Use Astra Control Provisioner

Astra Control Service

NetApp
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Configure storage backend encryption

Using Astra Control Provisioner, you can improve data access security by enabling encryption for the traffic between your managed cluster and the storage backend.

Astra Control Provisioner supports Kerberos encryption for two types of storage backends:

- **On-premises ONTAP** - Astra Control Provisioner supports Kerberos encryption over NFSv3 and NFSv4 connections from Red Hat OpenShift and upstream Kubernetes clusters to on-premises ONTAP volumes.
- **Azure NetApp Files** - Astra Control Provisioner supports Kerberos encryption over NFSv4.1 connections from upstream Kubernetes clusters to Azure NetApp Files volumes.

You can create, delete, resize, snapshot, clone, read-only clone, and import volumes that use NFS encryption.

Configure in-flight Kerberos encryption with on-premises ONTAP volumes

You can enable Kerberos encryption on the storage traffic between your managed cluster and an on-premises ONTAP storage backend.

Kerberos encryption for NFS traffic with on-premises ONTAP storage backends is only supported using the `ontap-nas` storage driver.

Before you begin

- Ensure that you have enabled Astra Control Provisioner on the managed cluster.
- Ensure that you have access to the `tridentctl` utility.
- Ensure you have administrator access to the ONTAP storage backend.
- Ensure you know the name of the volume or volumes you will be sharing from the ONTAP storage backend.
- Ensure that you have prepared the ONTAP storage VM to support Kerberos encryption for NFS volumes. Refer to Enable Kerberos on a data LIF for instructions.
- Ensure that any NFSv4 volumes you use with Kerberos encryption are configured correctly. Refer to the NetApp NFSv4 Domain Configuration section (page 13) of the NetApp NFSv4 Enhancements and Best Practices Guide.

Add or modify ONTAP export policies

You need to add rules to existing ONTAP export policies or create new export polices that support Kerberos encryption for the ONTAP storage VM root volume as well as any ONTAP volumes shared with the upstream Kubernetes cluster. The export policy rules you add, or new export policies you create, need to support the following access protocols and access permissions:

Access protocols

Configure the export policy with NFS, NFSv3, and NFSv4 access protocols.

Access details

You can configure one of three different versions of Kerberos encryption, depending on your needs for the

volume:

- **Kerberos 5** - (authentication and encryption)
- **Kerberos 5i** - (authentication and encryption with identity protection)
- **Kerberos 5p** - (authentication and encryption with identity and privacy protection)

Configure the ONTAP export policy rule with the appropriate access permissions. For example, if clusters will be mounting the NFS volumes with a mixture of Kerberos 5i and Kerberos 5p encryption, use the following access settings:

Type	Read-only access	Read/Write access	Superuser access
UNIX	Enabled	Enabled	Enabled
Kerberos 5i	Enabled	Enabled	Enabled
Kerberos 5p	Enabled	Enabled	Enabled

Refer to the following documentation for how to create ONTAP export policies and export policy rules:

- Create an export policy
- Add a rule to an export policy

Create a storage backend

You can create an Astra Control Provisioner storage backend configuration that includes Kerberos encryption capability.

About this task

When you create a storage backend configuration file that configures Kerberos encryption, you can specify one of three different versions of Kerberos encryption using the `spec.nfsMountOptions` parameter:

- `spec.nfsMountOptions: sec=krb5` (authentication and encryption)
- `spec.nfsMountOptions: sec=krb5i` (authentication and encryption with identity protection)
- `spec.nfsMountOptions: sec=krb5p` (authentication and encryption with identity and privacy protection)

Specify only one Kerberos level. If you specify more than one Kerberos encryption level in the parameter list, only the first option is used.

Steps

1. On the managed cluster, create a storage backend configuration file using the following example. Replace values in brackets <> with information from your environment:

```
apiVersion: v1
kind: Secret
metadata:
  name: backend-ontap-nas-secret
type: Opaque
stringData:
  clientID: <CLIENT_ID>
  clientSecret: <CLIENT_SECRET>
---
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-ontap-nas
spec:
  version: 1
  storageDriverName: "ontap-nas"
  managementLIF: <STORAGE_VM_MGMT_LIF_IP_ADDRESS>
  dataLIF: <PROTOCOL_LIF_FQDN_OR_IP_ADDRESS>
  svm: <STORAGE_VM_NAME>
  username: <STORAGE_VM_USERNAME_CREDENTIAL>
  password: <STORAGE_VM_PASSWORD_CREDENTIAL>
  nasType: nfs
  nfsMountOptions: ["sec=krb5i"] #can be krb5, krb5i, or krb5p
  qtreesPerFlexvol:
  credentials:
    name: backend-ontap-nas-secret
```

2. Use the configuration file you created in the previous step to create the backend:

```
tridentctl create backend -f <backend-configuration-file>
```

If the backend creation fails, something is wrong with the backend configuration. You can view the logs to determine the cause by running the following command:

```
tridentctl logs
```

After you identify and correct the problem with the configuration file, you can run the create command again.

Create a storage class

You can create a storage class to provision volumes with Kerberos encryption.

About this task

When you create a storage class object, you can specify one of three different versions of Kerberos encryption using the `mountOptions` parameter:

- `mountOptions: sec=krb5` (authentication and encryption)
- `mountOptions: sec=krb5i` (authentication and encryption with identity protection)
- `mountOptions: sec=krb5p` (authentication and encryption with identity and privacy protection)

Specify only one Kerberos level. If you specify more than one Kerberos encryption level in the parameter list, only the first option is used. If the level of encryption you specified in the storage backend configuration is different than the level you specify in the storage class object, the storage class object takes precedence.

Steps

1. Create a StorageClass Kubernetes object, using the following example:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: ontap-nas-sc
provisioner: csi.trident.netapp.io
mountOptions: ["sec=krb5i"] #can be krb5, krb5i, or krb5p
parameters:
  backendType: "ontap-nas"
  storagePools: "ontapnas_pool"
  trident.netapp.io/nasType: "nfs"
allowVolumeExpansion: True
```

2. Create the storage class:

```
kubectl create -f sample-input/storage-class-ontap-nas-sc.yaml
```

3. Make sure that the storage class has been created:

```
kubectl get sc ontap-nas-sc
```

   You should see output similar to the following:

```
NAME            PROVISIONER             AGE
ontap-nas-sc    csi.trident.netapp.io   15h
```

Provision volumes

After you create a storage backend and a storage class, you can now provision a volume. Refer to these instructions for provisioning a volume.

Configure in-flight Kerberos encryption with Azure NetApp Files volumes

You can enable Kerberos encryption on the storage traffic between your managed cluster and a single Azure NetApp Files storage backend or a virtual pool of Azure NetApp Files storage backends.

Before you begin

- Ensure that you have enabled Astra Control Provisioner on the managed Red Hat OpenShift cluster. Refer to Enable Astra Control Provisioner for instructions.
- Ensure that you have access to the `tridentctl` utility.
- Ensure that you have prepared the Azure NetApp Files storage backend for Kerberos encryption by noting the requirements and following the instructions in Azure NetApp Files documentation.
- Ensure that any NFSv4 volumes you use with Kerberos encryption are configured correctly. Refer to the NetApp NFSv4 Domain Configuration section (page 13) of the NetApp NFSv4 Enhancements and Best Practices Guide.

Create a storage backend

You can create an Azure NetApp Files storage backend configuration that includes Kerberos encryption capability.

About this task

When you create a storage backend configuration file that configures Kerberos encryption, you can define it so that it should be applied at one of two possible levels:

- The **storage backend level** using the `spec.kerberos` field
- The **virtual pool level** using the `spec.storage.kerberos` field

When you define the configuration at the virtual pool level, the pool is selected using the label in the storage class.

At either level, you can specify one of three different versions of Kerberos encryption:

- `kerberos: sec=krb5` (authentication and encryption)
- `kerberos: sec=krb5i` (authentication and encryption with identity protection)
- `kerberos: sec=krb5p` (authentication and encryption with identity and privacy protection)

Steps

1. On the managed cluster, create a storage backend configuration file using one of the following examples, depending on where you need to define the storage backend (storage backend level or virtual pool level). Replace values in brackets <> with information from your environment:

Storage backend level example

```
apiVersion: v1
kind: Secret
metadata:
  name: backend-tbc-anf-secret
type: Opaque
stringData:
  clientID: <CLIENT_ID>
  clientSecret: <CLIENT_SECRET>
---
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-anf
spec:
  version: 1
  storageDriverName: azure-netapp-files
  subscriptionID: <SUBSCRIPTION_ID>
  tenantID: <TENANT_ID>
  location: <AZURE_REGION_LOCATION>
  serviceLevel: Standard
  networkFeatures: Standard
  capacityPools: <CAPACITY_POOL>
  resourceGroups: <RESOURCE_GROUP>
  netappAccounts: <NETAPP_ACCOUNT>
  virtualNetwork: <VIRTUAL_NETWORK>
  subnet: <SUBNET>
  nasType: nfs
  kerberos: sec=krb5i #can be krb5, krb5i, or krb5p
  credentials:
    name: backend-tbc-anf-secret
```

Virtual pool level example

```
apiVersion: v1
kind: Secret
metadata:
  name: backend-tbc-anf-secret
type: Opaque
stringData:
  clientID: <CLIENT_ID>
  clientSecret: <CLIENT_SECRET>
---
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-anf
spec:
  version: 1
  storageDriverName: azure-netapp-files
  subscriptionID: <SUBSCRIPTION_ID>
  tenantID: <TENANT_ID>
  location: <AZURE_REGION_LOCATION>
  serviceLevel: Standard
  networkFeatures: Standard
  capacityPools: <CAPACITY_POOL>
  resourceGroups: <RESOURCE_GROUP>
  netappAccounts: <NETAPP_ACCOUNT>
  virtualNetwork: <VIRTUAL_NETWORK>
  subnet: <SUBNET>
  nasType: nfs
  storage:
    - labels:
        type: encryption
      kerberos: sec=krb5i #can be krb5, krb5i, or krb5p
  credentials:
    name: backend-tbc-anf-secret
```

2. Use the configuration file you created in the previous step to create the backend:

```
tridentctl create backend -f <backend-configuration-file>
```

If the backend creation fails, something is wrong with the backend configuration. You can view the logs to determine the cause by running the following command:

```
tridentctl logs
```

After you identify and correct the problem with the configuration file, you can run the create command again.

Create a storage class

You can create a storage class to provision volumes with Kerberos encryption.

Steps

1. Create a StorageClass Kubernetes object, using the following example:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: anf-sc-nfs
provisioner: csi.trident.netapp.io
parameters:
  backendType: "azure-netapp-files"
  trident.netapp.io/nasType: "nfs"
  selector: "type=encryption"
```

2. Create the storage class:

```
kubectl create -f sample-input/storage-class-anf-sc-nfs.yaml
```

3. Make sure that the storage class has been created:

```
kubectl get sc anf-sc-nfs
```

You should see output similar to the following:

```
NAME          PROVISIONER             AGE
anf-sc-nfs    csi.trident.netapp.io   15h
```

Provision volumes

After you create a storage backend and a storage class, you can now provision a volume. Refer to these instructions for provisioning a volume.

Recover volume data using a snapshot

Astra Control Provisioner provides rapid, in-place volume restoration from a snapshot using the `TridentActionSnapshotRestore` (TASR) CR. This CR functions as an imperative Kubernetes action and does not persist after the operation completes.

Astra Control Provisioner supports snapshot restore on the `ontap-san`, `ontap-san-economy`, `ontap-nas`, `ontap-nas-flexgroup`, `azure-netapp-files`, `gcp-cvs`, and `solidfire-san` drivers.

Before you begin

You must have a bound PVC and available volume snapshot.

- Verify the PVC status is bound.

```
kubectl get pvc
```

- Verify the volume snapshot is ready to use.

```
kubectl get vs
```

Steps

1. Create the TASR CR. This example creates a CR for PVC `pvc1` and volume snapshot `pvc1-snapshot`.

```
cat tasr-pvc1-snapshot.yaml

apiVersion: v1
kind: TridentActionSnapshotRestore
metadata:
  name: this-doesnt-matter
  namespace: trident
spec:
  pvcName: pvc1
  volumeSnapshotName: pvc1-snapshot
```

2. Apply the CR to restore from the snapshot. This example restores from snapshot `pvc1`.

```
kubectl create -f tasr-pvc1-snapshot.yaml

tridentactionsnapshotrestore.trident.netapp.io/this-doesnt-matter
created
```

Results

Astra Control Provisioner restores the data from the snapshot. You can verify the snapshot restore status.

```
kubectl get tasr -o yaml

apiVersion: v1
items:
- apiVersion: trident.netapp.io/v1
  kind: TridentActionSnapshotRestore
  metadata:
    creationTimestamp: "2023-04-14T00:20:33Z"
    generation: 3
    name: this-doesnt-matter
    namespace: trident
    resourceVersion: "3453847"
    uid: <uid>
  spec:
    pvcName: pvc1
    volumeSnapshotName: pvc1-snapshot
  status:
    startTime: "2023-04-14T00:20:34Z"
    completionTime: "2023-04-14T00:20:37Z"
    state: Succeeded
kind: List
metadata:
  resourceVersion: ""
```

- In most cases, Astra Control Provisioner will not automatically retry the operation in case of failure. You will need to perform the operation again.
- Kubernetes users without admin access might have to be granted permission by the admin to create a TASR CR in their application namespace.

Replicate volumes using SnapMirror

Using Astra Control Provisioner, you can create mirror relationships between a source volume on one cluster and the destination volume on the peered cluster for replicating data for disaster recovery. You can use a namespaced Custom Resource Definition (CRD) to perform the following operations:

- Create mirror relationships between volumes (PVCs)
- Remove mirror relationships between volumes
- Break the mirror relationships
- Promote the secondary volume during disaster conditions (failovers)
- Perform lossless transition of applications from cluster to cluster (during planned failovers or migrations)

Replication prerequisites

Ensure that the following prerequisites are met before you begin:

ONTAP clusters

- **Astra Control Provisioner**: Astra Control Provisioner version 23.10 or later must exist on both the source and destination Kubernetes clusters that utilize ONTAP as a backend.
- **Licenses**: ONTAP SnapMirror asynchronous licenses using the Data Protection bundle must be enabled on both the source and destination ONTAP clusters. Refer to SnapMirror licensing overview in ONTAP for more information.

Peering

- **Cluster and SVM**: The ONTAP storage backends must be peered. Refer to Cluster and SVM peering overview for more information.

> Ensure that the SVM names used in the replication relationship between two ONTAP clusters are unique.

- **Astra Control Provisioner and SVM**: The peered remote SVMs must be available to Astra Control Provisioner on the destination cluster.

Supported drivers

- Volume replication is supported for the ontap-nas and ontap-san drivers.

Create a mirrored PVC

Follow these steps and use the CRD examples to create mirror relationship between primary and secondary volumes.

Steps

1. Perform the following steps on the primary Kubernetes cluster:
   a. Create a StorageClass object with the `trident.netapp.io/replication: true` parameter.

      Example

      ```
      apiVersion: storage.k8s.io/v1
      kind: StorageClass
      metadata:
        name: csi-nas
      provisioner: csi.trident.netapp.io
      parameters:
        backendType: "ontap-nas"
        fsType: "nfs"
        trident.netapp.io/replication: "true"
      ```

   b. Create a PVC with previously created StorageClass.

Example

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: csi-nas
spec:
  accessModes:
  - ReadWriteMany
  resources:
    requests:
      storage: 1Gi
  storageClassName: csi-nas
```

c. Create a MirrorRelationship CR with local information.

Example

```
kind: TridentMirrorRelationship
apiVersion: trident.netapp.io/v1
metadata:
  name: csi-nas
spec:
  state: promoted
  volumeMappings:
  - localPVCName: csi-nas
```

Astra Control Provisioner fetches the internal information for the volume and the volume's current data protection (DP) state, then populates the status field of the MirrorRelationship.

d. Get the TridentMirrorRelationship CR to obtain the internal name and SVM of the PVC.

```
kubectl get tmr csi-nas
```

```
kind: TridentMirrorRelationship
apiVersion: trident.netapp.io/v1
metadata:
  name: csi-nas
  generation: 1
spec:
  state: promoted
  volumeMappings:
  - localPVCName: csi-nas
status:
  conditions:
  - state: promoted
    localVolumeHandle:
"datavserver:trident_pvc_3bedd23c_46a8_4384_b12b_3c38b313c1e1"
    localPVCName: csi-nas
    observedGeneration: 1
```

2. Perform the following steps on the secondary Kubernetes cluster:
   a. Create a StorageClass with the trident.netapp.io/replication: true parameter.

      Example

      ```
      apiVersion: storage.k8s.io/v1
      kind: StorageClass
      metadata:
        name: csi-nas
      provisioner: csi.trident.netapp.io
      parameters:
        trident.netapp.io/replication: true
      ```

   b. Create a MirrorRelationship CR with destination and source information.

      Example

      ```
      kind: TridentMirrorRelationship
      apiVersion: trident.netapp.io/v1
      metadata:
        name: csi-nas
      spec:
        state: established
        volumeMappings:
        - localPVCName: csi-nas
          remoteVolumeHandle:
      "datavserver:trident_pvc_3bedd23c_46a8_4384_b12b_3c38b313c1e1"
      ```

Astra Control Provisioner will create a SnapMirror relationship with the configured relationship policy name (or default for ONTAP) and initialize it.

c. Create a PVC with previously created StorageClass to act as the secondary (SnapMirror destination).

Example

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: csi-nas
  annotations:
    trident.netapp.io/mirrorRelationship: csi-nas
spec:
  accessModes:
  - ReadWriteMany
resources:
  requests:
    storage: 1Gi
storageClassName: csi-nas
```

Astra Control Provisioner will check for the TridentMirrorRelationship CRD and fail to create the volume if the relationship does not exist. If the relationship exists, Astra Control Provisioner will ensure the new FlexVol volume is placed onto an SVM that is peered with the remote SVM defined in the MirrorRelationship.

Volume Replication States

A Trident Mirror Relationship (TMR) is a CRD that represents one end of a replication relationship between PVCs. The destination TMR has a state, which tells Astra Control Provisioner what the desired state is. The destination TMR has the following states:

- **Established**: the local PVC is the destination volume of a mirror relationship, and this is a new relationship.
- **Promoted**: the local PVC is ReadWrite and mountable, with no mirror relationship currently in effect.
- **Reestablished**: the local PVC is the destination volume of a mirror relationship and was also previously in that mirror relationship.
  - The reestablished state must be used if the destination volume was ever in a relationship with the source volume because it overwrites the destination volume contents.
  - The reestablished state will fail if the volume was not previously in a relationship with the source.

Promote secondary PVC during an unplanned failover

Perform the following step on the secondary Kubernetes cluster:

- Update the *spec.state* field of TridentMirrorRelationship to `promoted`.

Promote secondary PVC during a planned failover

During a planned failover (migration), perform the following steps to promote the secondary PVC:

Steps

1. On the primary Kubernetes cluster, create a snapshot of the PVC and wait until the snapshot is created.
2. On the primary Kubernetes cluster, create the SnapshotInfo CR to obtain internal details.

   Example

   ```
   kind: SnapshotInfo
   apiVersion: trident.netapp.io/v1
   metadata:
     name: csi-nas
   spec:
     snapshot-name: csi-nas-snapshot
   ```

3. On secondary Kubernetes cluster, update the *spec.state* field of the *TridentMirrorRelationship* CR to *promoted* and *spec.promotedSnapshotHandle* to be the internalName of the snapshot.
4. On secondary Kubernetes cluster, confirm the status (status.state field) of TridentMirrorRelationship to promoted.

Restore a mirror relationship after a failover

Before restoring a mirror relationship, choose the side that you want to make as the new primary.

Steps

1. On the secondary Kubernetes cluster, ensure that the values for the *spec.remoteVolumeHandle* field on the TridentMirrorRelationship is updated.
2. On secondary Kubernetes cluster, update the *spec.mirror* field of TridentMirrorRelationship to `reestablished`.

Additional operations

Astra Control Provisioner supports the following operations on the primary and secondary volumes:

Replicate primary PVC to a new secondary PVC

Ensure that you already have a primary PVC and a secondary PVC.

Steps

1. Delete the PersistentVolumeClaim and TridentMirrorRelationship CRDs from the established secondary (destination) cluster.
2. Delete the TridentMirrorRelationship CRD from the primary (source) cluster.
3. Create a new TridentMirrorRelationship CRD on the primary (source) cluster for the new secondary (destination) PVC you want to establish.

Resize a mirrored, primary or secondary PVC

The PVC can be resized as normal, ONTAP will automatically expand any destination flevxols if the amount of data exceeds the current size.

Remove replication from a PVC

To remove replication, perform one of the following operations on the current secondary volume:

- Delete the MirrorRelationship on the secondary PVC. This breaks the replication relationship.
- Or, update the spec.state field to *promoted*.

Delete a PVC (that was previously mirrored)

Astra Control Provisioner checks for replicated PVCs, and releases the replication relationship before attempting to delete the volume.

Delete a TMR

Deleting a TMR on one side of a mirrored relationship causes the remaining TMR to transition to *promoted* state before Astra Control Provisioner completes the deletion. If the TMR selected for deletion is already in *promoted* state, there is no existing mirror relationship and the TMR will be removed and Astra Control Provisioner will promote the local PVC to *ReadWrite*. This deletion releases SnapMirror metadata for the local volume in ONTAP. If this volume is used in a mirror relationship in the future, it must use a new TMR with an *established* volume replication state when creating the new mirror relationship.

Update mirror relationships when ONTAP is online

Mirror relationships can be updated any time after they are established. You can use the `state: promoted` or `state: reestablished` fields to update the relationships.
When promoting a destination volume to a regular ReadWrite volume, you can use *promotedSnapshotHandle* to specify a specific snapshot to restore the current volume to.

Update mirror relationships when ONTAP is offline

You can use a CRD to perform a SnapMirror update without Astra Control having direct connectivity to the ONTAP cluster. Refer to the following example format of the TridentActionMirrorUpdate:

Example

```
apiVersion: trident.netapp.io/v1
kind: TridentActionMirrorUpdate
metadata:
  name: update-mirror-b
spec:
  snapshotHandle: "pvc-1234/snapshot-1234"
  tridentMirrorRelationshipName: mirror-b
```

`status.state` reflects the state of the TridentActionMirrorUpdate CRD. It can take a value from *Succeeded*, *In Progress*, or *Failed*.

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