, then the volume created for that SVM is automatically configured with NVE.

You can enable encryption on a new or existing volume. NVE supports the full range of storage efficiency features, including deduplication and compression.

If you are using SnapLock, you can enable encryption only on new, empty SnapLock volumes. You cannot enable encryption on an existing SnapLock volume.

You can use NVE on any type of aggregate (HDD, SSD, hybrid, array LUN), with any RAID type, and in any supported ONTAP implementation, including ONTAP Select. You can also use NVE with hardware-based encryption to “double encrypt” data on self-encrypting drives.

AFF A220, AFF A800, FAS2720, FAS2750, and later systems store core dumps on their boot device. When NVE is enabled on these systems, the core dump is also encrypted.

Aggregate-level encryption

Ordinarily, every encrypted volume is assigned a unique key. When the volume is deleted, the key is deleted with it.

Beginning with ONTAP 9.6, you can use *NetApp Aggregate Encryption (NAE)* to assign keys to the containing aggregate for the volumes to be encrypted. When an encrypted volume is deleted, the keys for the aggregate

are preserved. The keys are deleted the entire aggregate is deleted.

You must use aggregate-level encryption if you plan to perform inline or background aggregate-level deduplication. Aggregate-level deduplication is otherwise not supported by NVE.

Beginning with ONTAP 9.7, aggregate and volume encryption is enabled by default if you have a volume encryption (VE) license and use an onboard or external key manager.

NVE and NAE volumes can coexist on the same aggregate. Volumes encrypted under aggregate-level encryption are NAE volumes by default. You can override the default when you encrypt the volume.

You can use the `volume move` command to convert an NVE volume to an NAE volume, and vice versa. You can replicate an NAE volume to an NVE volume.

When to use external key management servers

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

- Your encryption key management solution must comply with Federal Information Processing Standards (FIPS) 140-2 or the OASIS KMIP standard.
- 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.

Scope of external key management

The scope of external key management determines whether key management servers secure all the SVMs in the cluster or selected SVMs only:

- You can use a *cluster scope* to configure external key management for all the SVMs in the cluster. The cluster administrator has access to every key stored on the servers.
- Beginning with ONTAP 9.6, you can use an *SVM scope* to configure external key management for a named SVM in the cluster. That's best for multitenant environments in which each tenant uses a different SVM (or set of SVMs) to serve data. Only the SVM administrator for a given tenant has access to the keys for that tenant.
- Beginning with ONTAP 9.10.1, you can use Azure Key Vault and Google Cloud KMS to protect NVE keys only for data vservers.

You can use both scopes in the same cluster. If key management servers have been configured for an SVM, ONTAP uses only those servers to secure keys. Otherwise, ONTAP secures keys with the key management servers configured for the cluster.

A list of validated external key managers is available in the NetApp Interoperability Matrix Tool (IMT). You can find this list by entering the term "key managers" into the IMT's search feature.

Support details

The following table shows NVE support details:

Resource or feature	Support details

Platforms	AES-NI offload capability required. See the Hardware Universe (HWU) to verify that NVE and NAE are supported for your platform.

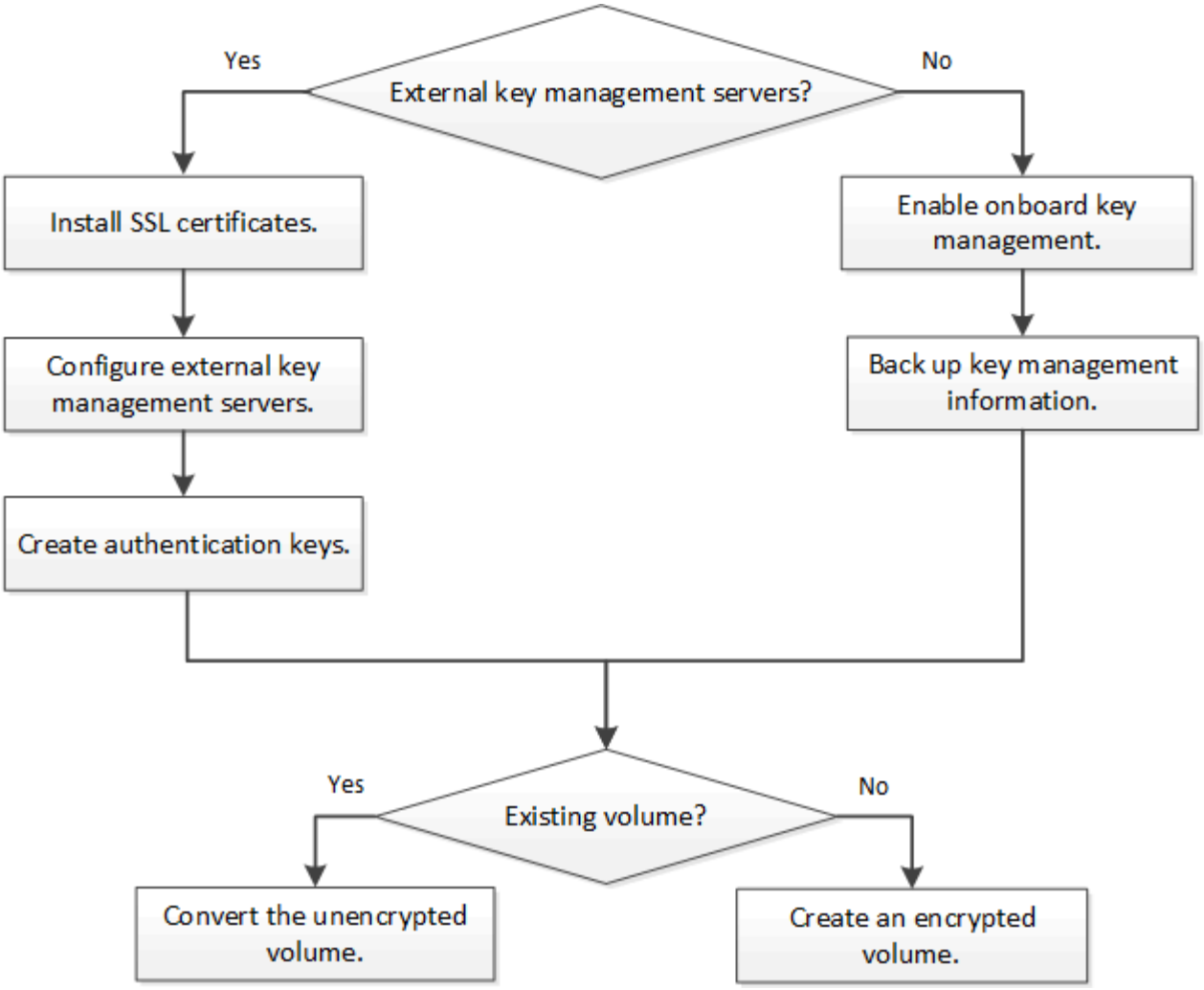
Encryption	Beginning with ONTAP 9.7, newly created aggregates and volumes are encrypted by default when you add a volume encryption (VE) license and have an onboard or external key manager configured. If you need to create an unencrypted aggregate, use the following command:
	
	`storage aggregate create -encrypt-with-aggr-key false`
	
	If you need to create a plain text volume, use the following command:
	
	`volume create -encrypt false`
	
	Encryption is not enabled by default when:
	
	• VE license is not installed.
	• Key manager is not configured.
	• Platform or software does not support encryption.
	• Hardware encryption is enabled.

ONTAP	All ONTAP implementations. Support for ONTAP Cloud is available in ONTAP 9.5 and later.
Devices	HDD, SSD, hybrid, array LUN.
RAID	RAID0, RAID4, RAID-DP, RAID-TEC.
Volumes	Data volumes and existing root volumes. You cannot encrypt data on an SVM root volume or MetroCluster metadata volumes.
Aggregate-level encryption	Beginning with ONTAP 9.6, NVE supports aggregate-level encryption (NAE): • You must use aggregate-level encryption if you plan to perform inline or background aggregate-level deduplication. • You cannot rekey an aggregate-level encryption volume. • Secure-purge is not supported on aggregate-level encryption volumes. • In addition to data volumes, NAE supports encryption of SVM root volumes and the MetroCluster metadata volume. NAE does not support encryption of the root volume.
SVM scope	Beginning with ONTAP 9.6, NVE supports SVM scope for external key management only, not for Onboard Key Manager. MetroCluster is supported beginning with ONTAP 9.8.

Storage efficiency	Deduplication, compression, compaction, FlexClone. Clones use the same key as the parent, even after splitting the clone from the parent. You are warned to rekey the split clone.
Replication	• For volume replication, the destination volume must have been enabled for encryption. Encryption can be configured for the source and unconfigured for the destination, and vice versa. • For SVM replication, the destination volume is automatically encrypted, unless the destination does not contain a node that supports volume encryption, in which case replication succeeds, but the destination volume is not encrypted. • For MetroCluster configurations, each cluster pulls external key management keys from its configured key servers. OKM keys are replicated to the partner site by the configuration replication service.
Compliance	Beginning with ONTAP 9.2, SnapLock is supported in both Compliance and Enterprise modes, for new volumes only. You cannot enable encryption on an existing SnapLock volume.
FlexGroups	Beginning with ONTAP 9.2, FlexGroups are supported. Destination aggregates must be of the same type as source aggregates, either volume-level or aggregate-level. Beginning with ONTAP 9.5, in-place rekey of FlexGroup volumes is supported.
7-Mode transition	Beginning with 7-Mode Transition Tool 3.3, you can use the 7-Mode Transition Tool CLI to perform copy-based transition to NVE-enabled destination volumes on the clustered system.

NetApp Volume Encryption workflow

You must configure key management services before you can enable volume encryption. You can enable encryption on a new volume or on an existing volume.



You must install the VE license and configure key management services before you can encrypt data with NVE. Before installing the license, you should determine whether your ONTAP version supports NVE.

Configure NVE

Determine whether your cluster version supports NVE

You should determine whether your cluster version supports NVE before you install the license. You can use the `version` command to determine the cluster version.

About this task

The cluster version is the lowest version of ONTAP running on any node in the cluster.

Step

1. Determine whether your cluster version supports NVE:

   ```
   version -v
   ```

   NVE is not supported if the command output displays the text “1Ono-DARE” (for “no Data At Rest Encryption”), or if you are using a platform that is not listed in Support details.

   The following command determines whether NVE is supported on `cluster1`.

```
cluster1::> version -v
NetApp Release 9.1.0: Tue May 10 19:30:23 UTC 2016 <1Ono-DARE>
```

The text “1Ono-DARE” in the command output indicates that NVE is not supported on your cluster version.

Install the license

A VE license entitles you to use the feature on all nodes in the cluster. You must install the license before you can encrypt data with NVE.

What you’ll need

You must be a cluster administrator to perform this task.

About this task

You should have received the VE license key from your sales representative.

Steps

1. Install the VE license for a node:

   `system license add -license-code license_key`

   The following command installs the license with the key `AAAAAAAAAAAAAAAAAAAAAAAAAAAA`.

   ```
   cluster1::> system license add -license-code
   AAAAAAAAAAAAAAAAAAAAAAAAAAAA
   ```

2. Verify that the license is installed by displaying all the licenses on the cluster:

   `system license show`

   For complete command syntax, see the man page for the command.

   The following command displays all the licenses on `cluster1`:

   ```
   cluster1::> system license show
   ```

   The VE license package name is “VE”.

Configure external key management

Configure external key management overview

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).

> For ONTAP 9.1 and earlier versions, node management LIFs must be assigned to ports that are configured with the node management role before you can use the external key manager.

NetApp Volume Encryption (NVE) supports Onboard Key Manager in ONTAP 9.1 and later. Beginning in ONTAP 9.3, NVE supports external key management (KMIP) and Onboard Key Manager. Beginning in ONTAP 9.10.1, you can use Azure Key Vault or Google Cloud Key Manager Service to protect your NVE keys. Beginning in ONTAP 9.11.1, you can configure multiple external key managers in a cluster. See Configure clustered key servers.

Install SSL certificates on the 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.

What you'll need

- 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.

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

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.

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
   ```

Enable external key management in ONTAP 9.6 and later (NVE)

You can use one or more KMIP servers to secure the keys the cluster uses to access encrypted data. Beginning with ONTAP 9.6, you can use one or more KMIP servers to secure the keys a given SVM uses to access encrypted data.

Beginning in 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 or SVM administrator to perform this task.
- If you want to enable external key management for a MetroCluster environment, MetroCluster must be fully configured before enabling external key management.

About this task

You can connect up to four KMIP servers to a cluster or SVM. A minimum of two servers is recommended for redundancy and disaster recovery.

The scope of external key management determines whether key management servers secure all the SVMs in the cluster or selected SVMs only:

- You can use a *cluster scope* to configure external key management for all the SVMs in the cluster. The cluster administrator has access to every key stored on the servers.
- Beginning with ONTAP 9.6, you can use an *SVM scope* to configure external key management for a data SVM in the cluster. That's best for multitenant environments in which each tenant uses a different SVM (or set of SVMs) to serve data. Only the SVM administrator for a given tenant has access to the keys for that tenant.
- For multitenant environments, install a license for *MT_EK_MGMT* by using the following command:

  ```
  system license add -license-code <MT_EK_MGMT license code>
  ```

  For complete command syntax, see the man page for the command.

You can use both scopes in the same cluster. If key management servers have been configured for an SVM, ONTAP uses only those servers to secure keys. Otherwise, ONTAP secures keys with the key management servers configured for the cluster.

You can configure onboard key management at the cluster scope and external key management at the SVM scope. You can use the `security key-manager key migrate` command to migrate keys from onboard key management at the cluster scope to external key managers at the SVM scope.

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. If you run the command at the cluster login prompt, *`admin_SVM`* defaults to the admin SVM of the current cluster. You must be the cluster administrator to configure cluster scope. You can run the `security key-manager external modify` command to change the external key management configuration.

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:

```
clusterl::> security key-manager external enable -vserver cluster1 -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. Configure a key manager an SVM:

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

   If you run the command at the SVM login prompt, `SVM` defaults to the current SVM. You must be a cluster or SVM administrator to configure SVM scope. You can run the `security key-manager external modify` command to change the external key management configuration.

   The following command enables external key management for `svm1` with a single key server listening on the default port 5696:

   ```
   svm1l::> security key-manager external enable -vserver svm1 -key-servers
   keyserver.svm1.com -client-cert SVM1ClientCert -server-ca-certs
   SVM1ServerCaCert
   ```

3. Repeat the last step for any additional SVMs.

   You can also use the `security key-manager external add-servers` command to configure additional SVMs. The `security key-manager external add-servers` command replaces the `security key-manager add` command. For complete command syntax, see the man page.

4. Verify that all configured KMIP servers are connected:

   `security key-manager external show-status -node node_name`

The `security key-manager external show-status` command replaces the `security key-manager show -status` command. For complete command syntax, see the man page.

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

Node  Vserver  Key Server                                       Status
----  -------  ---------------------------------------
-------------
node1
      svm1
               keyserver.svm1.com:5696                         available
      cluster1
               10.0.0.10:5696                                  available
               fd20:8b1e:b255:814e:32bd:f35c:832c:5a09:1234    available
               ks1.local:15696                                 available
node2
      svm1
               keyserver.svm1.com:5696                         available
      cluster1
               10.0.0.10:5696                                  available
               fd20:8b1e:b255:814e:32bd:f35c:832c:5a09:1234    available
               ks1.local:15696                                 available

8 entries were displayed.
```

Enable external key management 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.

What you'll need

- 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.

About this task

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

Steps

1. Configure key manager connectivity for cluster nodes:

   `security key-manager setup`

   The key manager setup starts.

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
   ```

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
   ```

5. Verify that all configured KMIP servers are connected:

   `security key-manager show -status`

   For complete command syntax, see the man page.

   ```
   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
   ```

Manage keys with Azure Key Vault or Google Cloud KMS

Beginning in ONTAP 9.10.1, you can use Azure Key Vault (AKV) and Google Cloud Platform's Key Management Service (Cloud KMS) to protect your ONTAP encryption keys in a Azure- or Google Cloud Platform-deployed application.

AKV and Cloud KMS can be used to protect NetApp Volume Encryption (NVE) keys only for data vservers.

Key management with AKV or Cloud KMS can be enabled with the CLI or the ONTAP REST API.

When using AKV or Cloud KMS, be aware that by default a data vserver LIF is used to communicate with the cloud key management endpoint. A node management network is used to communicate with the cloud provider's authentication services (login.microsoftonline.com for Azure; oauth2.googleapis.com for Cloud KMS). If the cluster network is not configured correctly, the cluster will not properly utilize the key management service.

Prerequisites

- The ONTAP cluster's nodes must support NVE

- Volume Encryption (VE) license installed
- Multi-tenant Encryption Key Management (MTEKM) license installed
- You must be a cluster or vserver administrator

Limitations

- AKV and Cloud KMS are not available for NSE and NAE. External KMIPs can be used instead
- AKV and Cloud KMS are not available for MetroCluster configurations.
- AKV and Cloud KMS can only be configured on a data vserver

Enable external key management with the CLI

Enabling external key management depends on the specific key manager you use. If you are enabling AKV in a Cloud Volumes ONTAP, note that there is a separate procedure. Choose the tab of the key manager and environment that suits your needs:

Azure for ONTAP

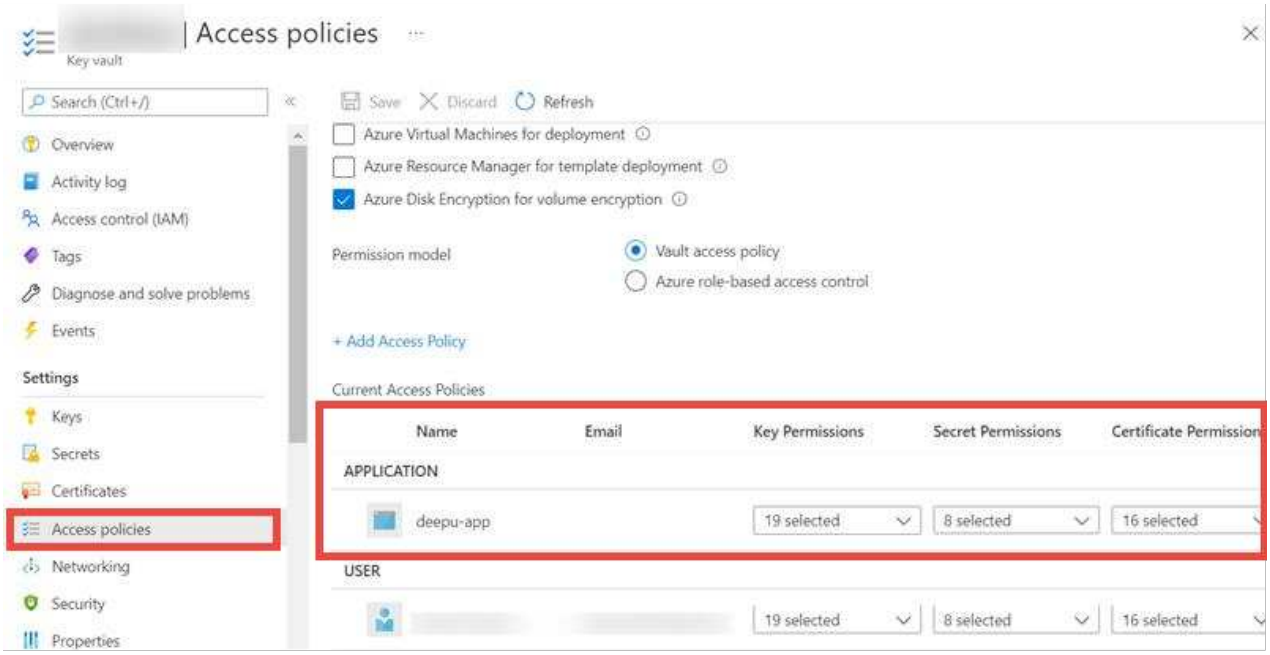
Enable Azure Key Vault for ONTAP

1. Before you begin, you need to obtain the appropriate authentication credentials from your Azure account, either a client secret or certificate.
   You must also ensure all nodes in the cluster are healthy. You can check this with the command `cluster show`.
2. Set privileged level to advanced
   `set -priv advanced`
3. Enable AKV on the SVM
   `security key-manager external azure enable -client-id client_id -tenant-id tenant_id -name -key-id key_id -authentication-method {certificate|client-secret}`
   When prompted, enter either the client certificate or client secret from your Azure account.
4. Verify AKV is enabled correctly:
   `security key-manager external azure show vserver vserver_name`
   If the service reachability is not OK, establish the connectivity to the AKV key management service via data vserver LIF.

Azure for Cloud Volumes ONTAP

Enable Azure Key Vault for Cloud Volumes ONTAP

1. Before you begin, you need to obtain the appropriate authentication credentials from your Azure account, either a client secret or certificate.
   You must also ensure all nodes in the cluster are healthy. You can check this with the command `cluster show`.
2. Set privileged level to advanced
   `set -priv advanced`
3. Enable AKV on the SVM
   `security key-manager external azure enable -client-id client_id -tenant-id tenant_id -name -key-id key_id -authentication-method {certificate|client-secret}`
   When prompted, enter either the client certificate or client secret from your Azure account.
4. Set up DNS for the data SVM:
   `dns create -domains domain_name -name-servers server_address -vserver vserver_name`
5. Go to the Azure portal for the subscription that contains your key vault. Select the **Access policies** menu. Provide the application the key permissions, secret permissions, and certificate permissions and then save.



6. Verify AKV is enabled correctly:
   `security key-manager external azure show vserver` *`vserver_name`*
   If the service reachability is not OK, establish the connectivity to the AKV key management service via data vserver LIF.

Google Cloud for ONTAP

Enable Cloud KMS with the CLI for ONTAP

1. Before you begin, you need to obtain the private key for the Google Cloud KMS account key file in a JSON format. This can be found in your GCP account.
   You must also ensure all nodes in the cluster are healthy. You can check this with the command `cluster show`.
2. Set privileged level to advanced
   `set -priv advanced`
3. Enable Cloud KMS on the SVM
   `security key-manager external gcp enable -vserver` *`data_svm_name`* `-project-id` *`project_id`*`-key-ring-name` *`key_ring_name`* `-key-ring-location` *`key_ring_location`* `-key-name` *`key_name`*
   When prompted, enter the contents of the JSON file with the Service Account Private Key
4. Verify that Cloud KMS is configured with the correct parameters:
   `security key-manager external gcp show vserver` *`vserver_name`*
   The status of `kms_wrapped_key_status` will be "`UNKNOWN`" if no encrypted volumes have been created.
   If the service reachability is not OK, establish the connectivity to the GCP key management service via data vserver LIF.

If one or more encrypted volumes is already configured for a data vserver and the corresponding NVE keys are managed by the admin vserver onboard key manager, those keys should be migrated to the external key management service. To do this with the CLI, run:
`security key-manager key migrate -from-Vserver` *`admin_vserver`* `-to-Vserver` *`data_vserver`*
New encrypted volumes cannot be created for the tenant's data vserver until all NVE keys of the data vserver

are successfully migrated.

Enable onboard key management in ONTAP 9.6 and later (NVE)

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.

What you'll need

- You must be a cluster administrator to perform this task.
- You must configure the MetroCluster environment before you configure an external key manager.

About this task

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

If you have a MetroCluster configuration 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.

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

For NVE, if you set `cc-mode-enabled=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`.

When configuring ONTAP data at rest encryption, to meet the requirements for Commercial Solutions for Classified (CSfC) you must use NSE with NVE and ensure the Onboard Key Manager is enabled in Common Criteria mode. Refer to the CSfC Solution Brief for more information on CSfC.

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 you fail to enter the correct cluster passphrase at boot, encrypted volumes are not mounted. To correct this, you must reboot the node and enter the correct cluster passphrase. 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. The image update process proceeds to the next step if validation succeeds; otherwise, the image update fails. See the “cluster image” man page for information concerning system updates.

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.

Steps

1. Start the key manager setup:

   ```
   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. For NVE, if you set `cc-mode-enabled=yes`, volumes you create with the `volume create` and `volume move start` commands are automatically encrypted. 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:

   ```
   cluster1::> security key-manager onboard enable

   Enter the cluster-wide passphrase for onboard key management in Vserver
   "cluster1"::    <32..256 ASCII characters long text>
   Reenter the cluster-wide passphrase:    <32..256 ASCII characters long
   text>
   ```

2. 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.

3. At the passphrase confirmation prompt, reenter the passphrase.
4. Verify that the authentication keys have been created:

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

   The `security key-manager key query` command replaces the `security key-manager query key` command. For complete command syntax, see the man page.

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

```
cluster1::> security key-manager key query -key-type NSE-AK
       Vserver: cluster1
   Key Manager: onboard
          Node: node1

Key Tag                                  Key Type  Restored
---------------------------------------  --------  --------
node1                                    NSE-AK    yes
    Key ID:
000000000000000002000000000001000c11b3863f78c2273343d7ec5a67762e00000000
00000000
node1                                    NSE-AK    yes
    Key ID:
000000000000000002000000000001006f4e2513353a674305872a4c9f3bf79700000000
00000000

       Vserver: svm1
   Key Manager: onboard
          Node: node1
    Key Server: keyserver.svm1.com:5965

Key Tag                                  Key Type  Restored
---------------------------------------  --------  --------
eb9f8311-e8d8-487e-9663-7642d7788a75     VEK       yes
    Key ID:
000000000000000002000000000004001cb18336f7c8223743d3e75c6a7726e00000000
00000000
9d09cbbf-0da9-4696-87a1-8e083d8261bb     VEK       yes
    Key ID:
000000000000000002000000000004064f2e1533356a470385274a9c3ffb97700000000
```

```
00000000

       Vserver: cluster1
   Key Manager: onboard
          Node: node2

Key Tag                                  Key Type  Restored
---------------------------------------  --------  --------
node1                                    NSE-AK    yes
    Key ID:
000000000000000002000000000001000c11b3863f78c2273343d7ec5a67762e00000000
00000000
node1                                    NSE-AK    yes
    Key ID:
000000000000000002000000000001006f4e2513353a674305872a4c9f3bf79700000000
00000000

       Vserver: svm1
   Key Manager: onboard
          Node: node2
    Key Server: keyserver.svm1.com:5965

Key Tag                                  Key Type  Restored
---------------------------------------  --------  --------
eb9f8311-e8d8-487e-9663-7642d7788a75     VEK       yes
    Key ID:
000000000000000002000000000004001cb18336f7c8223743d3e75c6a7726e00000000
00000000
9d09cbbf-0da9-4696-87a1-8e083d8261bb     VEK       yes
    Key ID:
000000000000000002000000000004064f2e1533356a470385274a9c3ffb97700000000
00000000
```

After you finish

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

All key management information is automatically backed up to the replicated database (RDB) for the cluster. You should also back up the information manually for use in case of a disaster.

Enable onboard key management in ONTAP 9.5 and earlier (NVE)

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.

What you'll need

- 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.

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.

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 key show`

   For the complete command syntax, see the man page.

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

Node: node1
Key Store: onboard
Key ID                                                           Used By
-----------------------------------------------------------------
--------
000000000000000020000000000010059851742AF2703FC91369B7DB47C4722 NSE-AK
000000000000000020000000000001008C07CC0AF1EF49E0105300EFC83004BF NSE-AK

Node: node2
Key Store: onboard
Key ID                                                           Used By
-----------------------------------------------------------------
--------
000000000000000020000000000010059851742AF2703FC91369B7DB47C4722 NSE-AK
000000000000000020000000000001008C07CC0AF1EF49E0105300EFC83004BF NSE-AK
```

After you finish

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

All key management information is automatically backed up to the replicated database (RDB) for the cluster.

Whenever you configure the Onboard Key Manager passphrase, you should also back up the information manually to a secure location outside the storage system for use in case of a disaster. See Back up onboard key management information manually.

Enable onboard key management in newly added nodes

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.

> For ONTAP 9.5 and earlier, you must run the `security key-manager setup` command each time you add a node to the cluster.
>
> For ONTAP 9.6 and later, you must run the `security key-manager sync` command each time you add a node to the cluster.
>
> If you add a node to a cluster that has onboard key management configured, you will run this command to refresh the missing keys.

If you have a MetroCluster configuration, review these guidelines:

- Beginning with ONTAP 9.6, 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.
- 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.

Encrypt volume data with NVE

Encrypt volume data with NVE overview

Beginning with ONTAP 9.7, aggregate and volume encryption is enabled by default when you have the VE license and onboard or external key management. For ONTAP 9.6 and earlier, you can enable encryption on a new volume or on an existing volume. You must have installed the VE license and enabled key management before you can enable volume encryption. NVE is FIPS-140-2 level 1 compliant.

Enable aggregate-level encryption with VE license

Beginning with ONTAP 9.7, newly created aggregates and volumes are encrypted by default when you have the VE license and onboard or external key management. Beginning with ONTAP 9.6, you can use aggregate-level encryption to assign keys to the containing aggregate for the volumes to be encrypted. Volumes you create in the aggregate are encrypted by default. You can override the default when you encrypt the volume.

What you'll need

You must be a cluster administrator to perform this task.

About this task

You must use aggregate-level encryption if you plan to perform inline or background aggregate-level deduplication. Aggregate-level deduplication is otherwise not supported by NVE.

An aggregate enabled for aggregate-level encryption is called an *NAE aggregate* (for NetApp Aggregate Encryption). Plain text volumes are not supported in NAE aggregates.

Steps

1. Enable or disable aggregate-level encryption:

To…	Use this command…
Create an NAE aggregate with ONTAP 9.7 or later	`storage aggregate create -aggregate aggregate_name -node node_name`
Create an NAE aggregate with ONTAP 9.6	`storage aggregate create -aggregate aggregate_name -node node_name -encrypt-with -aggr-key true`
Convert a non-NAE aggregate to an NAE aggregate	`storage aggregate modify -aggregate aggregate_name -node node_name -encrypt-with -aggr-key true`
Convert an NAE aggregate to a non-NAE aggregate	`storage aggregate modify -aggregate aggregate_name -node node_name -encrypt-with -aggr-key false`

For complete command syntax, see the man pages.

The following command enables aggregate-level encryption on `aggr1`:

- ONTAP 9.7 or later:

```
cluster1::> storage aggregate create -aggregate aggr1
```

- ONTAP 9.6 or earlier:

```
cluster1::> storage aggregate create -aggregate aggr1 -encrypt-with
-aggr-key true
```

2. Verify that the aggregate is enabled for encryption:

   `storage aggregate show -fields encrypt-with-aggr-key`

   For complete command syntax, see the man page.

   The following command verifies that `aggr1` is enabled for encryption:

```
cluster1::> storage aggregate show -fields encrypt-with-aggr-key
aggregate            encrypt-aggr-key
-------------------- ----------------
aggr0_vsim4          false
aggr1                true
2 entries were displayed.
```

After you finish

Run the `volume create` command to create the encrypted volumes.

If you are using a KMIP server to store the encryption keys for a node, ONTAP automatically “pushes” an encryption key to the server when you encrypt a volume.

Enable encryption on a new volume

You can use the `volume create` command to enable encryption on a new volume.

About this task

Beginning with ONTAP 9.2, you can enable encryption on a SnapLock volume.

Beginning with ONTAP 9.4, if you enable “cc-mode” when you set up the Onboard Key Manager, volumes you create with the `volume create` command are automatically encrypted, whether or not you specify `-encrypt true`.

Beginning with ONTAP 9.6, you can use aggregate-level encryption to assign keys to the containing aggregate for the volumes to be encrypted. Volumes you create in the aggregate are encrypted by default. You can use the `-encrypt` option to override the default when you create the volume.

Beginning with ONTAP 9.7, newly created volumes are encrypted by default when you have the VE license and onboard or external key management.

A volume encrypted with a unique key is called an *NVE volume*. A volume encrypted with an aggregate-level key is called an *NAE aggregate* (for NetApp Aggregate Encryption). Plaintext volumes are not supported in NAE aggregates.

Steps

1. Create a new volume and specify whether encryption is enabled on the volume:

To create…	Use this command…
An ONTAP 9.7 or later NAE volume	`volume create -vserver SVM_name -volume volume_name -aggregate aggregate_name`
An ONTAP 9.6 NAE volume (assuming aggregate-level encryption is enabled)	`volume create -vserver SVM_name -volume volume_name -aggregate aggregate_name`
An ONTAP 9.7 or later NVE volume	`volume create -vserver SVM_name -volume volume_name -aggregate aggregate_name`
An ONTAP 9.6 or earlier NVE volume	`volume create -vserver SVM_name -volume volume_name -aggregate aggregate_name -encrypt true`
A plain text volume	`volume create -vserver SVM_name -volume volume_name -aggregate aggregate_name -encrypt false`

For complete command syntax, see the man page for the command.

Beginning with ONTAP 9.7 or later, the following command creates an NAE volume named `vol1` on `aggr1`:

```
cluster1::> volume create -vserver vs1 -volume vol1 -aggregate aggr1
```

Using ONTAP 9.6, assuming aggregate-level encryption is enabled, the following command creates an NAE volume named `vol1` on `aggr1`:

```
cluster1::> volume create -vserver vs1 -volume vol1 -aggregate aggr1
```

Beginning with ONTAP 9.7 or later, the following command creates an NVE volume named `vol2` on `aggr1`:

```
cluster1::> volume create -vserver vs1 -volume vol2 -aggregate aggr1
```

Using ONTAP 9.6 or earlier, the following command creates an NVE volume named `vol2` on `aggr1`:

```
cluster1::> volume create -vserver vs1 -volume vol2 -aggregate aggr1
-encrypt true
```

The following command creates a plaintext volume named `vol3` on `aggr1`:

```
cluster1::> volume create -vserver vs1 -volume vol3 -aggregate aggr1
-encrypt false
```

2. Verify that volumes are enabled for encryption:

   `volume show -is-encrypted true`

   For complete command syntax, see the man page for the command.

   The following command displays the encrypted volumes on `cluster2`:

```
cluster2::> volume show -is-encrypted true

Vserver  Volume  Aggregate  State  Type  Size  Available  Used
-------  ------  ---------  -----  ----  -----  ---------  ----
vs1      vol1    aggr2     online    RW  200GB    160.0GB  20%
```

Result

If you are using a KMIP server to store the encryption keys for a node, ONTAP automatically “pushes” an encryption key to the server when you encrypt a volume.

Enable encryption on an existing volume with the volume encryption conversion start command

Beginning with ONTAP 9.3, you can use the `volume encryption conversion start` command to enable encryption of an existing volume "in place," without having to move the volume to a different location.

About this task

Once you start a conversion operation, it must complete. If you encounter a performance issue during the operation, you can run the `volume encryption conversion pause` command to pause the operation, and the `volume encryption conversion resume` command to resume the operation.

You cannot use `volume encryption conversion start` to convert a SnapLock volume.

Steps

1. Enable encryption on an existing volume:

`volume encryption conversion start -vserver SVM_name -volume volume_name`

For complete command syntax, see the man page for the command.

The following command enables encryption on the existing volume `vol1`:

```
cluster1::> volume encryption conversion start -vserver vs1 -volume vol1
```

The system creates an encryption key for the volume. The data on the volume is encrypted.

2. Verify the status of the conversion operation:

   `volume encryption conversion show`

   For complete command syntax, see the man page for the command.

   The following command displays the status of the conversion operation:

```
cluster1::> volume encryption conversion show

Vserver   Volume   Start Time           Status
-------   ------   ------------------   --------------------------
vs1       vol1     9/18/2017 17:51:41   Phase 2 of 2 is in progress.
```

3. When the conversion operation is complete, verify that the volume is enabled for encryption:

   `volume show -is-encrypted true`

   For complete command syntax, see the man page for the command.

   The following command displays the encrypted volumes on `cluster1`:

```
cluster1::> volume show -is-encrypted true

Vserver  Volume  Aggregate  State  Type  Size  Available  Used
-------  ------  ---------  -----  ----  -----  ---------  ----
vs1      vol1    aggr2     online    RW  200GB    160.0GB  20%
```

Result

If you are using a KMIP server to store the encryption keys for a node, ONTAP automatically “pushes” an encryption key to the server when you encrypt a volume.

Enable encryption on an existing volume with the volume move start command

You can use the `volume move start` command to enable encryption by moving an existing volume. You must use `volume move start` in ONTAP 9.2 and earlier. You can

use the same aggregate or a different aggregate.

What you'll need

You must be a cluster administrator to perform this task, or an SVM administrator to whom the cluster administrator has delegated authority.

Delegating authority to run the volume move command

About this task

Beginning with ONTAP 9.8, you can use `volume move start` to enable encryption on a SnapLock or FlexGroup volume.

Beginning with ONTAP 9.4, if you enable "cc-mode" when you set up the Onboard Key Manager, volumes you create with the `volume move start` command are automatically encrypted. You need not specify `-encrypt-destination true`.

Beginning with ONTAP 9.6, you can use aggregate-level encryption to assign keys to the containing aggregate for the volumes to be moved. A volume encrypted with a unique key is called an *NVE volume*. A volume encrypted with an aggregate-level key is called an *NAE volume* (for NetApp Aggregate Encryption). Plaintext volumes are not supported in NAE aggregates.

Steps

1. Move an existing volume and specify whether encryption is enabled on the volume:

To convert…	Use this command…
A plaintext volume to an NVE volume	`volume move start -vserver SVM_name -volume volume_name -destination-aggregate aggregate_name -encrypt-destination true`
An NVE or plaintext volume to an NAE volume (assuming aggregate-level encryption is enabled on the destination)	`volume move start -vserver SVM_name -volume volume_name -destination-aggregate aggregate_name -encrypt-with-aggr-key true`
An NAE volume to an NVE volume	`volume move start -vserver SVM_name -volume volume_name -destination-aggregate aggregate_name -encrypt-with-aggr-key false`
An NAE volume to a plaintext volume	`volume move start -vserver SVM_name -volume volume_name -destination-aggregate aggregate_name -encrypt-destination false -encrypt-with-aggr-key false`
An NVE volume to a plaintext volume	`volume move start -vserver SVM_name -volume volume_name -destination-aggregate aggregate_name -encrypt-destination false`

For complete command syntax, see the man page for the command.

The following command converts a plaintext volume named `vol1` to an NVE volume:

```
cluster1::> volume move start -vserver vs1 -volume vol1 -destination
-aggregate aggr2 -encrypt-destination true
```

Assuming aggregate-level encryption is enabled on the destination, the following command converts an NVE or plaintext volume named `vol1` to an NAE volume:

```
cluster1::> volume move start -vserver vs1 -volume vol1 -destination
-aggregate aggr2 -encrypt-with-aggr-key true
```

The following command converts an NAE volume named `vol2` to an NVE volume:

```
cluster1::> volume move start -vserver vs1 -volume vol2 -destination
-aggregate aggr2 -encrypt-with-aggr-key false
```

The following command converts an NAE volume named `vol2` to a plaintext volume:

```
cluster1::> volume move start -vserver vs1 -volume vol2 -destination
-aggregate aggr2 -encrypt-destination false -encrypt-with-aggr-key false
```

The following command converts an NVE volume named `vol2` to a plaintext volume:

```
cluster1::> volume move start -vserver vs1 -volume vol2 -destination
-aggregate aggr2 -encrypt-destination false
```

2. View the encryption type of cluster volumes:

   `volume show -fields encryption-type none|volume|aggregate`

   The `encryption-type` field is available in ONTAP 9.6 and later.

   For complete command syntax, see the man page for the command.

   The following command displays the encryption type of volumes in `cluster2`:

```
cluster2::> volume show -fields encryption-type

vserver  volume  encryption-type
-------  ------  ---------------
vs1      vol1    none
vs2      vol2    volume
vs3      vol3    aggregate
```

3. Verify that volumes are enabled for encryption:

   `volume show -is-encrypted true`

   For complete command syntax, see the man page for the command.

   The following command displays the encrypted volumes on `cluster2`:

```
cluster2::> volume show -is-encrypted true

Vserver  Volume  Aggregate  State  Type  Size  Available  Used
-------  ------  ---------  -----  ----  -----  ---------  ----
vs1      vol1    aggr2     online    RW  200GB    160.0GB  20%
```

Result

If you are using a KMIP server to store the encryption keys for a node, ONTAP automatically “pushes” an encryption key to the server when you encrypt a volume.

Enable node root volume encryption

Beginning with ONTAP 9.8, you can use NetApp Volume Encryption to protect the root volume of your node.

What you’ll need

- Your system must be using an HA configuration.

  Root volume encryption is not supported on single node configurations.

- Your node root volume must already be created.
- Your system must have an onboard key manager or an external key management server using the Key Management Interoperability Protocol (KMIP).

About this task

This procedure applies to the node root volume. It does not apply to SVM root volumes. SVM root volumes can be protected through aggregate-level encryption.

Once root volume encryption begins, it must complete. You cannot pause the operation. Once encryption is complete, you cannot assign a new key to the root volume and you cannot perform a secure-purge operation.

Steps

1. Encrypt the root volume:

   ```
   volume encryption conversion start -vserver SVM_name -volume root_vol_name
   ```

2. Verify the status of the conversion operation:

   ```
   volume encryption conversion show
   ```

3. When the conversion operation is complete, verify that the volume is encrypted:

   ```
   volume show -fields
   ```

   The following shows example output for an encrypted volume.

   ```
   ::> volume show -vserver xyz  -volume vol0 -fields is-encrypted
   vserver    volume is-encrypted
   ---------- ------ ------------
   xyz        vol0   true
   ```