



## Use Trident

Trident

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# Use Trident

## Prepare the worker node

All worker nodes in the Kubernetes cluster must be able to mount the volumes you have provisioned for your pods. To prepare the worker nodes, you must install NFS, iSCSI, NVMe/TCP, or FC tools based on your driver selection.

### Selecting the right tools

If you are using a combination of drivers, you should install all required tools for your drivers. Recent versions of RedHat CoreOS have the tools installed by default.

#### NFS tools

[Install the NFS tools](#) if you are using: `ontap-nas`, `ontap-nas-economy`, `ontap-nas-flexgroup`, `azure-netapp-files`, `gcp-cvs`.

#### iSCSI tools

[Install the iSCSI tools](#) if you are using: `ontap-san`, `ontap-san-economy`, `solidfire-san`.

#### NVMe tools

[Install the NVMe tools](#) if you are using `ontap-san` for nonvolatile memory express (NVMe) over TCP (NVMe/TCP) protocol.



We recommend ONTAP 9.12 or later for NVMe/TCP.

#### SCSI over FC tools

**SCSI over Fibre Channel (FC) is a tech preview feature in the Trident 24.10 release.**

[Install the FC tools](#) if you are using `ontap-san` with `sanType fcp` (SCSI over FC).

Refer to [Ways to configure FC & FC-NVMe SAN hosts](#) for more information.

## Node service discovery

Trident attempts to automatically detect if the node can run iSCSI or NFS services.



Node service discovery identifies discovered services but does not guarantee services are properly configured. Conversely, the absence of a discovered service does not guarantee the volume mount will fail.

### Review events

Trident creates events for the node to identify the discovered services. To review these events, run:

```
kubectl get event -A --field-selector involvedObject.name=<Kubernetes node name>
```

## Review discovered services

Trident identifies services enabled for each node on the Trident node CR. To view the discovered services, run:

```
tridentctl get node -o wide -n <Trident namespace>
```

## NFS volumes

Install the NFS tools using the commands for your operating system. Ensure the NFS service is started up during boot time.

### RHEL 8+

```
sudo yum install -y nfs-utils
```

### Ubuntu

```
sudo apt-get install -y nfs-common
```



Reboot your worker nodes after installing the NFS tools to prevent failure when attaching volumes to containers.

## iSCSI volumes

Trident can automatically establish an iSCSI session, scan LUNs, and discover multipath devices, format them, and mount them to a pod.

### iSCSI self-healing capabilities

For ONTAP systems, Trident runs iSCSI self-healing every five minutes to:

1. **Identify** the desired iSCSI session state and the current iSCSI session state.
2. **Compare** the desired state to the current state to identify needed repairs. Trident determines repair priorities and when to preempt repairs.
3. **Perform repairs** required to return the current iSCSI session state to the desired iSCSI session state.



Logs of self-healing activity are located in the `trident-main` container on the respective Daemonset pod. To view logs, you must have set `debug` to "true" during Trident installation.

Trident iSCSI self-healing capabilities can help prevent:

- Stale or unhealthy iSCSI sessions that could occur after a network connectivity issue. In the case of a stale session, Trident waits seven minutes before logging out to reestablish the connection with a portal.



For example, if CHAP secrets were rotated on the storage controller and the network loses connectivity, the old (*stale*) CHAP secrets could persist. Self-healing can recognize this and automatically reestablish the session to apply the updated CHAP secrets.

- Missing iSCSI sessions
- Missing LUNs

## Points to consider before upgrading Trident

- If only per-node igroups (introduced in 23.04+) are in use, iSCSI self-healing will initiate SCSI rescans for all devices in the SCSI bus.
- If only backend-scoped igroups (deprecated as of 23.04) are in use, iSCSI self-healing will initiate SCSI rescans for exact LUN IDs in the SCSI bus.
- If a mix of per-node igroups and backend-scoped igroups are in use, iSCSI self-healing will initiate SCSI rescans for exact LUN IDs in the SCSI bus.

## Install the iSCSI tools

Install the iSCSI tools using the commands for your operating system.

### Before you begin

- Each node in the Kubernetes cluster must have a unique IQN. **This is a necessary prerequisite.**
- If using RHCOS version 4.5 or later, or other RHEL-compatible Linux distribution, with the `solidfire-san` driver and Element OS 12.5 or earlier, ensure that the CHAP authentication algorithm is set to MD5 in `/etc/iscsi/iscsid.conf`. Secure FIPS-compliant CHAP algorithms SHA1, SHA-256, and SHA3-256 are available with Element 12.7.

```
sudo sed -i 's/^\(node.session.auth.chap_algs\)\.*'\1 = MD5/'  
/etc/iscsi/iscsid.conf
```

- When using worker nodes that run RHEL/RedHat CoreOS with iSCSI PVs, specify the `discard` `mountOption` in the `StorageClass` to perform inline space reclamation. Refer to [RedHat documentation](#).

## RHEL 8+

1. Install the following system packages:

```
sudo yum install -y lsscsi iscsi-initiator-utils device-mapper-multipath
```

2. Check that iscsi-initiator-utils version is 6.2.0.874-2.el7 or later:

```
rpm -q iscsi-initiator-utils
```

3. Enable multipathing:

```
sudo mpathconf --enable --with_multipathd y --find_multipaths n
```



Ensure `etc/multipath.conf` contains `find_multipaths n` under `defaults`.

4. Ensure that `iscsid` and `multipathd` are running:

```
sudo systemctl enable --now iscsid multipathd
```

5. Enable and start `iscsi`:

```
sudo systemctl enable --now iscsi
```

## Ubuntu

1. Install the following system packages:

```
sudo apt-get install -y open-iscsi lsscsi sg3-utils multipath-tools scsitoools
```

2. Check that `open-iscsi` version is 2.0.874-5ubuntu2.10 or later (for bionic) or 2.0.874-7.1ubuntu6.1 or later (for focal):

```
dpkg -l open-iscsi
```

3. Set scanning to manual:

```
sudo sed -i 's/^(node.session.scan\).*$/\1 = manual/'  
/etc/iscsi/iscsid.conf
```

#### 4. Enable multipathing:

```
sudo tee /etc/multipath.conf <<-EOF  
defaults {  
    user_friendly_names yes  
    find_multipaths no  
}  
EOF  
sudo systemctl enable --now multipath-tools.service  
sudo service multipath-tools restart
```



Ensure `/etc/multipath.conf` contains `find_multipaths no` under `defaults`.

#### 5. Ensure that `open-iscsi` and `multipath-tools` are enabled and running:

```
sudo systemctl status multipath-tools  
sudo systemctl enable --now open-iscsi.service  
sudo systemctl status open-iscsi
```



For Ubuntu 18.04, you must discover target ports with `iscsiadm` before starting `open-iscsi` for the iSCSI daemon to start. You can alternatively modify the `iscsi` service to start `iscsid` automatically.

### Configure or disable iSCSI self healing

You can configure the following Trident iSCSI self-healing settings to fix stale sessions:

- **iSCSI self-healing interval:** Determines the frequency at which iSCSI self-healing is invoked (default: 5 minutes). You can configure it to run more frequently by setting a smaller number or less frequently by setting a larger number.



Setting the iSCSI self-healing interval to 0 stops iSCSI self-healing completely. We do not recommend disabling iSCSI Self-healing; it should only be disabled in certain scenarios when iSCSI self-healing is not working as intended or for debugging purposes.

- **iSCSI Self-Healing Wait Time:** Determines the duration iSCSI self-healing waits before logging out of an unhealthy session and trying to log in again (default: 7 minutes). You can configure it to a larger number so that sessions that are identified as unhealthy have to wait longer before being logged out and then an attempt is made to log back in, or a smaller number to log out and log in earlier.

## Helm

To configure or change iSCSI self-healing settings, pass the `iscsiSelfHealingInterval` and `iscsiSelfHealingWaitTime` parameters during the helm installation or helm update.

The following example sets the iSCSI self-healing interval to 3 minutes and self-healing wait time to 6 minutes:

```
helm install trident trident-operator-100.2410.0.tgz --set  
iscsiSelfHealingInterval=3m0s --set iscsiSelfHealingWaitTime=6m0s -n  
trident
```

## tridentctl

To configure or change iSCSI self-healing settings, pass the `iscsi-self-healing-interval` and `iscsi-self-healing-wait-time` parameters during the tridentctl installation or update.

The following example sets the iSCSI self-healing interval to 3 minutes and self-healing wait time to 6 minutes:

```
tridentctl install --iscsi-self-healing-interval=3m0s --iscsi-self  
-healing-wait-time=6m0s -n trident
```

## NVMe/TCP volumes

Install the NVMe tools using the commands for your operating system.

- NVMe requires RHEL 9 or later.
- If the kernel version of your Kubernetes node is too old or if the NVMe package is not available for your kernel version, you might have to update the kernel version of your node to one with the NVMe package.

### RHEL 9

```
sudo yum install nvme-cli  
sudo yum install linux-modules-extra-$ (uname -r)  
sudo modprobe nvme-tcp
```

### Ubuntu

```
sudo apt install nvme-cli  
sudo apt -y install linux-modules-extra-$ (uname -r)  
sudo modprobe nvme-tcp
```

## Verify installation

After installation, verify that each node in the Kubernetes cluster has a unique NQN using the command:

```
cat /etc/nvme/hostnqn
```



Trident modifies the `ctrl_device_tmo` value to ensure NVMe doesn't give up on the path if it goes down. Do not change this setting.

## Install the FC tools

Install the FC tools using the commands for your operating system.

- When using worker nodes that run RHEL/RedHat CoreOS with FC PVs, specify the `discard` mountOption in the StorageClass to perform inline space reclamation. Refer to [RedHat documentation](#).

## RHEL 8+

1. Install the following system packages:

```
sudo yum install -y lsscsi device-mapper-multipath
```

2. Enable multipathing:

```
sudo mpathconf --enable --with_multipathd y --find_multipaths n
```



Ensure `etc/multipath.conf` contains `find_multipaths no` under `defaults`.

3. Ensure that `multipathd` is running:

```
sudo systemctl enable --now multipathd
```

## Ubuntu

1. Install the following system packages:

```
sudo apt-get install -y lsscsi sg3-utils multipath-tools scsitoools
```

2. Enable multipathing:

```
sudo tee /etc/multipath.conf <<-EOF
defaults {
    user_friendly_names yes
    find_multipaths no
}
EOF
sudo systemctl enable --now multipath-tools.service
sudo service multipath-tools restart
```



Ensure `etc/multipath.conf` contains `find_multipaths no` under `defaults`.

3. Ensure that `multipath-tools` is enabled and running:

```
sudo systemctl status multipath-tools
```

## Fibre Channel (FC) support

You can now use the Fibre Channel (FC) protocol with Trident to provision and manage storage resources on ONTAP system.

**SCSI over Fibre Channel (FC) is a tech preview feature in the Trident 24.10 release.**

Fibre Channel is a widely adopted protocol in enterprise storage environments due to its high performance, reliability, and scalability. It provides a robust and efficient communication channel for storage devices, enabling fast and secure data transfers.

By using SCSI over Fibre Channel, you can leverage their existing SCSI-based storage infrastructure while benefiting from the high-performance and long-distance capabilities of Fibre Channel. It enables the consolidation of storage resources and the creation of scalable and efficient storage area networks (SANs) that can handle large amounts of data with low latency.

Using the FC feature with Trident, you can do the following:

- Dynamically provision PVCs using a deployment spec.
- Take volume snapshots and create a new volume from the snapshot.
- Clone an existing FC-PVC.
- Resize an already deployed volume.

## Prerequisites

Configure the required network and node settings for FC.

### Network settings

1. Get the WWPN of the target interfaces. Refer to [network interface show](#) for more information.
2. Get the WWPN for the interfaces on initiator (Host).

Refer to the corresponding host operating system utilities.

3. Configure zoning on the FC switch using WWPNs of the Host and target.

Refer to the respective switch vendor documentation for information.

Refer to the following ONTAP documentation for details:

- [Fibre Channel and FCoE zoning overview](#)
- [Ways to configure FC & FC-NVMe SAN hosts](#)

### Prepare the worker node

All worker nodes in the Kubernetes cluster must be able to mount the volumes you have provisioned for your pods. To prepare the worker nodes for FC, you must install the required tools.

### Install the FC tools

Install the FC tools using the commands for your operating system.

- When using worker nodes that run RHEL/RedHat CoreOS with FC PVs, specify the `discard` mountOption in the StorageClass to perform inline space reclamation. Refer to [RedHat documentation](#).

## RHEL 8+

1. Install the following system packages:

```
sudo yum install -y lsscsi device-mapper-multipath
```

2. Enable multipathing:

```
sudo mpathconf --enable --with_multipathd y --find_multipaths n
```



Ensure `etc/multipath.conf` contains `find_multipaths no` under `defaults`.

3. Ensure that `multipathd` is running:

```
sudo systemctl enable --now multipathd
```

## Ubuntu

1. Install the following system packages:

```
sudo apt-get install -y lsscsi sg3-utils multipath-tools scsitoools
```

2. Enable multipathing:

```
sudo tee /etc/multipath.conf <<-EOF
defaults {
    user_friendly_names yes
    find_multipaths no
}
EOF
sudo systemctl enable --now multipath-tools.service
sudo service multipath-tools restart
```



Ensure `etc/multipath.conf` contains `find_multipaths no` under `defaults`.

3. Ensure that `multipath-tools` is enabled and running:

```
sudo systemctl status multipath-tools
```

## Create a backend configuration

Create a Trident backend for `ontap-san` driver and `fcp` as the `sanType`.

Refer to:

- [Prepare to configure backend with ONTAP SAN drivers](#)
- [ONTAP SAN configuration options and examples](#)

### Backend configuration example with FC

```
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-ontap-san
spec:
  version: 1
  backendName: ontap-san-backend
  storageDriverName: ontap-san
  managementLIF: 10.0.0.1
  sanType: fcp
  svm: trident_svm
  credentials:
    name: backend-tbc-ontap-san-secret
```

## Create a storage class

For more information, refer to:

- [Storage configuration options](#)

### Storage class example

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: fcp-sc
provisioner: csi.trident.netapp.io
parameters:
  backendType: "ontap-san"
  storagePools: "ontap-san-backend:.*"
  fsType: "ext4"
allowVolumeExpansion: True
```

## Configure and manage backends

## Configure backends

A backend defines the relationship between Trident and a storage system. It tells Trident how to communicate with that storage system and how Trident should provision volumes from it.

Trident automatically offers up storage pools from backends that match the requirements defined by a storage class. Learn how to configure the backend for your storage system.

- [Configure an Azure NetApp Files backend](#)
- [Configure a Google Cloud NetApp Volumes backend](#)
- [Configure a Cloud Volumes Service for Google Cloud Platform backend](#)
- [Configure a NetApp HCI or SolidFire backend](#)
- [Configure a backend with ONTAP or Cloud Volumes ONTAP NAS drivers](#)
- [Configure a backend with ONTAP or Cloud Volumes ONTAP SAN drivers](#)
- [Use Trident with Amazon FSx for NetApp ONTAP](#)

## Azure NetApp Files

### Configure an Azure NetApp Files backend

You can configure Azure NetApp Files as the backend for Trident. You can attach NFS and SMB volumes using an Azure NetApp Files backend. Trident also supports credential management using managed identities for Azure Kubernetes Services (AKS) clusters.

#### Azure NetApp Files driver details

Trident provides the following Azure NetApp Files storage drivers to communicate with the cluster. Supported access modes are: *ReadWriteOnce* (RWO), *ReadOnlyMany* (ROX), *ReadWriteMany* (RWX), *ReadWriteOncePod* (RWOP).

Driver	Protocol	volumeMode	Access modes supported	File systems supported
azure-netapp-files	NFS SMB	Filesystem	RWO, ROX, RWX, RWOP	nfs, smb

#### Considerations

- The Azure NetApp Files service does not support volumes smaller than 50 GiB. Trident automatically creates 50-GiB volumes if a smaller volume is requested.
- Trident supports SMB volumes mounted to pods running on Windows nodes only.

#### Managed identities for AKS

Trident supports [managed identities](#) for Azure Kubernetes Services clusters. To take advantage of streamlined credential management offered by managed identities, you must have:

- A Kubernetes cluster deployed using AKS

- Managed identities configured on the AKS kubernetes cluster
- Trident installed that includes the `cloudProvider` to specify "Azure".

### Trident operator

To install Trident using the Trident operator, edit `tridentoperator_cr.yaml` to set `cloudProvider` to "Azure". For example:

```
apiVersion: trident.netapp.io/v1
kind: TridentOrchestrator
metadata:
  name: trident
spec:
  debug: true
  namespace: trident
  imagePullPolicy: IfNotPresent
  cloudProvider: "Azure"
```

### Helm

The following example installs Trident sets `cloudProvider` to Azure using the environment variable `$CP`:

```
helm install trident trident-operator-100.2410.0.tgz --create
--namespace --namespace <trident-namespace> --set cloudProvider=$CP
```

`tridentctl`

The following example installs Trident and sets the `cloudProvider` flag to Azure:

```
tridentctl install --cloud-provider="Azure" -n trident
```

### Cloud identity for AKS

Cloud identity enables Kubernetes pods to access Azure resources by authenticating as a workload identity instead of by providing explicit Azure credentials.

To take advantage of cloud identity in Azure, you must have:

- A Kubernetes cluster deployed using AKS
- Workload identity and oidc-issuer configured on the AKS Kubernetes cluster
- Trident installed that includes the `cloudProvider` to specify "Azure" and `cloudIdentity` specifying workload identity

## Trident operator

To install Trident using the Trident operator, edit `tridentoperator_cr.yaml` to set `cloudProvider` to "Azure" and set `cloudIdentity` to `azure.workload.identity/client-id: xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx`.

For example:

```
apiVersion: trident.netapp.io/v1
kind: TridentOrchestrator
metadata:
  name: trident
spec:
  debug: true
  namespace: trident
  imagePullPolicy: IfNotPresent
  cloudProvider: "Azure"
  *cloudIdentity: 'azure.workload.identity/client-id: xxxxxxxx-xxxx-
xxxx-xxxx-xxxxxxxxxxxx'*
```

## Helm

Set the values for **cloud-provider (CP)** and **cloud-identity (CI)** flags using the following environment variables:

```
export CP="Azure"
export CI="'azure.workload.identity/client-id: xxxxxxxx-xxxx-xxxx-xxxx-
xxxxxxxxxxxx'"
```

The following example installs Trident and sets `cloudProvider` to Azure using the environment variable `$CP` and sets the `cloudIdentity` using the environment variable `$CI`:

```
helm install trident trident-operator-100.2410.0.tgz --set
cloudProvider=$CP --set cloudIdentity="$CI"
```

`tridentctl`

Set the values for **cloud provider** and **cloud identity** flags using the following environment variables:

```
export CP="Azure"
export CI="azure.workload.identity/client-id: xxxxxxxx-xxxx-xxxx-xxxx-
xxxxxxxxxxxx"
```

The following example installs Trident and sets the `cloud-provider` flag to `$CP`, and `cloud-identity` to `$CI`:

```
tridentctl install --cloud-provider=$CP --cloud-identity="$CI" -n  
trident
```

## Prepare to configure an Azure NetApp Files backend

Before you can configure your Azure NetApp Files backend, you need to ensure the following requirements are met.

### Prerequisites for NFS and SMB volumes

If you are using Azure NetApp Files for the first time or in a new location, some initial configuration is required to set up Azure NetApp files and create an NFS volume. Refer to [Azure: Set up Azure NetApp Files and create an NFS volume](#).

To configure and use an [Azure NetApp Files](#) backend, you need the following:

- **subscriptionID**, **tenantID**, **clientID**, **location**, and **clientSecret** are optional when using managed identities on an AKS cluster.
- **tenantID**, **clientID**, and **clientSecret** are optional when using a cloud identity on an AKS cluster.

• A capacity pool. Refer to [Microsoft: Create a capacity pool for Azure NetApp Files](#).

• A subnet delegated to Azure NetApp Files. Refer to [Microsoft: Delegate a subnet to Azure NetApp Files](#).

• **subscriptionID** from an Azure subscription with Azure NetApp Files enabled.

• **tenantID**, **clientID**, and **clientSecret** from an [App Registration](#) in Azure Active Directory with sufficient permissions to the Azure NetApp Files service. The App Registration should use either:

- The Owner or Contributor role [predefined by Azure](#).
- A [custom Contributor role](#) at the subscription level (`assignableScopes`) with the following permissions that are limited to only what Trident requires. After creating the custom role, [assign the role using the Azure portal](#).

## Custom contributor role

```
{
  "id": "/subscriptions/<subscription-id>/providers/Microsoft.Authorization/roleDefinitions/<role-definition-id>",
  "properties": {
    "roleName": "custom-role-with-limited-perms",
    "description": "custom role providing limited permissions",
    "assignableScopes": [
      "/subscriptions/<subscription-id>"
    ],
    "permissions": [
      {
        "actions": [
          "Microsoft.NetApp/netAppAccounts/capacityPools/read",
          "Microsoft.NetApp/netAppAccounts/capacityPools/write",
          "Microsoft.NetApp/netAppAccounts/capacityPools/volumes/read",
          "Microsoft.NetApp/netAppAccounts/capacityPools/volumes/write",
          "Microsoft.NetApp/netAppAccounts/capacityPools/volumes/delete",
          "Microsoft.NetApp/netAppAccounts/capacityPools/volumes/snapshots/read",
          "Microsoft.NetApp/netAppAccounts/capacityPools/volumes/snapshots/write",
          "Microsoft.NetApp/netAppAccounts/capacityPools/volumes/snapshots/delete",
          "Microsoft.NetApp/netAppAccounts/capacityPools/volumes/MountTargets/read",
          "Microsoft.Network/virtualNetworks/read",
          "Microsoft.Network/virtualNetworks/subnets/read",
          "Microsoft.Features/featureProviders/subscriptionFeatureRegistrations/read",
          "Microsoft.Features/featureProviders/subscriptionFeatureRegistrations/write"
        ]
      }
    ]
  }
}
```

```

    "ions/write",

    "Microsoft.Features/featureProviders/subscriptionFeatureRegistrations/delete",
        "Microsoft.Features/features/read",
        "Microsoft.Features/operations/read",
        "Microsoft.Features/providers/features/read",

    "Microsoft.Features/providers/features/register/action",

    "Microsoft.Features/providers/features/unregister/action",

    "Microsoft.Features/subscriptionFeatureRegistrations/read"
        ],
        "notActions": [],
        "dataActions": [],
        "notDataActions": []
    }
]
}
}

```

- The Azure location that contains at least one [delegated subnet](#). As of Trident 22.01, the location parameter is a required field at the top level of the backend configuration file. Location values specified in virtual pools are ignored.
- To use Cloud Identity, get the client ID from a [user-assigned managed identity](#) and specify that ID in `azure.workload.identity/client-id: xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxx`.

#### Additional requirements for SMB volumes

To create an SMB volume, you must have:

- Active Directory configured and connected to Azure NetApp Files. Refer to [Microsoft: Create and manage Active Directory connections for Azure NetApp Files](#).
- A Kubernetes cluster with a Linux controller node and at least one Windows worker node running Windows Server 2022. Trident supports SMB volumes mounted to pods running on Windows nodes only.
- At least one Trident secret containing your Active Directory credentials so Azure NetApp Files can authenticate to Active Directory. To generate secret `smbcreds`:

```

kubectl create secret generic smbcreds --from-literal username=user
--from-literal password='password'

```

- A CSI proxy configured as a Windows service. To configure a `csi-proxy`, refer to [GitHub: CSI Proxy](#) or [GitHub: CSI Proxy for Windows](#) for Kubernetes nodes running on Windows.

## Azure NetApp Files backend configuration options and examples

Learn about NFS and SMB backend configuration options for Azure NetApp Files and review configuration examples.

### Backend configuration options

Trident uses your backend configuration (subnet, virtual network, service level, and location), to create Azure NetApp Files volumes on capacity pools that are available in the requested location and match the requested service level and subnet.



Trident does not support Manual QoS capacity pools.

Azure NetApp Files backends provide these configuration options.

Parameter	Description	Default
version		Always 1
storageDriverName	Name of the storage driver	"azure-netapp-files"
backendName	Custom name or the storage backend	Driver name + "_" + random characters
subscriptionID	The subscription ID from your Azure subscription  Optional when managed identities is enabled on an AKS cluster.	
tenantID	The tenant ID from an App Registration  Optional when managed identities or cloud identity is used on an AKS cluster.	
clientID	The client ID from an App Registration  Optional when managed identities or cloud identity is used on an AKS cluster.	
clientSecret	The client secret from an App Registration  Optional when managed identities or cloud identity is used on an AKS cluster.	
serviceLevel	One of Standard, Premium, or Ultra	"" (random)

Parameter	Description	Default
location	<p>Name of the Azure location where the new volumes will be created</p> <p>Optional when managed identities is enabled on an AKS cluster.</p>	
resourceGroups	List of resource groups for filtering discovered resources	"[]" (no filter)
netappAccounts	List of NetApp accounts for filtering discovered resources	"[]" (no filter)
capacityPools	List of capacity pools for filtering discovered resources	"[]" (no filter, random)
virtualNetwork	Name of a virtual network with a delegated subnet	""
subnet	Name of a subnet delegated to Microsoft.Netapp/volumes	""
networkFeatures	<p>Set of VNet features for a volume, may be Basic or Standard.</p> <p>Network Features is not available in all regions and might have to be enabled in a subscription.</p> <p>Specifying <code>networkFeatures</code> when the functionality is not enabled causes volume provisioning to fail.</p>	""
nfsMountOptions	<p>Fine-grained control of NFS mount options.</p> <p>Ignored for SMB volumes.</p> <p>To mount volumes using NFS version 4.1, include <code>nfsvers=4</code> in the comma-delimited mount options list to choose NFS v4.1.</p> <p>Mount options set in a storage class definition override mount options set in backend configuration.</p>	"nfsvers=3"
limitVolumeSize	Fail provisioning if the requested volume size is above this value	"" (not enforced by default)

Parameter	Description	Default
debugTraceFlags	Debug flags to use when troubleshooting. Example, <code>\{"api": false, "method": true, "discovery": true\}</code> . Do not use this unless you are troubleshooting and require a detailed log dump.	null
nasType	Configure NFS or SMB volumes creation.  Options are <code>nfs</code> , <code>smb</code> or <code>null</code> . Setting to <code>null</code> defaults to NFS volumes.	<code>nfs</code>
supportedTopologies	Represents a list of regions and zones that are supported by this backend.  For more information, refer to <a href="#">Use CSI Topology</a> .	



For more information on Network Features, refer to [Configure network features for an Azure NetApp Files volume](#).

## Required permissions and resources

If you receive a “No capacity pools found” error when creating a PVC, it is likely your app registration doesn’t have the required permissions and resources (subnet, virtual network, capacity pool) associated. If debug is enabled, Trident will log the Azure resources discovered when the backend is created. Verify an appropriate role is being used.

The values for `resourceGroups`, `netappAccounts`, `capacityPools`, `virtualNetwork`, and `subnet` can be specified using short or fully-qualified names. Fully-qualified names are recommended in most situations as short names can match multiple resources with the same name.

The `resourceGroups`, `netappAccounts`, and `capacityPools` values are filters that restrict the set of discovered resources to those available to this storage backend and may be specified in any combination. Fully-qualified names follow this format:

Type	Format
Resource group	<code>&lt;resource group&gt;</code>
NetApp account	<code>&lt;resource group&gt;/&lt;netapp account&gt;</code>
Capacity pool	<code>&lt;resource group&gt;/&lt;netapp account&gt;/&lt;capacity pool&gt;</code>
Virtual network	<code>&lt;resource group&gt;/&lt;virtual network&gt;</code>
Subnet	<code>&lt;resource group&gt;/&lt;virtual network&gt;/&lt;subnet&gt;</code>

## Volume provisioning

You can control default volume provisioning by specifying the following options in a special section of the configuration file. Refer to [Example configurations](#) for details.

Parameter	Description	Default
exportRule	Export rules for new volumes.  exportRule must be a comma-separated list of any combination of IPv4 addresses or IPv4 subnets in CIDR notation.  Ignored for SMB volumes.	"0.0.0.0/0"
snapshotDir	Controls visibility of the .snapshot directory	"true" for NFSv4 "false" for NFSv3
size	The default size of new volumes	"100G"
unixPermissions	The unix permissions of new volumes (4 octal digits).  Ignored for SMB volumes.	"" (preview feature, requires whitelisting in subscription)

## Example configurations

The following examples show basic configurations that leave most parameters to default. This is the easiest way to define a backend.

## Minimal configuration

This is the absolute minimum backend configuration. With this configuration, Trident discovers all of your NetApp accounts, capacity pools, and subnets delegated to Azure NetApp Files in the configured location, and places new volumes on one of those pools and subnets randomly. Because `nasType` is omitted, the `nfs` default applies and the backend will provision for NFS volumes.

This configuration is ideal when you are just getting started with Azure NetApp Files and trying things out, but in practice you are going to want to provide additional scoping for the volumes you provision.

```
---
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-anf-1
  namespace: trident
spec:
  version: 1
  storageDriverName: azure-netapp-files
  subscriptionID: 9f87c765-4774-fake-ae98-a721add45451
  tenantID: 68e4f836-edc1-fake-bff9-b2d865ee56cf
  clientID: dd043f63-bf8e-fake-8076-8de91e5713aa
  clientSecret: SECRET
  location: eastus
```

## Managed identities for AKS

This backend configuration omits `subscriptionID`, `tenantID`, `clientID`, and `clientSecret`, which are optional when using managed identities.

```
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-anf-1
  namespace: trident
spec:
  version: 1
  storageDriverName: azure-netapp-files
  capacityPools: ["ultra-pool"]
  resourceGroups: ["aks-ami-eastus-rg"]
  netappAccounts: ["smb-na"]
  virtualNetwork: eastus-prod-vnet
  subnet: eastus-anf-subnet
```

## Cloud identity for AKS

This backend configuration omits `tenantID`, `clientID`, and `clientSecret`, which are optional when using a cloud identity.

```
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-anf-1
  namespace: trident
spec:
  version: 1
  storageDriverName: azure-netapp-files
  capacityPools: ["ultra-pool"]
  resourceGroups: ["aks-ami-eastus-rg"]
  netappAccounts: ["smb-na"]
  virtualNetwork: eastus-prod-vnet
  subnet: eastus-anf-subnet
  location: eastus
  subscriptionID: 9f87c765-4774-fake-ae98-a721add45451
```

## Specific service level configuration with capacity pool filters

This backend configuration places volumes in Azure's `eastus` location in an `Ultra` capacity pool. Trident automatically discovers all of the subnets delegated to Azure NetApp Files in that location and places a new volume on one of them randomly.

```
---
version: 1
storageDriverName: azure-netapp-files
subscriptionID: 9f87c765-4774-fake-ae98-a721add45451
tenantID: 68e4f836-edc1-fake-bff9-b2d865ee56cf
clientID: dd043f63-bf8e-fake-8076-8de91e5713aa
clientSecret: SECRET
location: eastus
serviceLevel: Ultra
capacityPools:
- application-group-1/account-1/ultra-1
- application-group-1/account-1/ultra-2
```

## Advanced configuration

This backend configuration further reduces the scope of volume placement to a single subnet, and also modifies some volume provisioning defaults.

```
---
```

```
version: 1
storageDriverName: azure-netapp-files
subscriptionID: 9f87c765-4774-fake-ae98-a721add45451
tenantID: 68e4f836-edc1-fake-bff9-b2d865ee56cf
clientID: dd043f63-bf8e-fake-8076-8de91e5713aa
clientSecret: SECRET
location: eastus
serviceLevel: Ultra
capacityPools:
- application-group-1/account-1/ultra-1
- application-group-1/account-1/ultra-2
virtualNetwork: my-virtual-network
subnet: my-subnet
networkFeatures: Standard
nfsMountOptions: vers=3,proto=tcp,timeo=600
limitVolumeSize: 500Gi
defaults:
  exportRule: 10.0.0.0/24,10.0.1.0/24,10.0.2.100
  snapshotDir: 'true'
  size: 200Gi
  unixPermissions: '0777'
```

## Virtual pool configuration

This backend configuration defines multiple storage pools in a single file. This is useful when you have multiple capacity pools supporting different service levels and you want to create storage classes in Kubernetes that represent those. Virtual pool labels were used to differentiate the pools based on performance.

```
---
```

```
version: 1
storageDriverName: azure-netapp-files
subscriptionID: 9f87c765-4774-fake-ae98-a721add45451
tenantID: 68e4f836-edc1-fake-bff9-b2d865ee56cf
clientID: dd043f63-bf8e-fake-8076-8de91e5713aa
clientSecret: SECRET
location: eastus
resourceGroups:
- application-group-1
networkFeatures: Basic
nfsMountOptions: vers=3,proto=tcp,timeo=600
labels:
  cloud: azure
storage:
- labels:
    performance: gold
    serviceLevel: Ultra
    capacityPools:
    - ultra-1
    - ultra-2
    networkFeatures: Standard
- labels:
    performance: silver
    serviceLevel: Premium
    capacityPools:
    - premium-1
- labels:
    performance: bronze
    serviceLevel: Standard
    capacityPools:
    - standard-1
    - standard-2
```

## Supported topologies configuration

Trident facilitates provisioning of volumes for workloads based on regions and availability zones. The `supportedTopologies` block in this backend configuration is used to provide a list of regions and zones per backend. The region and zone values specified here must match the region and zone values from the labels on each Kubernetes cluster node. These regions and zones represent the list of permissible values that can be provided in a storage class. For storage classes that contain a subset of the regions and zones provided in a backend, Trident creates volumes in the mentioned region and zone. For more information, refer to [Use CSI Topology](#).

```
---
version: 1
storageDriverName: azure-netapp-files
subscriptionID: 9f87c765-4774-fake-ae98-a721add45451
tenantID: 68e4f836-edc1-fake-bff9-b2d865ee56cf
clientID: dd043f63-bf8e-fake-8076-8de91e5713aa
clientSecret: SECRET
location: eastus
serviceLevel: Ultra
capacityPools:
- application-group-1/account-1/ultra-1
- application-group-1/account-1/ultra-2
supportedTopologies:
- topology.kubernetes.io/region: eastus
  topology.kubernetes.io/zone: eastus-1
- topology.kubernetes.io/region: eastus
  topology.kubernetes.io/zone: eastus-2
```

## Storage class definitions

The following `StorageClass` definitions refer to the storage pools above.

### Example definitions using `parameter.selector` field

Using `parameter.selector` you can specify for each `StorageClass` the virtual pool that is used to host a volume. The volume will have the aspects defined in the chosen pool.

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: gold
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=gold"
allowVolumeExpansion: true
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: silver
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=silver"
allowVolumeExpansion: true
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: bronze
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=bronze"
allowVolumeExpansion: true
```

## Example definitions for SMB volumes

Using `nasType`, `node-stage-secret-name`, and `node-stage-secret-namespace`, you can specify an SMB volume and provide the required Active Directory credentials.

## Basic configuration on default namespace

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: anf-sc-smb
provisioner: csi.trident.netapp.io
parameters:
  backendType: "azure-netapp-files"
  trident.netapp.io/nasType: "smb"
  csi.storage.k8s.io/node-stage-secret-name: "smbcreds"
  csi.storage.k8s.io/node-stage-secret-namespace: "default"
```

## Using different secrets per namespace

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: anf-sc-smb
provisioner: csi.trident.netapp.io
parameters:
  backendType: "azure-netapp-files"
  trident.netapp.io/nasType: "smb"
  csi.storage.k8s.io/node-stage-secret-name: "smbcreds"
  csi.storage.k8s.io/node-stage-secret-namespace: ${pvc.namespace}
```

## Using different secrets per volume

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: anf-sc-smb
provisioner: csi.trident.netapp.io
parameters:
  backendType: "azure-netapp-files"
  trident.netapp.io/nasType: "smb"
  csi.storage.k8s.io/node-stage-secret-name: ${pvc.name}
  csi.storage.k8s.io/node-stage-secret-namespace: ${pvc.namespace}
```



nasType: smb filters for pools which support SMB volumes. nasType: nfs or nasType: null filters for NFS pools.

### Create the backend

After you create the backend configuration file, run the following command:

```
tridentctl create backend -f <backend-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.

## Google Cloud NetApp Volumes

### Configure a Google Cloud NetApp Volumes backend

You can now configure Google Cloud NetApp Volumes as the backend for Trident. You can attach NFS volumes using a Google Cloud NetApp Volumes backend.

#### Google Cloud NetApp Volumes driver details

Trident provides the `google-cloud-netapp-volumes` driver to communicate with the cluster. Supported access modes are: `ReadWriteOnce` (RWO), `ReadOnlyMany` (ROX), `ReadWriteMany` (RWX), `ReadWriteOncePod` (RWOP).

Driver	Protocol	volumeMode	Access modes supported	File systems supported
google-cloud-netapp-volumes	NFS	Filesystem	RWO, ROX, RWX, RWOP	nfs

### Cloud identity for GKE

Cloud identity enables Kubernetes pods to access Google Cloud resources by authenticating as a workload identity instead of by providing explicit Google Cloud credentials.

To take advantage of cloud identity in Google Cloud, you must have:

- A Kubernetes cluster deployed using GKE.
- Workload identity configured on the GKE cluster and GKE MetaData Server configured on the node pools.
- A GCP Service account with the Google Cloud NetApp Volumes Admin (roles/netapp.admin) role or a custom role.
- Trident installed that includes the cloudProvider to specify "GCP" and cloudIdentity specifying the new GCP service account. An example is given below.

## Trident operator

To install Trident using the Trident operator, edit `tridentoperator_cr.yaml` to set `cloudProvider` to "GCP" and set `cloudIdentity` to `iam.gke.io/gcp-service-account: cloudvolumes-admin-sa@mygcpproject.iam.gserviceaccount.com`.

For example:

```
apiVersion: trident.netapp.io/v1
kind: TridentOrchestrator
metadata:
  name: trident
spec:
  debug: true
  namespace: trident
  imagePullPolicy: IfNotPresent
  cloudProvider: "GCP"
  cloudIdentity: 'iam.gke.io/gcp-service-account: cloudvolumes-
admin-sa@mygcpproject.iam.gserviceaccount.com'
```

## Helm

Set the values for **cloud-provider (CP)** and **cloud-identity (CI)** flags using the following environment variables:

```
export CP="GCP"
export ANNOTATION="iam.gke.io/gcp-service-account: cloudvolumes-admin-
sa@mygcpproject.iam.gserviceaccount.com"
```

The following example installs Trident and sets `cloudProvider` to GCP using the environment variable `$CP` and sets the `cloudIdentity` using the environment variable `$ANNOTATION`:

```
helm install trident trident-operator-100.2406.0.tgz --set
cloudProvider=$CP --set cloudIdentity="$ANNOTATION"
```

`tridentctl`

Set the values for **cloud provider** and **cloud identity** flags using the following environment variables:

```
export CP="GCP"
export ANNOTATION="iam.gke.io/gcp-service-account: cloudvolumes-admin-
sa@mygcpproject.iam.gserviceaccount.com"
```

The following example installs Trident and sets the `cloud-provider` flag to `$CP`, and `cloud-identity` to `$ANNOTATION`:

```
tridentctl install --cloud-provider=$CP --cloud
-identity="$ANNOTATION" -n trident
```

## Prepare to configure a Google Cloud NetApp Volumes backend

Before you can configure your Google Cloud NetApp Volumes backend, you need to ensure the following requirements are met.

### Prerequisites for NFS volumes

If you are using Google Cloud NetApp Volumes for the first time or in a new location, some initial configuration is required to set up Google Cloud NetApp Volumes and create an NFS volume. Refer to [Before you begin](#).

Ensure that you have the following before configuring Google Cloud NetApp Volumes backend:

- A Google Cloud account configured with Google Cloud NetApp Volumes service. Refer to [Google Cloud NetApp Volumes](#).
- Project number of your Google Cloud account. Refer to [Identifying projects](#).
- A Google Cloud service account with the NetApp Volumes Admin (`roles/netapp.admin`) role. Refer to [Identity and Access Management roles and permissions](#).
- API key file for your GCNV account. Refer to [Create a service account key](#)
- A storage pool. Refer to [Storage pools overview](#) .

For more information about how to set up access to Google Cloud NetApp Volumes, refer to [Set up access to Google Cloud NetApp Volumes](#).

## Google Cloud NetApp Volumes backend configuration options and examples

Learn about NFS backend configuration options for Google Cloud NetApp Volumes and review configuration examples.

### Backend configuration options

Each backend provisions volumes in a single Google Cloud region. To create volumes in other regions, you can define additional backends.

Parameter	Description	Default
version		Always 1
storageDriverName	Name of the storage driver	The value of <code>storageDriverName</code> must be specified as "google-cloud-netapp-volumes".
backendName	(Optional) Custom name of the storage backend	Driver name + "_" + part of API key

Parameter	Description	Default
storagePools	Optional parameter used to specify storage pools for volume creation.	
projectNumber	Google Cloud account project number. The value is found on the Google Cloud portal home page.	
location	<p>The Google Cloud location where Trident creates GCNV volumes. When creating cross-region Kubernetes clusters, volumes created in a location can be used in workloads scheduled on nodes across multiple Google Cloud regions.</p> <p>Cross-region traffic incurs an additional cost.</p>	
apiKey	<p>API key for the Google Cloud service account with the netapp.admin role.</p> <p>It includes the JSON-formatted contents of a Google Cloud service account's private key file (copied verbatim into the backend configuration file).</p> <p>The apiKey must include key-value pairs for the following keys: type, project_id, client_email, client_id, auth_uri, token_uri, auth_provider_x509_cert_url, and client_x509_cert_url.</p>	
nfsMountOptions	Fine-grained control of NFS mount options.	"nfsvers=3"
limitVolumeSize	Fail provisioning if the requested volume size is above this value.	"" (not enforced by default)
serviceLevel	The service level of a storage pool and its volumes. The values are flex, standard, premium, or extreme.	
network	Google Cloud network used for GCNV volumes.	
debugTraceFlags	<p>Debug flags to use when troubleshooting. Example, {"api":false, "method":true}.</p> <p>Do not use this unless you are troubleshooting and require a detailed log dump.</p>	null
supportedTopologies	<p>Represents a list of regions and zones that are supported by this backend.</p> <p>For more information, refer to <a href="#">Use CSI Topology</a>.  For example:</p> <pre> supportedTopologies: - topology.kubernetes.io/region: asia-east1 topology.kubernetes.io/zone: asia-east1-a </pre>	

## Volume provisioning options

You can control default volume provisioning in the `defaults` section of the configuration file.

Parameter	Description	Default
<code>exportRule</code>	The export rules for new volumes. Must be a comma-separated list of any combination of IPv4 addresses.	"0.0.0.0/0"
<code>snapshotDir</code>	Access to the <code>.snapshot</code> directory	"true" for NFSv4 "false" for NFSv3
<code>snapshotReserve</code>	Percentage of volume reserved for snapshots	"" (accept default of 0)
<code>unixPermissions</code>	The unix permissions of new volumes (4 octal digits).	""

## Example configurations

The following examples show basic configurations that leave most parameters to default. This is the easiest way to define a backend.

## Minimal configuration

This is the absolute minimum backend configuration. With this configuration, Trident discovers all of your storage pools delegated to Google Cloud NetApp Volumes in the configured location, and places new volumes on one of those pools randomly. Because `nasType` is omitted, the `nfs` default applies and the backend will provision for NFS volumes.

This configuration is ideal when you are just getting started with Google Cloud NetApp Volumes and trying things out, but in practice you will most likely need to provide additional scoping for the volumes you provision.

```
XsYg6gyxy4zq70lwWgLwGa==\n
-----END PRIVATE KEY-----\n
```

```
---
```

```
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-gcnv
spec:
  version: 1
  storageDriverName: google-cloud-netapp-volumes
  projectNumber: '123455380079'
  location: europe-west6
  serviceLevel: premium
  apiKey:
    type: service_account
    project_id: my-gcnv-project
    client_email: myproject-prod@my-gcnv-
project.iam.gserviceaccount.com
    client_id: '103346282737811234567'
    auth_uri: https://accounts.google.com/o/oauth2/auth
    token_uri: https://oauth2.googleapis.com/token
    auth_provider_x509_cert_url:
      https://www.googleapis.com/oauth2/v1/certs
    client_x509_cert_url:
      https://www.googleapis.com/robot/v1/metadata/x509/myproject-prod%40my-
gcnv-project.iam.gserviceaccount.com
  credentials:
    name: backend-tbc-gcnv-secret
```

## Configuration with StoragePools filter

```
apiVersion: v1
kind: Secret
metadata:
  name: backend-tbc-gcnv-secret
type: Opaque
stringData:
  private_key_id: 'f2cb6ed6d7cc10c453f7d3406fc700c5df0ab9ec'
  private_key: |
    -----BEGIN PRIVATE KEY-----
    znHczZsrrtHisIsAbOguSaPIKeyAZNchRAGzlzZE4jK3b1/qp8B4Kws8zX5ojY9m
    XsYg6gyxy4zq7OlwWgLwGa==
    -----END PRIVATE KEY-----
    ----
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-gcnv
spec:
```

```
version: 1
storageDriverName: google-cloud-netapp-volumes
projectNumber: '123455380079'
location: europe-west6
serviceLevel: premium
storagePools:
- premium-pool1-europe-west6
- premium-pool2-europe-west6
apiKey:
  type: service_account
  project_id: my-gcnv-project
  client_email: myproject-prod@my-gcnv-
project.iam.gserviceaccount.com
  client_id: '103346282737811234567'
  auth_uri: https://accounts.google.com/o/oauth2/auth
  token_uri: https://oauth2.googleapis.com/token
  auth_provider_x509_cert_url:
https://www.googleapis.com/oauth2/v1/certs
  client_x509_cert_url:
https://www.googleapis.com/robot/v1/metadata/x509/myproject-prod%40my-
gcnv-project.iam.gserviceaccount.com
credentials:
  name: backend-tbc-gcnv-secret
```

## Virtual pool configuration

This backend configuration defines multiple virtual pools in a single file. Virtual pools are defined in the storage section. They are useful when you have multiple storage pools supporting different service levels and you want to create storage classes in Kubernetes that represent those. Virtual pool labels are used to differentiate the pools. For instance, in the example below `performance` label and `serviceLevel` type is used to differentiate virtual pools.

You can also set some default values to be applicable to all virtual pools, and overwrite the default values for individual virtual pools. In the following example, `snapshotReserve` and `exportRule` serve as defaults for all virtual pools.

For more information, refer to [Virtual pools](#).

```

znHczzsrrtHisIsAbOguSaPIKeyAZNchRAGzlzzE4jK3b1/qp8B4Kws8zX5ojY9m
znHczzsrrtHisIsAbOguSaPIKeyAZNchRAGzlzzE4jK3b1/qp8B4Kws8zX5ojY9m
znHczzsrrtHisIsAbOguSaPIKeyAZNchRAGzlzzE4jK3b1/qp8B4Kws8zX5ojY9m
XsYg6gyxy4zq70lwWgLwGa==
-----END PRIVATE KEY-----

---

apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-gcnv
spec:
  version: 1
  storageDriverName: google-cloud-netapp-volumes
  projectNumber: '123455380079'
  location: europe-west6
  apiKey:
    type: service_account
    project_id: my-gcnv-project
    client_email: myproject-prod@my-gcnv-
project.iam.gserviceaccount.com
    client_id: '103346282737811234567'
    auth_uri: https://accounts.google.com/o/oauth2/auth
    token_uri: https://oauth2.googleapis.com/token
    auth_provider_x509_cert_url:
      https://www.googleapis.com/oauth2/v1/certs
    client_x509_cert_url:
      https://www.googleapis.com/robot/v1/metadata/x509/myproject-prod%40my-
gcnv-project.iam.gserviceaccount.com
  credentials:
    name: backend-tbc-gcnv-secret
  defaults:
    snapshotReserve: '10'
    exportRule: 10.0.0.0/24
  storage:
    - labels:
        performance: extreme
        serviceLevel: extreme
        defaults:
          snapshotReserve: '5'
          exportRule: 0.0.0.0/0
    - labels:
        performance: premium
        serviceLevel: premium
    - labels:

```

```
  performance: standard
  serviceLevel: standard
```

## Cloud identity for GKE

```
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-gcp-gcnv
spec:
  version: 1
  storageDriverName: google-cloud-netapp-volumes
  projectNumber: '012345678901'
  network: gcnv-network
  location: us-west2
  serviceLevel: Premium
  storagePool: pool-premium1
```

## Supported topologies configuration

Trident facilitates provisioning of volumes for workloads based on regions and availability zones. The `supportedTopologies` block in this backend configuration is used to provide a list of regions and zones per backend. The region and zone values specified here must match the region and zone values from the labels on each Kubernetes cluster node. These regions and zones represent the list of permissible values that can be provided in a storage class. For storage classes that contain a subset of the regions and zones provided in a backend, Trident creates volumes in the mentioned region and zone. For more information, refer to [Use CSI Topology](#).

```
---
version: 1
storageDriverName: google-cloud-netapp-volumes
subscriptionID: 9f87c765-4774-fake-ae98-a721add45451
tenantID: 68e4f836-edc1-fake-bff9-b2d865ee56cf
clientID: dd043f63-bf8e-fake-8076-8de91e5713aa
clientSecret: SECRET
location: asia-east1
serviceLevel: flex
supportedTopologies:
- topology.kubernetes.io/region: asia-east1
  topology.kubernetes.io/zone: asia-east1-a
- topology.kubernetes.io/region: asia-east1
  topology.kubernetes.io/zone: asia-east1-b
```

## What's next?

After you create the backend configuration file, run the following command:

```
kubectl create -f <backend-file>
```

To verify that the backend is successfully created, run the following command:

```
kubectl get tridentbackendconfig
```

NAME	BACKEND NAME	BACKEND UUID
PHASE STATUS		
backend-tbc-gcnv	backend-tbc-gcnv	b2fd1ff9-b234-477e-88fd-713913294f65
Bound Success		

If the backend creation fails, something is wrong with the backend configuration. You can describe the backend using the `kubectl get tridentbackendconfig <backend-name>` command or 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 delete the backend and run the create command again.

## More examples

### Storage class definition examples

The following is a basic `StorageClass` definition that refers to the backend above.

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: gcnv-nfs-sc
provisioner: csi.trident.netapp.io
parameters:
  backendType: "google-cloud-netapp-volumes"
```

### Example definitions using the `parameter.selector` field:

Using `parameter.selector` you can specify for each `StorageClass` the [virtual pool](#) that is used to host a volume. The volume will have the aspects defined in the chosen pool.

```

apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: extreme-sc
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=extreme"
  backendType: "google-cloud-netapp-volumes"
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: premium-sc
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=premium"
  backendType: "google-cloud-netapp-volumes"
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: standard-sc
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=standard"
  backendType: "google-cloud-netapp-volumes"

```

For more details on storage classes, refer to [Create a storage class](#).

### PVC definition example

```

kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: gcnv-nfs-pvc
spec:
  accessModes:
    - ReadWriteMany
  resources:
    requests:
      storage: 100Gi
  storageClassName: gcnv-nfs-sc

```

To verify if the PVC is bound, run the following command:

```
kubectl get pvc gcnv-nfs-pvc
```

NAME	STATUS	VOLUME	CAPACITY
ACCESS MODES	STORAGECLASS	AGE	
gcnv-nfs-pvc	Bound	pvc-b00f2414-e229-40e6-9b16-ee03eb79a213	100Gi
RWX	gcnv-nfs-sc	1m	

## Configure a Cloud Volumes Service for Google Cloud backend

Learn how to configure NetApp Cloud Volumes Service for Google Cloud as the backend for your Trident installation using the sample configurations provided.

### Google Cloud driver details

Trident provides the `gcp-cvs` driver to communicate with the cluster. Supported access modes are: `ReadWriteOnce` (RWO), `ReadOnlyMany` (ROX), `ReadWriteMany` (RWX), `ReadWriteOncePod` (RWOP).

Driver	Protocol	volumeMode	Access modes supported	File systems supported
gcp-cvs	NFS	Filesystem	RWO, ROX, RWX, RWOP	nfs

### Learn about Trident support for Cloud Volumes Service for Google Cloud

Trident can create Cloud Volumes Service volumes in one of two [service types](#):

- **CVS-Performance:** The default Trident service type. This performance-optimized service type is best suited for production workloads that value performance. The CVS-Performance service type is a hardware option supporting volumes with a minimum 100 GiB size. You can choose one of [three service levels](#):
  - standard
  - premium
  - extreme
- **CVS:** The CVS service type provides high zonal availability with limited to moderate performance levels. The CVS service type is a software option that uses storage pools to support volumes as small as 1 GiB. The storage pool can contain up to 50 volumes where all volumes share the capacity and performance of the pool. You can choose one of [two service levels](#):
  - standardsw
  - zoneredundantstandardsw

### What you'll need

To configure and use the [Cloud Volumes Service for Google Cloud](#) backend, you need the following:

- A Google Cloud account configured with NetApp Cloud Volumes Service
- Project number of your Google Cloud account
- Google Cloud service account with the `netappcloudvolumes.admin` role

- API key file for your Cloud Volumes Service account

## Backend configuration options

Each backend provisions volumes in a single Google Cloud region. To create volumes in other regions, you can define additional backends.

Parameter	Description	Default
version		Always 1
storageDriverName	Name of the storage driver	"gcp-cvs"
backendName	Custom name or the storage backend	Driver name + "_" + part of API key
storageClass	<p>Optional parameter used to specify the CVS service type.</p> <p>Use <code>software</code> to select the CVS service type. Otherwise, Trident assumes CVS-Performance service type (<code>hardware</code>).</p>	
storagePools	CVS service type only. Optional parameter used to specify storage pools for volume creation.	
projectNumber	Google Cloud account project number. The value is found on the Google Cloud portal home page.	
hostProjectNumber	Required if using a shared VPC network. In this scenario, <code>projectNumber</code> is the service project, and <code>hostProjectNumber</code> is the host project.	
apiRegion	<p>The Google Cloud region where Trident creates Cloud Volumes Service volumes. When creating cross-region Kubernetes clusters, volumes created in an <code>apiRegion</code> can be used in workloads scheduled on nodes across multiple Google Cloud regions.</p> <p>Cross-region traffic incurs an additional cost.</p>	
apiKey	<p>API key for the Google Cloud service account with the <code>netappcloudvolumes.admin</code> role.</p> <p>It includes the JSON-formatted contents of a Google Cloud service account's private key file (copied verbatim into the backend configuration file).</p>	
proxyURL	<p>Proxy URL if proxy server required to connect to CVS account. The proxy server can either be an HTTP proxy or an HTTPS proxy.</p> <p>For an HTTPS proxy, certificate validation is skipped to allow the usage of self-signed certificates in the proxy server.</p> <p>Proxy servers with authentication enabled are not supported.</p>	

Parameter	Description	Default
nfsMountOptions	Fine-grained control of NFS mount options.	"nfsvers=3"
limitVolumeSize	Fail provisioning if the requested volume size is above this value.	"" (not enforced by default)
serviceLevel	<p>The CVS-Performance or CVS service level for new volumes.</p> <p>CVS-Performance values are standard, premium, or extreme.</p> <p>CVS values are standardsw or zoneredundantstandardsw.</p>	<p>CVS-Performance default is "standard".</p> <p>CVS default is "standardsw".</p>
network	Google Cloud network used for Cloud Volumes Service volumes.	"default"
debugTraceFlags	<p>Debug flags to use when troubleshooting. Example, \{"api":false, "method":true}.</p> <p>Do not use this unless you are troubleshooting and require a detailed log dump.</p>	null
allowedTopologies	<p>To enable cross-region access, your StorageClass definition for allowedTopologies must include all regions.</p> <p>For example:</p> <ul style="list-style-type: none"> <li>- key: topology.kubernetes.io/region</li> <li>- values:</li> <li>- us-east1</li> <li>- europe-west1</li> </ul>	

## Volume provisioning options

You can control default volume provisioning in the defaults section of the configuration file.

Parameter	Description	Default
exportRule	The export rules for new volumes. Must be a comma-separated list of any combination of IPv4 addresses or IPv4 subnets in CIDR notation.	"0.0.0.0/0"
snapshotDir	Access to the .snapshot directory	"false"
snapshotReserve	Percentage of volume reserved for snapshots	"" (accept CVS default of 0)
size	<p>The size of new volumes.</p> <p>CVS-Performance minimum is 100 GiB.</p> <p>CVS minimum is 1 GiB.</p>	<p>CVS-Performance service type defaults to "100GiB".</p> <p>CVS service type does not set a default but requires a 1 GiB minimum.</p>

## CVS-Performance service type examples

The following examples provide sample configurations for the CVS-Performance service type.

### Example 1: Minimal configuration

This is the minimum backend configuration using default CVS-Performance service type with the default "standard" service level.

```
---
version: 1
storageDriverName: gcp-cvs
projectNumber: '012345678901'
apiRegion: us-west2
apiKey:
  type: service_account
  project_id: my-gcp-project
  private_key_id: "<id_value>"
  private_key: |
    -----BEGIN PRIVATE KEY-----
    <key_value>
    -----END PRIVATE KEY-----
client_email: cloudvolumes-admin-sa@my-gcp-
project.iam.gserviceaccount.com
client_id: '123456789012345678901'
auth_uri: https://accounts.google.com/o/oauth2/auth
token_uri: https://oauth2.googleapis.com/token
auth_provider_x509_cert_url:
https://www.googleapis.com/oauth2/v1/certs
client_x509_cert_url:
https://www.googleapis.com/robot/v1/metadata/x509/cloudvolumes-admin-
sa%40my-gcp-project.iam.gserviceaccount.com
```

## Example 2: Service level configuration

This sample illustrates backend configuration options, including service level, and volume defaults.

```
---
version: 1
storageDriverName: gcp-cvs
projectNumber: '012345678901'
apiRegion: us-west2
apiKey:
  type: service_account
  project_id: my-gcp-project
  private_key_id: "<id_value>"
  private_key: |
    -----BEGIN PRIVATE KEY-----
    <key_value>
    -----END PRIVATE KEY-----
  client_email: cloudvolumes-admin-sa@my-gcp-
project.iam.gserviceaccount.com
  client_id: '123456789012345678901'
  auth_uri: https://accounts.google.com/o/oauth2/auth
  token_uri: https://oauth2.googleapis.com/token
  auth_provider_x509_cert_url:
    https://www.googleapis.com/oauth2/v1/certs
  client_x509_cert_url:
    https://www.googleapis.com/robot/v1/metadata/x509/cloudvolumes-admin-
sa%40my-gcp-project.iam.gserviceaccount.com
  proxyURL: http://proxy-server-hostname/
  nfsMountOptions: vers=3,proto=tcp,timeo=600
  limitVolumeSize: 10Ti
  serviceLevel: premium
  defaults:
    snapshotDir: 'true'
    snapshotReserve: '5'
    exportRule: 10.0.0.0/24,10.0.1.0/24,10.0.2.100
    size: 5Ti
```

### Example 3: Virtual pool configuration

This sample uses storage to configure virtual pools and the StorageClasses that refer back to them. Refer to [Storage class definitions](#) to see how the storage classes were defined.

Here, specific defaults are set for all virtual pools, which set the `snapshotReserve` at 5% and the `exportRule` to 0.0.0.0/0. The virtual pools are defined in the `storage` section. Each individual virtual pool defines its own `serviceLevel`, and some pools overwrite the default values. Virtual pool labels were used to differentiate the pools based on performance and protection.

```
---
version: 1
storageDriverName: gcp-cvs
projectNumber: '012345678901'
apiRegion: us-west2
apiKey:
  type: service_account
  project_id: my-gcp-project
  private_key_id: "<id_value>"
  private_key: |
    -----BEGIN PRIVATE KEY-----
    <key_value>
    -----END PRIVATE KEY-----
client_email: cloudvolumes-admin-sa@my-gcp-
project.iam.gserviceaccount.com
client_id: '123456789012345678901'
auth_uri: https://accounts.google.com/o/oauth2/auth
token_uri: https://oauth2.googleapis.com/token
auth_provider_x509_cert_url:
https://www.googleapis.com/oauth2/v1/certs
client_x509_cert_url:
https://www.googleapis.com/robot/v1/metadata/x509/cloudvolumes-admin-
sa%40my-gcp-project.iam.gserviceaccount.com
nfsMountOptions: vers=3,proto=tcp,timeo=600
defaults:
  snapshotReserve: '5'
  exportRule: 0.0.0.0/0
labels:
  cloud: gcp
region: us-west2
storage:
- labels:
  performance: extreme
  protection: extra
  serviceLevel: extreme
  defaults:
    snapshotDir: 'true'
```

```
snapshotReserve: '10'
  exportRule: 10.0.0.0/24
- labels:
  performance: extreme
  protection: standard
  serviceLevel: extreme
- labels:
  performance: premium
  protection: extra
  serviceLevel: premium
  defaults:
    snapshotDir: 'true'
    snapshotReserve: '10'
- labels:
  performance: premium
  protection: standard
  serviceLevel: premium
- labels:
  performance: standard
  serviceLevel: standard
```

## Storage class definitions

The following StorageClass definitions apply to the virtual pool configuration example. Using `parameters.selector`, you can specify for each StorageClass the virtual pool used to host a volume. The volume will have the aspects defined in the chosen pool.

## Storage class example

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: cvs-extreme-extra-protection
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=extreme; protection=extra"
allowVolumeExpansion: true
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: cvs-extreme-standard-protection
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=premium; protection=standard"
allowVolumeExpansion: true
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: cvs-premium-extra-protection
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=premium; protection=extra"
allowVolumeExpansion: true
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: cvs-premium
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=premium; protection=standard"
allowVolumeExpansion: true
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: cvs-standard
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=standard"
allowVolumeExpansion: true
```

```
---  
apiVersion: storage.k8s.io/v1  
kind: StorageClass  
metadata:  
  name: cvs-extra-protection  
provisioner: csi.trident.netapp.io  
parameters:  
  selector: "protection=extra"  
allowVolumeExpansion: true
```

- The first StorageClass (cvs-extreme-extra-protection) maps to the first virtual pool. This is the only pool offering extreme performance with a snapshot reserve of 10%.
- The last StorageClass (cvs-extra-protection) calls out any storage pool which provides a snapshot reserve of 10%. Trident decides which virtual pool is selected and ensures that the snapshot reserve requirement is met.

### **CVS service type examples**

The following examples provide sample configurations for the CVS service type.

## Example 1: Minimum configuration

This is the minimum backend configuration using `storageClass` to specify the CVS service type and default `standardsw` service level.

```
---
version: 1
storageDriverName: gcp-cvs
projectNumber: '012345678901'
storageClass: software
apiRegion: us-east4
apiKey:
  type: service_account
  project_id: my-gcp-project
  private_key_id: "<id_value>"
  private_key: |
    -----BEGIN PRIVATE KEY-----
    <key_value>
    -----END PRIVATE KEY-----
client_email: cloudvolumes-admin-sa@my-gcp-
project.iam.gserviceaccount.com
client_id: '123456789012345678901'
auth_uri: https://accounts.google.com/o/oauth2/auth
token_uri: https://oauth2.googleapis.com/token
auth_provider_x509_cert_url:
  https://www.googleapis.com/oauth2/v1/certs
  client_x509_cert_url:
  https://www.googleapis.com/robot/v1/metadata/x509/cloudvolumes-admin-
sa%40my-gcp-project.iam.gserviceaccount.com
serviceLevel: standardsw
```

## Example 2: Storage pool configuration

This sample backend configuration uses `storagePools` to configure a storage pool.

```
---
version: 1
storageDriverName: gcp-cvs
backendName: gcp-std-so-with-pool
projectNumber: '531265380079'
apiRegion: europe-west1
apiKey:
  type: service_account
  project_id: cloud-native-data
  private_key_id: "<id_value>"
  private_key: |-
    -----BEGIN PRIVATE KEY-----
    <key_value>
    -----END PRIVATE KEY-----
client_email: cloudvolumes-admin-sa@cloud-native-
data.iam.gserviceaccount.com
client_id: '107071413297115343396'
auth_uri: https://accounts.google.com/o/oauth2/auth
token_uri: https://oauth2.googleapis.com/token
auth_provider_x509_cert_url:
  https://www.googleapis.com/oauth2/v1/certs
  client_x509_cert_url:
  https://www.googleapis.com/robot/v1/metadata/x509/cloudvolumes-admin-
sa%40cloud-native-data.iam.gserviceaccount.com
storageClass: software
zone: europe-west1-b
network: default
storagePools:
- 1bc7f380-3314-6005-45e9-c7dc8c2d7509
serviceLevel: Standardsw
```

## What's next?

After you create the backend configuration file, run the following command:

```
tridentctl create backend -f <backend-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.

## Configure a NetApp HCI or SolidFire backend

Learn how to create and use an Element backend with your Trident installation.

### Element driver details

Trident provides the `solidfire-san` storage driver to communicate with the cluster. Supported access modes are: `ReadWriteOnce` (RWO), `ReadOnlyMany` (ROX), `ReadWriteMany` (RWX), `ReadWriteOncePod` (RWOP).

The `solidfire-san` storage driver supports `file` and `block` volume modes. For the `Filesystem` `volumeMode`, Trident creates a volume and creates a filesystem. The filesystem type is specified by the `StorageClass`.

Driver	Protocol	VolumeMode	Access modes supported	File systems supported
solidfire-san	iSCSI	Block	RWO, ROX, RWX, RWOP	No Filesystem. Raw block device.
solidfire-san	iSCSI	Filesystem	RWO, RWOP	xfs, ext3, ext4

### Before you begin

You'll need the following before creating an Element backend.

- A supported storage system that runs Element software.
- Credentials to a NetApp HCI/SolidFire cluster admin or tenant user that can manage volumes.
- All of your Kubernetes worker nodes should have the appropriate iSCSI tools installed. Refer to [worker node preparation information](#).

### Backend configuration options

See the following table for the backend configuration options:

Parameter	Description	Default
version		Always 1
storageDriverName	Name of the storage driver	Always "solidfire-san"
backendName	Custom name or the storage backend	"solidfire_" + storage (iSCSI) IP address
Endpoint	MVIP for the SolidFire cluster with tenant credentials	

Parameter	Description	Default
SVIP	Storage (iSCSI) IP address and port	
labels	Set of arbitrary JSON-formatted labels to apply on volumes.	""
TenantName	Tenant name to use (created if not found)	
InitiatorIFace	Restrict iSCSI traffic to a specific host interface	"default"
UseCHAP	Use CHAP to authenticate iSCSI. Trident uses CHAP.	true
AccessGroups	List of Access Group IDs to use	Finds the ID of an access group named "trident"
Types	QoS specifications	
limitVolumeSize	Fail provisioning if requested volume size is above this value	"" (not enforced by default)
debugTraceFlags	Debug flags to use when troubleshooting. Example, {"api":false, "method":true}	null



Do not use `debugTraceFlags` unless you are troubleshooting and require a detailed log dump.

#### Example 1: Backend configuration for `solidfire-san` driver with three volume types

This example shows a backend file using CHAP authentication and modeling three volume types with specific QoS guarantees. Most likely you would then define storage classes to consume each of these using the `IOPS` storage class parameter.

```
---
version: 1
storageDriverName: solidfire-san
Endpoint: https://<user>:<password>@<mvip>/json-rpc/8.0
SVIP: "<svip>:3260"
TenantName: "<tenant>"
labels:
  k8scluster: dev1
  backend: dev1-element-cluster
UseCHAP: true
Types:
- Type: Bronze
  Qos:
    minIOPS: 1000
    maxIOPS: 2000
    burstIOPS: 4000
- Type: Silver
  Qos:
    minIOPS: 4000
    maxIOPS: 6000
    burstIOPS: 8000
- Type: Gold
  Qos:
    minIOPS: 6000
    maxIOPS: 8000
    burstIOPS: 10000
```

## Example 2: Backend and storage class configuration for solidfire-san driver with virtual pools

This example shows the backend definition file configured with virtual pools along with StorageClasses that refer back to them.

Trident copies labels present on a storage pool to the backend storage LUN at provisioning. For convenience, storage administrators can define labels per virtual pool and group volumes by label.

In the sample backend definition file shown below, specific defaults are set for all storage pools, which set the type at Silver. The virtual pools are defined in the storage section. In this example, some of the storage pools set their own type, and some pools override the default values set above.

```
---
version: 1
storageDriverName: solidfire-san
Endpoint: https://<user>:<password>@<mvip>/json-rpc/8.0
SVIP: "<svip>:3260"
TenantName: "<tenant>"
UseCHAP: true
```

```

Types:
- Type: Bronze
  QoS:
    minIOPS: 1000
    maxIOPS: 2000
    burstIOPS: 4000
- Type: Silver
  QoS:
    minIOPS: 4000
    maxIOPS: 6000
    burstIOPS: 8000
- Type: Gold
  QoS:
    minIOPS: 6000
    maxIOPS: 8000
    burstIOPS: 10000
type: Silver
labels:
  store: solidfire
  k8scluster: dev-1-cluster
region: us-east-1
storage:
- labels:
    performance: gold
    cost: '4'
    zone: us-east-1a
    type: Gold
- labels:
    performance: silver
    cost: '3'
    zone: us-east-1b
    type: Silver
- labels:
    performance: bronze
    cost: '2'
    zone: us-east-1c
    type: Bronze
- labels:
    performance: silver
    cost: '1'
    zone: us-east-1d

```

The following StorageClass definitions refer to the above virtual pools. Using the `parameters.selector` field, each StorageClass calls out which virtual pool(s) can be used to host a volume. The volume will have the aspects defined in the chosen virtual pool.

The first StorageClass (`solidfire-gold-four`) will map to the first virtual pool. This is the only pool offering gold performance with a Volume Type QoS of Gold. The last StorageClass (`solidfire-silver`) calls out any storage pool which offers a silver performance. Trident will decide which virtual pool is selected and ensures the storage requirement is met.

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: solidfire-gold-four
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=gold; cost=4"
  fsType: "ext4"
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: solidfire-silver-three
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=silver; cost=3"
  fsType: "ext4"
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: solidfire-bronze-two
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=bronze; cost=2"
  fsType: "ext4"
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: solidfire-silver-one
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=silver; cost=1"
  fsType: "ext4"
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: solidfire-silver
provisioner: csi.trident.netapp.io
parameters:
  selector: "performance=silver"
  fsType: "ext4"
```

## Find more information

- [Volume access groups](#)

## ONTAP SAN drivers

### ONTAP SAN driver overview

Learn about configuring an ONTAP backend with ONTAP and Cloud Volumes ONTAP SAN drivers.

### ONTAP SAN driver details

Trident provides the following SAN storage drivers to communicate with the ONTAP cluster. Supported access modes are: *ReadWriteOnce* (RWO), *ReadOnlyMany* (ROX), *ReadWriteMany* (RWX), *ReadWriteOncePod* (RWOP).

Driver	Protocol	volumeMode	Access modes supported	File systems supported
ontap-san	iSCSI SCSI over FC (tech preview in Trident 24.10)	Block	RWO, ROX, RWX, RWOP	No filesystem; raw block device
ontap-san	iSCSI SCSI over FC (tech preview in Trident 24.10)	Filesystem	RWO, RWOP  ROX and RWX are not available in Filesystem volume mode.	xfs, ext3, ext4
ontap-san	NVMe/TCP  Refer to <a href="#">Additional considerations for NVMe/TCP</a> .	Block	RWO, ROX, RWX, RWOP	No filesystem; raw block device
ontap-san	NVMe/TCP  Refer to <a href="#">Additional considerations for NVMe/TCP</a> .	Filesystem	RWO, RWOP  ROX and RWX are not available in Filesystem volume mode.	xfs, ext3, ext4

Driver	Protocol	volumeMode	Access modes supported	File systems supported
ontap-san-economy	iSCSI	Block	RWO, ROX, RWX, RWOP	No filesystem; raw block device
ontap-san-economy	iSCSI	Filesystem	RWO, RWOP ROX and RWX are not available in Filesystem volume mode.	xfs, ext3, ext4

 • Use `ontap-san-economy` only if persistent volume usage count is expected to be higher than [supported ONTAP volume limits](#).

• Use `ontap-nas-economy` only if persistent volume usage count is expected to be higher than [supported ONTAP volume limits](#) and the `ontap-san-economy` driver cannot be used.

• Do not use `ontap-nas-economy` if you anticipate the need for data protection, disaster recovery, or mobility.

#### User permissions

Trident expects to be run as either an ONTAP or SVM administrator, typically using the `admin` cluster user or a `vsadmin` SVM user, or a user with a different name that has the same role. For Amazon FSx for NetApp ONTAP deployments, Trident expects to be run as either an ONTAP or SVM administrator, using the cluster `fsxadmin` user or a `vsadmin` SVM user, or a user with a different name that has the same role. The `fsxadmin` user is a limited replacement for the cluster admin user.

 If you use the `limitAggregateUsage` parameter, cluster admin permissions are required.

When using Amazon FSx for NetApp ONTAP with Trident, the `limitAggregateUsage` parameter will not work with the `vsadmin` and `fsxadmin` user accounts. The configuration operation will fail if you specify this parameter.

While it is possible to create a more restrictive role within ONTAP that a Trident driver can use, we don't recommend it. Most new releases of Trident will call additional APIs that would have to be accounted for, making upgrades difficult and error-prone.

#### Additional considerations for NVMe/TCP

Trident supports the non-volatile memory express (NVMe) protocol using the `ontap-san` driver including:

- IPv6
- Snapshots and clones of NVMe volumes
- Resizing an NVMe volume
- Importing an NVMe volume that was created outside of Trident so that its lifecycle can be managed by Trident
- NVMe-native multipathing
- Graceful or ungraceful shutdown of the K8s nodes (24.06)

Trident does not support:

- DH-HMAC-CHAP that is supported by natively by NVMe
- Device mapper (DM) multipathing
- LUKS encryption

## Prepare to configure backend with ONTAP SAN drivers

Understand the requirements and authentication options for configuring an ONTAP backend with ONTAP SAN drivers.

### Requirements

For all ONTAP backends, Trident requires at least one aggregate assigned to the SVM.

Remember that you can also run more than one driver, and create storage classes that point to one or the other. For example, you could configure a `san-dev` class that uses the `ontap-san` driver and a `san-default` class that uses the `ontap-san-economy` one.

All your Kubernetes worker nodes must have the appropriate iSCSI tools installed. Refer to [Prepare the worker node](#) for details.

### Authenticate the ONTAP backend

Trident offers two modes of authenticating an ONTAP backend.

- Credential-based: The username and password to an ONTAP user with the required permissions. It is recommended to use a pre-defined security login role, such as `admin` or `vsadmin` to ensure maximum compatibility with ONTAP versions.
- Certificate-based: Trident can also communicate with an ONTAP cluster using a certificate installed on the backend. Here, the backend definition must contain Base64-encoded values of the client certificate, key, and the trusted CA certificate if used (recommended).

You can update existing backends to move between credential-based and certificate-based methods. However, only one authentication method is supported at a time. To switch to a different authentication method, you must remove the existing method from the backend configuration.



If you attempt to provide **both credentials and certificates**, backend creation will fail with an error that more than one authentication method was provided in the configuration file.

### Enable credential-based authentication

Trident requires the credentials to an SVM-scoped/cluster-scoped admin to communicate with the ONTAP backend. It is recommended to make use of standard, pre-defined roles such as `admin` or `vsadmin`. This ensures forward compatibility with future ONTAP releases that might expose feature APIs to be used by future Trident releases. A custom security login role can be created and used with Trident, but is not recommended.

A sample backend definition will look like this:

## YAML

```
---
version: 1
backendName: ExampleBackend
storageDriverName: ontap-san
managementLIF: 10.0.0.1
svm: svm_nfs
username: vsadmin
password: password
```

## JSON

```
{
  "version": 1,
  "backendName": "ExampleBackend",
  "storageDriverName": "ontap-san",
  "managementLIF": "10.0.0.1",
  "svm": "svm_nfs",
  "username": "vsadmin",
  "password": "password"
}
```

Keep in mind that the backend definition is the only place the credentials are stored in plain text. After the backend is created, usernames/passwords are encoded with Base64 and stored as Kubernetes secrets. The creation or update of a backend is the only step that requires knowledge of the credentials. As such, it is an admin-only operation, to be performed by the Kubernetes/storage administrator.

### Enable certificate-based authentication

New and existing backends can use a certificate and communicate with the ONTAP backend. Three parameters are required in the backend definition.

- clientCertificate: Base64-encoded value of client certificate.
- clientPrivateKey: Base64-encoded value of associated private key.
- trustedCACertificate: Base64-encoded value of trusted CA certificate. If using a trusted CA, this parameter must be provided. This can be ignored if no trusted CA is used.

A typical workflow involves the following steps.

### Steps

1. Generate a client certificate and key. When generating, set Common Name (CN) to the ONTAP user to authenticate as.

```
openssl req -x509 -nodes -days 1095 -newkey rsa:2048 -keyout k8senv.key  
-out k8senv.pem -subj "/C=US/ST=NC/L=RTP/O=NetApp/CN=admin"
```

2. Add trusted CA certificate to the ONTAP cluster. This might be already handled by the storage administrator. Ignore if no trusted CA is used.

```
security certificate install -type server -cert-name <trusted-ca-cert-name> -vserver <vserver-name>  
ssl modify -vserver <vserver-name> -server-enabled true -client-enabled true -common-name <common-name> -serial <SN-from-trusted-CA-cert> -ca <cert-authority>
```

3. Install the client certificate and key (from step 1) on the ONTAP cluster.

```
security certificate install -type client-ca -cert-name <certificate-name> -vserver <vserver-name>  
security ssl modify -vserver <vserver-name> -client-enabled true
```

4. Confirm the ONTAP security login role supports `cert` authentication method.

```
security login create -user-or-group-name admin -application ontapi  
-authentication-method cert  
security login create -user-or-group-name admin -application http  
-authentication-method cert
```

5. Test authentication using certificate generated. Replace <ONTAP Management LIF> and <vserver name> with Management LIF IP and SVM name.

```
curl -X POST -Lk https://<ONTAP-Management-LIF>/servlets/netapp.servlets.admin.XMLrequest_filer --key k8senv.key  
--cert ~/k8senv.pem -d '<?xml version="1.0" encoding="UTF-8"?><netapp  
xmlns="http://www.netapp.com/filer/admin" version="1.21"  
vfiler="<vserver-name>"><vserver-get></vserver-get></netapp>'
```

6. Encode certificate, key and trusted CA certificate with Base64.

```
base64 -w 0 k8senv.pem >> cert_base64  
base64 -w 0 k8senv.key >> key_base64  
base64 -w 0 trustedca.pem >> trustedca_base64
```

7. Create backend using the values obtained from the previous step.

```

cat cert-backend.json
{
  "version": 1,
  "storageDriverName": "ontap-san",
  "backendName": "SanBackend",
  "managementLIF": "1.2.3.4",
  "svm": "vserver_test",
  "clientCertificate": "Faaaakkkeeee...Vaaalllluuuueeee",
  "clientPrivateKey": "LS0tFaKE...0VaLuES0tLS0K",
  "trustedCACertificate": "QNFinfo...SiqOyN",
  "storagePrefix": "myPrefix_"
}

tridentctl create backend -f cert-backend.json -n trident
+-----+-----+
+-----+-----+
|     NAME      | STORAGE DRIVER |          UUID          |
STATE | VOLUMES |
+-----+-----+
+-----+-----+
| SanBackend | ontap-san      | 586b1cd5-8cf8-428d-a76c-2872713612c1 |
online |          0 |          |
+-----+-----+
+-----+-----+

```

### Update authentication methods or rotate credentials

You can update an existing backend to use a different authentication method or to rotate their credentials. This works both ways: backends that make use of username/password can be updated to use certificates; backends that utilize certificates can be updated to username/password based. To do this, you must remove the existing authentication method and add the new authentication method. Then use the updated `backend.json` file containing the required parameters to execute `tridentctl backend update`.

```

cat cert-backend-updated.json
{
  "version": 1,
  "storageDriverName": "ontap-san",
  "backendName": "SanBackend",
  "managementLIF": "1.2.3.4",
  "svm": "vserver_test",
  "username": "vsadmin",
  "password": "password",
  "storagePrefix": "myPrefix_"
}

#Update backend with tridentctl
tridentctl update backend SanBackend -f cert-backend-updated.json -n
trident
+-----+-----+-----+
+-----+-----+
|     NAME      | STORAGE DRIVER |                         UUID                         |
STATE  | VOLUMES | 
+-----+-----+-----+
+-----+-----+
| SanBackend | ontap-san      | 586b1cd5-8cf8-428d-a76c-2872713612c1 |
online |         9 | 
+-----+-----+-----+
+-----+-----+

```

 When rotating passwords, the storage administrator must first update the password for the user on ONTAP. This is followed by a backend update. When rotating certificates, multiple certificates can be added to the user. The backend is then updated to use the new certificate, following which the old certificate can be deleted from the ONTAP cluster.

Updating a backend does not disrupt access to volumes that have already been created, nor impact volume connections made after. A successful backend update indicates that Trident can communicate with the ONTAP backend and handle future volume operations.

### Create custom ONTAP role for Trident

You can create an ONTAP cluster role with minimum privileges so that you do not have to use the ONTAP admin role to perform operations in Trident. When you include the username in a Trident backend configuration, Trident uses the ONTAP cluster role you created to perform the operations.

Refer to [Trident custom-role generator](#) for more information about creating Trident custom roles.

## Using ONTAP CLI

1. Create a new role using the following command:

```
security login role create <role_name> -cmddirname "command" -access all  
-vserver <svm_name>
```

2. Create a username for the Trident user:

```
security login create -username <user_name> -application ontapi  
-authmethod <password> -role <name_of_role_in_step_1> -vserver  
<svm_name> -comment "user_description"
```

3. Map the role to the user:

```
security login modify username <user_name> -vserver <svm_name> -role  
<role_name> -application ontapi -application console -authmethod  
<password>
```

## Using System Manager

Perform the following steps in ONTAP System Manager:

1. **Create a custom role:**

- a. To create a custom role at the cluster-level, select **Cluster > Settings**.

(Or) To create a custom role at the SVM level, select **Storage > Storage VMs > required SVM > Settings > Users and Roles**.

- b. Select the arrow icon (→) next to **Users and Roles**.
- c. Select **+Add** under **Roles**.
- d. Define the rules for the role and click **Save**.

2. **Map the role to the Trident user:**

+ Perform the following steps on the **Users and Roles** page:

- a. Select Add icon **+** under **Users**.
- b. Select the required username, and select a role in the drop-down menu for **Role**.
- c. Click **Save**.

Refer to the following pages for more information:

- [Custom roles for administration of ONTAP](#) or [Define custom roles](#)
- [Work with roles and users](#)

### Authenticate connections with bidirectional CHAP

Trident can authenticate iSCSI sessions with bidirectional CHAP for the `ontap-san` and `ontap-san-economy` drivers. This requires enabling the `useCHAP` option in your backend definition. When set to `true`, Trident configures the SVM's default initiator security to bidirectional CHAP and set the username and secrets from the backend file. NetApp recommends using bidirectional CHAP to authenticate connections. See the following sample configuration:

```
---  
version: 1  
storageDriverName: ontap-san  
backendName: ontap_san_chap  
managementLIF: 192.168.0.135  
svm: ontap_iscsi_svm  
useCHAP: true  
username: vsadmin  
password: password  
chapInitiatorSecret: c19qxIm36DKyawxy  
chapTargetInitiatorSecret: rqxigXgkesIpwxyz  
chapTargetUsername: iJF4heBRT0TCwxyz  
chapUsername: uh2aNCLSd6cNwxyz
```

 The `useCHAP` parameter is a Boolean option that can be configured only once. It is set to false by default. After you set it to true, you cannot set it to false.

In addition to `useCHAP=true`, the `chapInitiatorSecret`, `chapTargetInitiatorSecret`, `chapTargetUsername`, and `chapUsername` fields must be included in the backend definition. The secrets can be changed after a backend is created by running `tridentctl update`.

## How it works

By setting `useCHAP` to true, the storage administrator instructs Trident to configure CHAP on the storage backend. This includes the following:

- Setting up CHAP on the SVM:
  - If the SVM’s default initiator security type is none (set by default) **and** there are no pre-existing LUNs already present in the volume, Trident will set the default security type to CHAP and proceed to configuring the CHAP initiator and target username and secrets.
  - If the SVM contains LUNs, Trident will not enable CHAP on the SVM. This ensures that access to LUNs that are already present on the SVM isn’t restricted.
- Configuring the CHAP initiator and target username and secrets; these options must be specified in the backend configuration (as shown above).

After the backend is created, Trident creates a corresponding `tridentbackend` CRD and stores the CHAP secrets and usernames as Kubernetes secrets. All PVs that are created by Trident on this backend will be mounted and attached over CHAP.

## Rotate credentials and update backends

You can update the CHAP credentials by updating the CHAP parameters in the `backend.json` file. This will require updating the CHAP secrets and using the `tridentctl update` command to reflect these changes.

 When updating the CHAP secrets for a backend, you must use `tridentctl` to update the backend. Do not update the credentials on the storage cluster through the CLI/ONTAP UI as Trident will not be able to pick up these changes.

```

cat backend-san.json
{
  "version": 1,
  "storageDriverName": "ontap-san",
  "backendName": "ontap_san_chap",
  "managementLIF": "192.168.0.135",
  "svm": "ontap_iscsi_svm",
  "useCHAP": true,
  "username": "vsadmin",
  "password": "password",
  "chapInitiatorSecret": "c19qxUpDaTeD",
  "chapTargetInitiatorSecret": "rqxigXgkeUpDaTeD",
  "chapTargetUsername": "iJF4heBRT0TCwxyz",
  "chapUsername": "uh2aNCLSD6cNwxyz",
}

./tridentctl update backend ontap_san_chap -f backend-san.json -n trident
+-----+-----+-----+
+-----+-----+
|   NAME          | STORAGE DRIVER |          UUID          |
STATE | VOLUMES |
+-----+-----+-----+
+-----+-----+
| ontap_san_chap | ontap-san      | aa458f3b-ad2d-4378-8a33-1a472ffbeb5c |
online |      7 |
+-----+-----+-----+
+-----+-----+

```

Existing connections will remain unaffected; they will continue to remain active if the credentials are updated by Trident on the SVM. New connections use the updated credentials and existing connections continue to remain active. Disconnecting and reconnecting old PVs will result in them using the updated credentials.

## ONTAP SAN configuration options and examples

Learn how to create and use ONTAP SAN drivers with your Trident installation. This section provides backend configuration examples and details for mapping backends to StorageClasses.

### Backend configuration options

See the following table for the backend configuration options:

Parameter	Description	Default
version		Always 1

Parameter	Description	Default
storageDriverName	Name of the storage driver	ontap-nas, ontap-nas-economy, ontap-nas-flexgroup, ontap-san, ontap-san-economy
backendName	Custom name or the storage backend	Driver name + " " + dataLIF
managementLIF	<p>IP address of a cluster or SVM management LIF. A fully-qualified domain name (FQDN) can be specified.</p> <p>Can be set to use IPv6 addresses if Trident was installed using the IPv6 flag. IPv6 addresses must be defined in square brackets, such as [28e8:d9fb:a825:b7bf:69a8:d02f:9e7b:3555].</p> <p>For seamless MetroCluster switchover, see the <a href="#">[mcc-best]</a>.</p>	"10.0.0.1", "[2001:1234:abcd::fefe]"
dataLIF	<p>IP address of protocol LIF.</p> <p>Can be set to use IPv6 addresses if Trident was installed using the IPv6 flag. IPv6 addresses must be defined in square brackets, such as [28e8:d9fb:a825:b7bf:69a8:d02f:9e7b:3555].</p> <p><b>Do not specify for iSCSI.</b> Trident uses <a href="#">ONTAP Selective LUN Map</a> to discover the iSCSI LIFs needed to establish a multi path session. A warning is generated if dataLIF is explicitly defined.</p> <p><b>Omit for Metrocluster.</b> See the <a href="#">[mcc-best]</a>.</p>	Derived by the SVM
svm	<p>Storage virtual machine to use</p> <p><b>Omit for Metrocluster.</b> See the <a href="#">[mcc-best]</a>.</p>	Derived if an SVM managementLIF is specified
useCHAP	<p>Use CHAP to authenticate iSCSI for ONTAP SAN drivers [Boolean].</p> <p>Set to true for Trident to configure and use bidirectional CHAP as the default authentication for the SVM given in the backend. Refer to <a href="#">Prepare to configure backend with ONTAP SAN drivers</a> for details.</p>	false
chapInitiatorSecret	CHAP initiator secret. Required if useCHAP=true	""
labels	Set of arbitrary JSON-formatted labels to apply on volumes	""

Parameter	Description	Default
chapTargetInitiatorSecret	CHAP target initiator secret. Required if useCHAP=true	""
chapUsername	Inbound username. Required if useCHAP=true	""
chapTargetUsername	Target username. Required if useCHAP=true	""
clientCertificate	Base64-encoded value of client certificate. Used for certificate-based auth	""
clientPrivateKey	Base64-encoded value of client private key. Used for certificate-based auth	""
trustedCACertificate	Base64-encoded value of trusted CA certificate. Optional. Used for certificate-based authentication.	""
username	Username needed to communicate with the ONTAP cluster. Used for credential-based authentication.	""
password	Password needed to communicate with the ONTAP cluster. Used for credential-based authentication.	""
svm	Storage virtual machine to use	Derived if an SVM managementLIF is specified
storagePrefix	Prefix used when provisioning new volumes in the SVM.  Cannot be modified later. To update this parameter, you will need to create a new backend.	trident
aggregate	Aggregate for provisioning (optional; if set, must be assigned to the SVM). For the <code>ontap-nas-flexgroup</code> driver, this option is ignored. If not assigned, any of the available aggregates can be used to provision a FlexGroup volume.   When the aggregate is updated in SVM, it is updated in Trident automatically by polling SVM without having to restart the Trident Controller. When you have configured a specific aggregate in Trident to provision volumes, if the aggregate is renamed or moved out of the SVM, the backend will move to failed state in Trident while polling the SVM aggregate. You must either change the aggregate to one that is present on the SVM or remove it altogether to bring the backend back online.	""

Parameter	Description	Default
limitAggregateUsage	<p>Fail provisioning if usage is above this percentage.</p> <p>If you are using an Amazon FSx for NetApp ONTAP backend, do not specify <code>limitAggregateUsage</code>. The provided <code>fsxadmin</code> and <code>vsadmin</code> do not contain the permissions required to retrieve aggregate usage and limit it using Trident.</p>	"" (not enforced by default)
limitVolumeSize	<p>Fail provisioning if requested volume size is above this value.</p> <p>Also restricts the maximum size of the volumes it manages for LUNs.</p>	"" (not enforced by default)
lunsPerFlexvol	Maximum LUNs per Flexvol, must be in range [50, 200]	100
debugTraceFlags	<p>Debug flags to use when troubleshooting. Example, <code>{"api":false, "method":true}</code></p> <p>Do not use unless you are troubleshooting and require a detailed log dump.</p>	null
useREST	<p>Boolean parameter to use ONTAP REST APIs.</p> <p><code>useREST</code> When set to <code>true</code>, Trident uses ONTAP REST APIs to communicate with the backend; when set to <code>false</code>, Trident uses ONTAP ZAPI calls to communicate with the backend. This feature requires ONTAP 9.11.1 and later. In addition, the ONTAP login role used must have access to the <code>ontap</code> application. This is satisfied by the pre-defined <code>vsadmin</code> and <code>cluster-admin</code> roles. Beginning with the Trident 24.06 release and ONTAP 9.15.1 or later, <code>useREST</code> is set to <code>true</code> by default; change <code>useREST</code> to <code>false</code> to use ONTAP ZAPI calls.</p> <p><code>useREST</code> is fully qualified for NVMe/TCP.</p>	true for ONTAP 9.15.1 or later, otherwise <code>false</code> .
sanType	<p>Use to select <code>iscsi</code> for iSCSI, <code>nvme</code> for NVMe/TCP or <code>fcp</code> for SCSI over Fibre Channel (FC).</p> <p><b>'fcp' (SCSI over FC) is a tech preview feature in the Trident 24.10 release.</b></p>	<code>iscsi</code> if blank

Parameter	Description	Default
formatOptions	<p>Use <code>formatOptions</code> to specify command line arguments for the <code>mkfs</code> command, which will be applied whenever a volume is formatted. This allows you to format the volume according to your preferences. Make sure to specify the <code>formatOptions</code> similar to that of the <code>mkfs</code> command options, excluding the device path.</p> <p>Example: <code>-E nodiscard</code></p> <p><b>Supported for <code>ontap-san</code> and <code>ontap-san-economy</code> drivers only.</b></p>	
limitVolumePoolSize	Maximum requestable FlexVol size when using LUNs in <code>ontap-san-economy</code> backend.	<code>""</code> (not enforced by default)
denyNewVolumePools	Restricts <code>ontap-san-economy</code> backends from creating new FlexVol volumes to contain their LUNs. Only preexisting Flexvols are used for provisioning new PVs.	

## Recommendations for using `formatOptions`

Trident recommends the following option to expedite the formatting process:

### **-E nodiscard:**

- Keep, do not attempt to discard blocks at `mkfs` time (discarding blocks initially is useful on solid state devices and sparse / thin-provisioned storage). This replaces the deprecated option `-K` and it is applicable to all the file systems (xfs, ext3, and ext4).

## Backend configuration options for provisioning volumes

You can control default provisioning using these options in the `defaults` section of the configuration. For an example, see the configuration examples below.

Parameter	Description	Default
spaceAllocation	Space-allocation for LUNs	<code>"true"</code>
spaceReserve	Space reservation mode; <code>"none"</code> (thin) or <code>"volume"</code> (thick)	<code>"none"</code>
snapshotPolicy	Snapshot policy to use	<code>"none"</code>

Parameter	Description	Default
qosPolicy	<p>QoS policy group to assign for volumes created. Choose one of qosPolicy or adaptiveQosPolicy per storage pool/backend.</p> <p>Using QoS policy groups with Trident requires ONTAP 9.8 or later. You should use a non-shared QoS policy group and ensuring the policy group is applied to each constituent individually. A shared QoS policy group enforces the ceiling for the total throughput of all workloads.</p>	""
adaptiveQosPolicy	Adaptive QoS policy group to assign for volumes created. Choose one of qosPolicy or adaptiveQosPolicy per storage pool/backend	""
snapshotReserve	Percentage of volume reserved for snapshots	"0" if snapshotPolicy is "none", otherwise ""
splitOnClone	Split a clone from its parent upon creation	"false"
encryption	<p>Enable NetApp Volume Encryption (NVE) on the new volume; defaults to <code>false</code>. NVE must be licensed and enabled on the cluster to use this option.</p> <p>If NAE is enabled on the backend, any volume provisioned in Trident will be NAE enabled.</p> <p>For more information, refer to: <a href="#">How Trident works with NVE and NAE</a>.</p>	"false"
luksEncryption	<p>Enable LUKS encryption. Refer to <a href="#">Use Linux Unified Key Setup (LUKS)</a>.</p> <p>LUKS encryption is not supported for NVMe/TCP.</p>	""
securityStyle	Security style for new volumes	unix
tieringPolicy	Tiering policy to use "none"	"snapshot-only" for pre-ONTAP 9.5 SVM-DR configuration
nameTemplate	Template to create custom volume names.	""

## Volume provisioning examples

Here's an example with defaults defined:

```
---
version: 1
storageDriverName: ontap-san
managementLIF: 10.0.0.1
svm: trident_svm
username: admin
password: <password>
labels:
  k8scluster: dev2
  backend: dev2-sanbackend
storagePrefix: alternate-trident
debugTraceFlags:
  api: false
  method: true
defaults:
  spaceReserve: volume
  qosPolicy: standard
  spaceAllocation: 'false'
  snapshotPolicy: default
  snapshotReserve: '10'
```

 For all volumes created using the `ontap-san` driver, Trident adds an extra 10 percent capacity to the FlexVol to accommodate the LUN metadata. The LUN will be provisioned with the exact size that the user requests in the PVC. Trident adds 10 percent to the FlexVol (shows as Available size in ONTAP). Users will now get the amount of usable capacity they requested. This change also prevents LUNs from becoming read-only unless the available space is fully utilized. This does not apply to `ontap-san-economy`.

For backends that define `snapshotReserve`, Trident calculates the size of volumes as follows:

```
Total volume size = [(PVC requested size) / (1 - (snapshotReserve percentage) / 100)] * 1.1
```

The 1.1 is the extra 10 percent Trident adds to the FlexVol to accommodate the LUN metadata. For `snapshotReserve = 5%`, and `PVC request = 5GiB`, the total volume size is 5.79GiB and the available size is 5.5GiB. The `volume show` command should show results similar to this example:

Vserver	Volume	Aggregate	State	Type	Size	Available	Used%
	_pvc_89f1c156_3801_4de4_9f9d_034d54c395f4		online	RW	10GB	5.00GB	0%
	_pvc_e42ec6fe_3baa_4af6_996d_134adb8e6d		online	RW	5.79GB	5.50GB	0%
	_pvc_e8372153_9ad9_474a_951a_08ae15e1c0ba		online	RW	1GB	511.8MB	0%
3 entries were displayed.							

Currently, resizing is the only way to use the new calculation for an existing volume.

#### Minimal configuration examples

The following examples show basic configurations that leave most parameters to default. This is the easiest way to define a backend.



If you are using Amazon FSx on NetApp ONTAP with Trident, we recommend you specify DNS names for LIFs instead of IP addresses.

#### ONTAP SAN example

This is a basic configuration using the `ontap-san` driver.

```
---  
version: 1  
storageDriverName: ontap-san  
managementLIF: 10.0.0.1  
svm: svm_iscsi  
labels:  
  k8scluster: test-cluster-1  
  backend: testcluster1-sanbackend  
username: vsadmin  
password: <password>
```

#### ONTAP SAN economy example

```
---  
version: 1  
storageDriverName: ontap-san-economy  
managementLIF: 10.0.0.1  
svm: svm_iscsi_eco  
username: vsadmin  
password: <password>
```

#### 1. example

You can configure the backend to avoid having to manually update the backend definition after switchover and switchback during [SVM replication and recovery](#).

For seamless switchover and switchback, specify the SVM using `managementLIF` and omit the `dataLIF` and `svm` parameters. For example:

```
---  
version: 1  
storageDriverName: ontap-san  
managementLIF: 192.168.1.66  
username: vsadmin  
password: password
```

### Certificate-based authentication example

In this basic configuration example `clientCertificate`, `clientPrivateKey`, and `trustedCACertificate` (optional, if using trusted CA) are populated in `backend.json` and take the base64-encoded values of the client certificate, private key, and trusted CA certificate, respectively.

```
---  
version: 1  
storageDriverName: ontap-san  
backendName: DefaultSANBackend  
managementLIF: 10.0.0.1  
svm: svm_iscsi  
useCHAP: true  
chapInitiatorSecret: cl9qxIm36DKyawxy  
chapTargetInitiatorSecret: rqxigXgkesIpwxyz  
chapTargetUsername: iJF4heBRT0TCwxyz  
chapUsername: uh2aNCLSd6cNwxyz  
clientCertificate: ZXROZXJwYXB...ICMgJ3BhcGVyc2  
clientPrivateKey: vciwKIyAgZG...0cnksIGRlc2NyaX  
trustedCACertificate: zcyBbaG...b3Igb3duIGNsYXNz
```

## Bidirectional CHAP examples

These examples create a backend with `useCHAP` set to `true`.

### ONTAP SAN CHAP example

```
---
version: 1
storageDriverName: ontap-san
managementLIF: 10.0.0.1
svm: svm_iscsi
labels:
  k8scluster: test-cluster-1
  backend: testcluster1-sanbackend
useCHAP: true
chapInitiatorSecret: cl9qxIm36DKyawxy
chapTargetInitiatorSecret: rqxigXgkesIpwxyz
chapTargetUsername: iJF4heBRT0TCwxyz
chapUsername: uh2aNCLSd6cNwxyz
username: vsadmin
password: <password>
```

### ONTAP SAN economy CHAP example

```
---
version: 1
storageDriverName: ontap-san-economy
managementLIF: 10.0.0.1
svm: svm_iscsi_eco
useCHAP: true
chapInitiatorSecret: cl9qxIm36DKyawxy
chapTargetInitiatorSecret: rqxigXgkesIpwxyz
chapTargetUsername: iJF4heBRT0TCwxyz
chapUsername: uh2aNCLSd6cNwxyz
username: vsadmin
password: <password>
```

## NVMe/TCP example

You must have an SVM configured with NVMe on your ONTAP backend. This is a basic backend configuration for NVMe/TCP.

```
---  
version: 1  
backendName: NVMeBackend  
storageDriverName: ontap-san  
managementLIF: 10.0.0.1  
svm: svm_nvme  
username: vsadmin  
password: password  
sanType: nvme  
useREST: true
```

## Backend configuration example with nameTemplate

```
---  
version: 1  
storageDriverName: ontap-san  
backendName: ontap-san-backend  
managementLIF: <ip address>  
svm: svm0  
username: <admin>  
password: <password>  
defaults: {  
    "nameTemplate":  
    "{{.volume.Name}}_{{.labels.cluster}}_{{.volume.Namespace}}_{{.volume.R  
equestName}}"  
},  
"labels": {"cluster": "ClusterA", "PVC":  
"{{.volume.Namespace}}_{{.volume.RequestName}}"}  
}
```

## formatOptions example for ontap-san-economy driver

```
version: 1
storageDriverName: ontap-san-economy
managementLIF: ''
svm: svml
username: ''
password: "!"
storagePrefix: whelk_
debugTraceFlags:
  method: true
  api: true
defaults:
  formatOptions: "-E nodiscard"
```

### Examples of backends with virtual pools

In these sample backend definition files, specific defaults are set for all storage pools, such as `spaceReserve` at `none`, `spaceAllocation` at `false`, and `encryption` at `false`. The virtual pools are defined in the `storage` section.

Trident sets provisioning labels in the "Comments" field. Comments are set on the FlexVol. Trident copies all labels present on a virtual pool to the storage volume at provisioning. For convenience, storage administrators can define labels per virtual pool and group volumes by label.

In these examples, some of the storage pools set their own `spaceReserve`, `spaceAllocation`, and `encryption` values, and some pools override the default values.

## ONTAP SAN example

```

---
version: 1
storageDriverName: ontap-san
managementLIF: 10.0.0.1
svm: svm_iscsi
useCHAP: true
chapInitiatorSecret: cl9qxIm36DKyawxy
chapTargetInitiatorSecret: rqxigXgkesIpwxyz
chapTargetUsername: iJF4heBRT0TCwxyz
chapUsername: uh2aNCLSd6cNwxyz
username: vsadmin
password: <password>
defaults:
  spaceAllocation: 'false'
  encryption: 'false'
  qosPolicy: standard
labels:
  store: san_store
  kubernetes-cluster: prod-cluster-1
region: us_east_1
storage:
- labels:
    protection: gold
    creditpoints: '40000'
    zone: us_east_1a
    defaults:
      spaceAllocation: 'true'
      encryption: 'true'
      adaptiveQosPolicy: adaptive-extreme
- labels:
    protection: silver
    creditpoints: '20000'
    zone: us_east_1b
    defaults:
      spaceAllocation: 'false'
      encryption: 'true'
      qosPolicy: premium
- labels:
    protection: bronze
    creditpoints: '5000'
    zone: us_east_1c
    defaults:
      spaceAllocation: 'true'
      encryption: 'false'

```

## ONTAP SAN economy example

```
---  
version: 1  
storageDriverName: ontap-san-economy  
managementLIF: 10.0.0.1  
svm: svm_iscsi_eco  
useCHAP: true  
chapInitiatorSecret: cl9qxIm36DKyawxy  
chapTargetInitiatorSecret: rqxigXgkesIpwxyz  
chapTargetUsername: iJF4heBRT0TCwxyz  
chapUsername: uh2aNCLSd6cNwxyz  
username: vsadmin  
password: <password>  
defaults:  
  spaceAllocation: 'false'  
  encryption: 'false'  
labels:  
  store: san_economy_store  
region: us_east_1  
storage:  
- labels:  
  app: oracledb  
  cost: '30'  
  zone: us_east_1a  
  defaults:  
    spaceAllocation: 'true'  
    encryption: 'true'  
- labels:  
  app: postgresdb  
  cost: '20'  
  zone: us_east_1b  
  defaults:  
    spaceAllocation: 'false'  
    encryption: 'true'  
- labels:  
  app: mysqldb  
  cost: '10'  
  zone: us_east_1c  
  defaults:  
    spaceAllocation: 'true'  
    encryption: 'false'  
- labels:  
  department: legal  
  creditpoints: '5000'  
  zone: us_east_1c
```

```
defaults:
  spaceAllocation: 'true'
  encryption: 'false'
```

## NVMe/TCP example

```
---
version: 1
storageDriverName: ontap-san
sanType: nvme
managementLIF: 10.0.0.1
svm: nvme_svm
username: vsadmin
password: <password>
useREST: true
defaults:
  spaceAllocation: 'false'
  encryption: 'true'
storage:
- labels:
  app: testApp
  cost: '20'
  defaults:
    spaceAllocation: 'false'
    encryption: 'false'
```

## Map backends to StorageClasses

The following StorageClass definitions refer to the [Examples of backends with virtual pools](#). Using the `parameters.selector` field, each StorageClass calls out which virtual pools can be used to host a volume. The volume will have the aspects defined in the chosen virtual pool.

- The `protection-gold` StorageClass will map to the first virtual pool in the `ontap-san` backend. This is the only pool offering gold-level protection.

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: protection-gold
provisioner: csi.trident.netapp.io
parameters:
  selector: "protection=gold"
  fsType: "ext4"
```

- The `protection-not-gold` StorageClass will map to the second and third virtual pool in `ontap-san` backend. These are the only pools offering a protection level other than gold.

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: protection-not-gold
  provisioner: csi.trident.netapp.io
parameters:
  selector: "protection!=gold"
  fsType: "ext4"
```

- The `app-mysqldb` StorageClass will map to the third virtual pool in `ontap-san-economy` backend. This is the only pool offering storage pool configuration for the `mysqldb` type app.

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: app-mysqldb
  provisioner: csi.trident.netapp.io
parameters:
  selector: "app=mysqldb"
  fsType: "ext4"
```

- The `protection-silver-creditpoints-20k` StorageClass will map to the second virtual pool in `ontap-san` backend. This is the only pool offering silver-level protection and 20000 creditpoints.

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: protection-silver-creditpoints-20k
  provisioner: csi.trident.netapp.io
parameters:
  selector: "protection=silver; creditpoints=20000"
  fsType: "ext4"
```

- The `creditpoints-5k` StorageClass will map to the third virtual pool in `ontap-san` backend and the fourth virtual pool in the `ontap-san-economy` backend. These are the only pool offerings with 5000 creditpoints.

```

apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: creditpoints-5k
provisioner: csi.trident.netapp.io
parameters:
  selector: "creditpoints=5000"
  fsType: "ext4"

```

- The `my-test-app-sc` StorageClass will map to the `testAPP` virtual pool in the `ontap-san` driver with `sanType: nvme`. This is the only pool offering `testApp`.

```

---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: my-test-app-sc
provisioner: csi.trident.netapp.io
parameters:
  selector: "app=testApp"
  fsType: "ext4"

```

Trident will decide which virtual pool is selected and ensures the storage requirement is met.

## ONTAP NAS drivers

### ONTAP NAS driver overview

Learn about configuring an ONTAP backend with ONTAP and Cloud Volumes ONTAP NAS drivers.

### ONTAP NAS driver details

Trident provides the following NAS storage drivers to communicate with the ONTAP cluster. Supported access modes are: `ReadWriteOnce` (RWO), `ReadOnlyMany` (ROX), `ReadWriteMany` (RWX), `ReadWriteOncePod` (RWOP).

Driver	Protocol	volumeMode	Access modes supported	File systems supported
ontap-nas	NFS SMB	Filesystem	RWO, ROX, RWX, RWOP	"", nfs, smb
ontap-nas-economy	NFS SMB	Filesystem	RWO, ROX, RWX, RWOP	"", nfs, smb

Driver	Protocol	volumeMode	Access modes supported	File systems supported
ontap-nas-flexgroup	NFS SMB	Filesystem	RWO, ROX, RWX, RWOP	"", nfs, smb

- Use `ontap-san-economy` only if persistent volume usage count is expected to be higher than [supported ONTAP volume limits](#).
- Use `ontap-nas-economy` only if persistent volume usage count is expected to be higher than [supported ONTAP volume limits](#) and the `ontap-san-economy` driver cannot be used.
- Do not use `ontap-nas-economy` if you anticipate the need for data protection, disaster recovery, or mobility.

#### User permissions

Trident expects to be run as either an ONTAP or SVM administrator, typically using the `admin` cluster user or a `vsadmin` SVM user, or a user with a different name that has the same role.

For Amazon FSx for NetApp ONTAP deployments, Trident expects to be run as either an ONTAP or SVM administrator, using the cluster `fsxadmin` user or a `vsadmin` SVM user, or a user with a different name that has the same role. The `fsxadmin` user is a limited replacement for the cluster admin user.

If you use the `limitAggregateUsage` parameter, cluster admin permissions are required.

When using Amazon FSx for NetApp ONTAP with Trident, the `limitAggregateUsage` parameter will not work with the `vsadmin` and `fsxadmin` user accounts. The configuration operation will fail if you specify this parameter.

While it is possible to create a more restrictive role within ONTAP that a Trident driver can use, we don't recommend it. Most new releases of Trident will call additional APIs that would have to be accounted for, making upgrades difficult and error-prone.

#### Prepare to configure a backend with ONTAP NAS drivers

Understand the requirements, authentication options, and export policies for configuring an ONTAP backend with ONTAP NAS drivers.

#### Requirements

- For all ONTAP backends, Trident requires at least one aggregate assigned to the SVM.
- You can run more than one driver, and create storage classes that point to one or the other. For example, you could configure a Gold class that uses the `ontap-nas` driver and a Bronze class that uses the `ontap-nas-economy` one.
- All your Kubernetes worker nodes must have the appropriate NFS tools installed. Refer to [here](#) for more details.
- Trident supports SMB volumes mounted to pods running on Windows nodes only. Refer to [Prepare to provision SMB volumes](#) for details.

## Authenticate the ONTAP backend

Trident offers two modes of authenticating an ONTAP backend.

- Credential-based: This mode requires sufficient permissions to the ONTAP backend. It is recommended to use an account associated with a pre-defined security login role, such as `admin` or `vsadmin` to ensure maximum compatibility with ONTAP versions.
- Certificate-based: This mode requires a certificate installed on the backend for Trident to communicate with an ONTAP cluster. Here, the backend definition must contain Base64-encoded values of the client certificate, key, and the trusted CA certificate if used (recommended).

You can update existing backends to move between credential-based and certificate-based methods. However, only one authentication method is supported at a time. To switch to a different authentication method, you must remove the existing method from the backend configuration.



If you attempt to provide **both credentials and certificates**, backend creation will fail with an error that more than one authentication method was provided in the configuration file.

### Enable credential-based authentication

Trident requires the credentials to an SVM-scoped/cluster-scoped admin to communicate with the ONTAP backend. It is recommended to make use of standard, pre-defined roles such as `admin` or `vsadmin`. This ensures forward compatibility with future ONTAP releases that might expose feature APIs to be used by future Trident releases. A custom security login role can be created and used with Trident, but is not recommended.

A sample backend definition will look like this:

## YAML

```
---
version: 1
backendName: ExampleBackend
storageDriverName: ontap-nas
managementLIF: 10.0.0.1
dataLIF: 10.0.0.2
svm: svm_nfs
username: vsadmin
password: password
```

## JSON

```
{
  "version": 1,
  "backendName": "ExampleBackend",
  "storageDriverName": "ontap-nas",
  "managementLIF": "10.0.0.1",
  "dataLIF": "10.0.0.2",
  "svm": "svm_nfs",
  "username": "vsadmin",
  "password": "password"
}
```

Keep in mind that the backend definition is the only place the credentials are stored in plain text. After the backend is created, usernames/passwords are encoded with Base64 and stored as Kubernetes secrets. The creation/updation of a backend is the only step that requires knowledge of the credentials. As such, it is an admin-only operation, to be performed by the Kubernetes/storage administrator.

### Enable certificate-based Authentication

New and existing backends can use a certificate and communicate with the ONTAP backend. Three parameters are required in the backend definition.

- clientCertificate: Base64-encoded value of client certificate.
- clientPrivateKey: Base64-encoded value of associated private key.
- trustedCACertificate: Base64-encoded value of trusted CA certificate. If using a trusted CA, this parameter must be provided. This can be ignored if no trusted CA is used.

A typical workflow involves the following steps.

### Steps

1. Generate a client certificate and key. When generating, set Common Name (CN) to the ONTAP user to authenticate as.

```
openssl req -x509 -nodes -days 1095 -newkey rsa:2048 -keyout k8senv.key  
-out k8senv.pem -subj "/C=US/ST=NC/L=RTP/O=NetApp/CN=vsadmin"
```

2. Add trusted CA certificate to the ONTAP cluster. This might be already handled by the storage administrator. Ignore if no trusted CA is used.

```
security certificate install -type server -cert-name <trusted-ca-cert-name> -vserver <vserver-name>  
ssl modify -vserver <vserver-name> -server-enabled true -client-enabled true -common-name <common-name> -serial <SN-from-trusted-CA-cert> -ca <cert-authority>
```

3. Install the client certificate and key (from step 1) on the ONTAP cluster.

```
security certificate install -type client-ca -cert-name <certificate-name> -vserver <vserver-name>  
security ssl modify -vserver <vserver-name> -client-enabled true
```

4. Confirm the ONTAP security login role supports cert authentication method.

```
security login create -user-or-group-name vsadmin -application ontapi  
-authentication-method cert -vserver <vserver-name>  
security login create -user-or-group-name vsadmin -application http  
-authentication-method cert -vserver <vserver-name>
```

5. Test authentication using certificate generated. Replace <ONTAP Management LIF> and <vserver name> with Management LIF IP and SVM name. You must ensure the LIF has its service policy set to default-data-management.

```
curl -X POST -Lk https://<ONTAP-Management-LIF>/servlets/netapp.servlets.admin.XMLrequest_filer --key k8senv.key  
--cert ~/k8senv.pem -d '<?xml version="1.0" encoding="UTF-8"?><netapp  
xmlns="http://www.netapp.com/filer/admin" version="1.21"  
vfiler="<vserver-name>"><vserver-get></vserver-get></netapp>'
```

6. Encode certificate, key and trusted CA certificate with Base64.

```
base64 -w 0 k8senv.pem >> cert_base64  
base64 -w 0 k8senv.key >> key_base64  
base64 -w 0 trustedca.pem >> trustedca_base64
```

7. Create backend using the values obtained from the previous step.

```
cat cert-backend-updated.json
{
  "version": 1,
  "storageDriverName": "ontap-nas",
  "backendName": "NasBackend",
  "managementLIF": "1.2.3.4",
  "dataLIF": "1.2.3.8",
  "svm": "vserver_test",
  "clientCertificate": "Faaaakkkeeee...Vaaalllluuuueeee",
  "clientPrivateKey": "LS0tFaKE...0VaLuES0tLS0K",
  "storagePrefix": "myPrefix_"
}

#Update backend with tridentctl
tridentctl update backend NasBackend -f cert-backend-updated.json -n
trident
+-----+-----+
+-----+-----+
|     NAME      | STORAGE DRIVER |                         UUID          |
STATE  | VOLUMES  |
+-----+-----+
+-----+-----+
| NasBackend | ontap-nas      | 98e19b74-aec7-4a3d-8dcf-128e5033b214 |
online |          9 |
+-----+-----+
+-----+-----+
```

### Update authentication methods or rotate credentials

You can update an existing backend to use a different authentication method or to rotate their credentials. This works both ways: backends that make use of username/password can be updated to use certificates; backends that utilize certificates can be updated to username/password based. To do this, you must remove the existing authentication method and add the new authentication method. Then use the updated backend.json file containing the required parameters to execute `tridentctl update backend`.

```

cat cert-backend-updated.json
{
  "version": 1,
  "storageDriverName": "ontap-nas",
  "backendName": "NasBackend",
  "managementLIF": "1.2.3.4",
  "dataLIF": "1.2.3.8",
  "svm": "vserver_test",
  "username": "vsadmin",
  "password": "password",
  "storagePrefix": "myPrefix_"
}

#Update backend with tridentctl
tridentctl update backend NasBackend -f cert-backend-updated.json -n
trident
+-----+-----+
+-----+-----+
|     NAME      | STORAGE DRIVER |          UUID          |
STATE | VOLUMES |
+-----+-----+
+-----+-----+
| NasBackend | ontap-nas      | 98e19b74-aec7-4a3d-8dcf-128e5033b214 |
online |         9 |
+-----+-----+
+-----+-----+

```

**i** When rotating passwords, the storage administrator must first update the password for the user on ONTAP. This is followed by a backend update. When rotating certificates, multiple certificates can be added to the user. The backend is then updated to use the new certificate, following which the old certificate can be deleted from the ONTAP cluster.

Updating a backend does not disrupt access to volumes that have already been created, nor impact volume connections made after. A successful backend update indicates that Trident can communicate with the ONTAP backend and handle future volume operations.

### Create custom ONTAP role for Trident

You can create an ONTAP cluster role with minimum privileges so that you do not have to use the ONTAP admin role to perform operations in Trident. When you include the username in a Trident backend configuration, Trident uses the ONTAP cluster role you created to perform the operations.

Refer to [Trident custom-role generator](#) for more information about creating Trident custom roles.

## Using ONTAP CLI

1. Create a new role using the following command:

```
security login role create <role_name> -cmddirname "command" -access all  
-vserver <svm_name>
```

2. Create a username for the Trident user:

```
security login create -username <user_name> -application ontapi  
-authmethod <password> -role <name_of_role_in_step_1> -vserver  
<svm_name> -comment "user_description"
```

3. Map the role to the user:

```
security login modify username <user_name> -vserver <svm_name> -role  
<role_name> -application ontapi -application console -authmethod  
<password>
```

## Using System Manager

Perform the following steps in ONTAP System Manager:

1. **Create a custom role:**

- a. To create a custom role at the cluster-level, select **Cluster > Settings**.

(Or) To create a custom role at the SVM level, select **Storage > Storage VMs > required SVM > Settings > Users and Roles**.

- b. Select the arrow icon (→) next to **Users and Roles**.
- c. Select **+Add** under **Roles**.
- d. Define the rules for the role and click **Save**.

2. **Map the role to the Trident user:**

+ Perform the following steps on the **Users and Roles** page:

- a. Select Add icon **+** under **Users**.
- b. Select the required username, and select a role in the drop-down menu for **Role**.
- c. Click **Save**.

Refer to the following pages for more information:

- [Custom roles for administration of ONTAP](#) or [Define custom roles](#)
- [Work with roles and users](#)

## Manage NFS export policies

Trident uses NFS export policies to control access to the volumes that it provisions.

Trident provides two options when working with export policies:

- Trident can dynamically manage the export policy itself; in this mode of operation, the storage administrator

specifies a list of CIDR blocks that represent admissible IP addresses. Trident adds applicable node IPs that fall in these ranges to the export policy automatically at publish time. Alternatively, when no CIDRs are specified, all global-scoped unicast IPs found on the node that the volume being published to will be added to the export policy.

- Storage administrators can create an export policy and add rules manually. Trident uses the default export policy unless a different export policy name is specified in the configuration.

## Dynamically manage export policies

Trident provides the ability to dynamically manage export policies for ONTAP backends. This provides the storage administrator the ability to specify a permissible address space for worker node IPs, rather than defining explicit rules manually. It greatly simplifies export policy management; modifications to the export policy no longer require manual intervention on the storage cluster. Moreover, this helps restrict access to the storage cluster only to worker nodes that are mounting volumes and have IPs in the range specified, supporting a fine-grained and automated management.



Do not use Network Address Translation (NAT) when using dynamic export policies. With NAT, the storage controller sees the frontend NAT address and not the actual IP host address, so access will be denied when no match is found in the export rules.



In Trident 24.10, `ontap-nas` storage driver will continue to work as in the earlier releases; no change has been made for `ontap-nas` driver. Only the `ontap-nas-economy` storage driver will have volume based granular access control in Trident 24.10.

## Example

There are two configuration options that must be used. Here's an example backend definition:

```
---
version: 1
storageDriverName: ontap-nas-economy
backendName: ontap_nas_auto_export
managementLIF: 192.168.0.135
svm: svm1
username: vsadmin
password: password
autoExportCIDRs:
- 192.168.0.0/24
autoExportPolicy: true
```



When using this feature, you must ensure that the root junction in your SVM has a previously created export policy with an export rule that permits the node CIDR block (such as the default export policy). Always follow NetApp recommended best practice to dedicate an SVM for Trident.

Here is an explanation of how this feature works using the example above:

- `autoExportPolicy` is set to `true`. This indicates that Trident creates an export policy for each volume provisioned with this backend for the `svm1` SVM and handle the addition and deletion of rules using

`autoexportCIDRs` address blocks. Until a volume is attached to a node, the volume uses an empty export policy with no rules to prevent unwanted access to that volume. When a volume is published to a node Trident creates an export policy with the same name as the underlying qtree containing the node IP within the specified CIDR block. These IPs will also be added to the export policy used by the parent FlexVol.

- For example:
  - backend UUID 403b5326-8482-40db-96d0-d83fb3f4daec
  - `autoExportPolicy` set to `true`
  - storage prefix `trident`
  - PVC UUID a79bcf5f-7b6d-4a40-9876-e2551f159c1c
  - qtree named `trident_pvc_a79bcf5f_7b6d_4a40_9876_e2551f159c1c` creates an export policy for the FlexVol named `trident-403b5326-8482-40db-96d0-d83fb3f4daec`, an export policy for the qtree named `trident_pvc_a79bcf5f_7b6d_4a40_9876_e2551f159c1c`, and an empty export policy named `trident_empty` on the SVM. The rules for the FlexVol export policy will be a superset of any rules contained in the qtree export policies. The empty export policy will be reused by any volumes that are not attached.
- `autoExportCIDRs` contains a list of address blocks. This field is optional and it defaults to `["0.0.0.0/0", "::/0"]`. If not defined, Trident adds all globally-scoped unicast addresses found on the worker nodes with publications.

In this example, the `192.168.0.0/24` address space is provided. This indicates that Kubernetes node IPs that fall within this address range with publications will be added to the export policy that Trident creates. When Trident registers a node it runs on, it retrieves the IP addresses of the node and checks them against the address blocks provided in `autoExportCIDRs`. At publish time, after filtering the IPs, Trident creates the export policy rules for the client IPs for the node it is publishing to.

You can update `autoExportPolicy` and `autoExportCIDRs` for backends after you create them. You can append new CIDRs for a backend that is automatically managed or delete existing CIDRs. Exercise care when deleting CIDRs to ensure that existing connections are not dropped. You can also choose to disable `autoExportPolicy` for a backend and fall back to a manually created export policy. This will require setting the `exportPolicy` parameter in your backend config.

After Trident creates or updates a backend, you can check the backend using `tridentctl` or the corresponding `tridentbackend` CRD:

```
./tridentctl get backends ontap_nas_auto_export -n trident -o yaml
items:
- backendUUID: 403b5326-8482-40db-96d0-d83fb3f4daec
  config:
    aggregate: ""
    autoExportCIDRs:
    - 192.168.0.0/24
    autoExportPolicy: true
    backendName: ontap_nas_auto_export
    chapInitiatorSecret: ""
    chapTargetInitiatorSecret: ""
    chapTargetUsername: ""
    chapUsername: ""
    dataLIF: 192.168.0.135
    debug: false
    debugTraceFlags: null
    defaults:
      encryption: "false"
      exportPolicy: <automatic>
      fileSystemType: ext4
```

When a node is removed, Trident checks all export policies to remove the access rules corresponding to the node. By removing this node IP from the export policies of managed backends, Trident prevents rogue mounts, unless this IP is reused by a new node in the cluster.

For previously existing backends, updating the backend with `tridentctl update backend` ensures that Trident manages the export policies automatically. This creates two new export policies named after the backend's UUID and qtree name when they are needed. Volumes that are present on the backend will use the newly created export policies after they are unmounted and mounted again.

 Deleting a backend with auto-managed export policies will delete the dynamically created export policy. If the backend is re-created, it is treated as a new backend and will result in the creation of a new export policy.

If the IP address of a live node is updated, you must restart the Trident pod on the node. Trident will then update the export policy for backends it manages to reflect this IP change.

#### Prepare to provision SMB volumes

With a little additional preparation, you can provision SMB volumes using `ontap-nas` drivers.

 You must configure both NFS and SMB/CIFS protocols on the SVM to create an `ontap-nas-economy` SMB volume for ONTAP on-premises. Failure to configure either of these protocols will cause SMB volume creation to fail.

 `autoExportPolicy` is not supported for SMB volumes.

## Before you begin

Before you can provision SMB volumes, you must have the following.

- A Kubernetes cluster with a Linux controller node and at least one Windows worker node running Windows Server 2022. Trident supports SMB volumes mounted to pods running on Windows nodes only.
- At least one Trident secret containing your Active Directory credentials. To generate secret `smbcreds`:

```
kubectl create secret generic smbcreds --from-literal username=user  
--from-literal password='password'
```

- A CSI proxy configured as a Windows service. To configure a `csi-proxy`, refer to [GitHub: CSI Proxy](#) or [GitHub: CSI Proxy for Windows](#) for Kubernetes nodes running on Windows.

## Steps

1. For on-premises ONTAP, you can optionally create an SMB share or Trident can create one for you.



SMB shares are required for Amazon FSx for ONTAP.

You can create the SMB admin shares in one of two ways either using the [Microsoft Management Console](#) Shared Folders snap-in or using the ONTAP CLI. To create the SMB shares using the ONTAP CLI:

- a. If necessary, create the directory path structure for the share.

The `vserver cifs share create` command checks the path specified in the `-path` option during share creation. If the specified path does not exist, the command fails.

- b. Create an SMB share associated with the specified SVM:

```
vserver cifs share create -vserver vserver_name -share-name  
share_name -path path [-share-properties share_properties,...]  
[other_attributes] [-comment text]
```

- c. Verify that the share was created:

```
vserver cifs share show -share-name share_name
```



Refer to [Create an SMB share](#) for full details.

2. When creating the backend, you must configure the following to specify SMB volumes. For all FSx for ONTAP backend configuration options, refer to [FSx for ONTAP configuration options and examples](#).

Parameter	Description	Example
smbShare	<p>You can specify one of the following: the name of an SMB share created using the Microsoft Management Console or ONTAP CLI; a name to allow Trident to create the SMB share; or you can leave the parameter blank to prevent common share access to volumes.</p> <p>This parameter is optional for on-premises ONTAP.</p> <p>This parameter is required for Amazon FSx for ONTAP backends and cannot be blank.</p>	smb-share
nasType	<b>Must set to smb.</b> If null, defaults to nfs.	smb
securityStyle	<p>Security style for new volumes.</p> <p><b>Must be set to ntfs or mixed for SMB volumes.</b></p>	ntfs or mixed for SMB volumes
unixPermissions	Mode for new volumes. <b>Must be left empty for SMB volumes.</b>	""

## ONTAP NAS configuration options and examples

Learn to create and use ONTAP NAS drivers with your Trident installation. This section provides backend configuration examples and details for mapping backends to StorageClasses.

### Backend configuration options

See the following table for the backend configuration options:

Parameter	Description	Default
version		Always 1
storageDriverName	Name of the storage driver	"ontap-nas", "ontap-nas-economy", "ontap-nas-flexgroup", "ontap-san", "ontap-san-economy"
backendName	Custom name or the storage backend	Driver name + "_" + dataLIF

Parameter	Description	Default
managementLIF	<p>IP address of a cluster or SVM management LIF</p> <p>A fully-qualified domain name (FQDN) can be specified.</p> <p>Can be set to use IPv6 addresses if Trident was installed using the IPv6 flag. IPv6 addresses must be defined in square brackets, such as [28e8:d9fb:a825:b7bf:69a8:d02f:9e7b:3555].</p> <p>For seamless MetroCluster switchover, see the <a href="#">[mcc-best]</a>.</p>	“10.0.0.1”, “[2001:1234:abcd::fefe]”
dataLIF	<p>IP address of protocol LIF.</p> <p>We recommend specifying dataLIF. If not provided, Trident fetches data LIFs from the SVM. You can specify a fully-qualified domain name (FQDN) to be used for the NFS mount operations, allowing you to create a round-robin DNS to load-balance across multiple data LIFs.</p> <p>Can be changed after initial setting. Refer to <a href="#">Update dataLIF after initial configuration</a>.</p> <p>Can be set to use IPv6 addresses if Trident was installed using the IPv6 flag. IPv6 addresses must be defined in square brackets, such as [28e8:d9fb:a825:b7bf:69a8:d02f:9e7b:3555].</p> <p><b>Omit for Metrocluster.</b> See the <a href="#">[mcc-best]</a>.</p>	Specified address or derived from SVM, if not specified (not recommended)
svm	<p>Storage virtual machine to use</p> <p><b>Omit for Metrocluster.</b> See the <a href="#">[mcc-best]</a>.</p>	Derived if an SVM managementLIF is specified
autoExportPolicy	<p>Enable automatic export policy creation and updating [Boolean].</p> <p>Using the autoExportPolicy and autoExportCIDRs options, Trident can manage export policies automatically.</p>	false
autoExportCIDRs	<p>List of CIDRs to filter Kubernetes' node IPs against when autoExportPolicy is enabled.</p> <p>Using the autoExportPolicy and autoExportCIDRs options, Trident can manage export policies automatically.</p>	["0.0.0.0/0", "::/0"]

Parameter	Description	Default
labels	Set of arbitrary JSON-formatted labels to apply on volumes	""
clientCertificate	Base64-encoded value of client certificate. Used for certificate-based auth	""
clientPrivateKey	Base64-encoded value of client private key. Used for certificate-based auth	""
trustedCACertificate	Base64-encoded value of trusted CA certificate. Optional. Used for certificate-based auth	""
username	Username to connect to the cluster/SVM. Used for credential-based auth	
password	Password to connect to the cluster/SVM. Used for credential-based auth	
storagePrefix	Prefix used when provisioning new volumes in the SVM. Cannot be updated after you set it <div style="margin-left: 20px;">  When using <code>ontap-nas-economy</code> and a <code>storagePrefix</code> that is 24 or more characters, the qtrees will not have the storage prefix embedded, though it will be in the volume name.           </div>	"trident"
aggregate	Aggregate for provisioning (optional; if set, must be assigned to the SVM). For the <code>ontap-nas-flexgroup</code> driver, this option is ignored. If not assigned, any of the available aggregates can be used to provision a FlexGroup volume. <div style="margin-left: 20px;">  When the aggregate is updated in SVM, it is updated in Trident automatically by polling SVM without having to restart the Trident Controller. When you have configured a specific aggregate in Trident to provision volumes, if the aggregate is renamed or moved out of the SVM, the backend will move to failed state in Trident while polling the SVM aggregate. You must either change the aggregate to one that is present on the SVM or remove it altogether to bring the backend back online.           </div>	""
limitAggregateUsage	Fail provisioning if usage is above this percentage. <div style="margin-left: 20px;"> <b>Does not apply to Amazon FSx for ONTAP</b> </div>	"" (not enforced by default)

Parameter	Description	Default
flexgroupAggregateList	<p>List of aggregates for provisioning (optional; if set, must be assigned to the SVM). All aggregates assigned to the SVM are used to provision a FlexGroup volume. Supported for the <b>ontap-nas-flexgroup</b> storage driver.</p> <p> When the aggregate list is updated in SVM, the list is updated in Trident automatically by polling SVM without having to restart the Trident Controller. When you have configured a specific aggregate list in Trident to provision volumes, if the aggregate list is renamed or moved out of SVM, the backend will move to failed state in Trident while polling the SVM aggregate. You must either change the aggregate list to one that is present on the SVM or remove it altogether to bring the backend back online.</p>	""
limitVolumeSize	<p>Fail provisioning if requested volume size is above this value.</p> <p>Also restricts the maximum size of the volumes it manages for qtrees, and the <code>qtreesPerFlexvol</code> option allows customizing the maximum number of qtrees per FlexVol.</p>	"" (not enforced by default)
debugTraceFlags	<p>Debug flags to use when troubleshooting. Example, <code>{"api":false, "method":true}</code></p> <p>Do not use <code>debugTraceFlags</code> unless you are troubleshooting and require a detailed log dump.</p>	null
nasType	<p>Configure NFS or SMB volumes creation.</p> <p>Options are <code>nfs</code>, <code>smb</code> or <code>null</code>. Setting to <code>null</code> defaults to NFS volumes.</p>	<code>nfs</code>
nfsMountOptions	<p>Comma-separated list of NFS mount options.</p> <p>The mount options for Kubernetes-persistent volumes are normally specified in storage classes, but if no mount options are specified in a storage class, Trident will fall back to using the mount options specified in the storage backend's configuration file.</p> <p>If no mount options are specified in the storage class or the configuration file, Trident will not set any mount options on an associated persistent volume.</p>	""

Parameter	Description	Default
qtreesPerFlexVol	Maximum Qtrees per FlexVol, must be in range [50, 300]	"200"
smbShare	<p>You can specify one of the following: the name of an SMB share created using the Microsoft Management Console or ONTAP CLI; a name to allow Trident to create the SMB share; or you can leave the parameter blank to prevent common share access to volumes.</p> <p>This parameter is optional for on-premises ONTAP.</p> <p>This parameter is required for Amazon FSx for ONTAP backends and cannot be blank.</p>	smb-share
useREST	<p>Boolean parameter to use ONTAP REST APIs.</p> <p><code>useREST</code> When set to <code>true</code>, Trident uses ONTAP REST APIs to communicate with the backend; when set to <code>false</code>, Trident uses ONTAP ZAPI calls to communicate with the backend. This feature requires ONTAP 9.11.1 and later. In addition, the ONTAP login role used must have access to the <code>ontap</code> application. This is satisfied by the pre-defined <code>vsadmin</code> and <code>cluster-admin</code> roles.</p> <p>Beginning with the Trident 24.06 release and ONTAP 9.15.1 or later, <code>useREST</code> is set to <code>true</code> by default; change <code>useREST</code> to <code>false</code> to use ONTAP ZAPI calls.</p>	true for ONTAP 9.15.1 or later, otherwise <code>false</code> .
limitVolumePoolSize	Maximum requestable FlexVol size when using Qtrees in <code>ontap-nas-economy</code> backend.	"" (not enforced by default)
denyNewVolumePools	Restricts <code>ontap-nas-economy</code> backends from creating new FlexVol volumes to contain their Qtrees. Only preexisting Flexvols are used for provisioning new PVs.	

#### Backend configuration options for provisioning volumes

You can control default provisioning using these options in the `defaults` section of the configuration. For an example, see the configuration examples below.

Parameter	Description	Default
spaceAllocation	Space-allocation for Qtrees	"true"
spaceReserve	Space reservation mode; "none" (thin) or "volume" (thick)	"none"
snapshotPolicy	Snapshot policy to use	"none"

Parameter	Description	Default
qosPolicy	QoS policy group to assign for volumes created. Choose one of qosPolicy or adaptiveQosPolicy per storage pool/backend	""
adaptiveQosPolicy	Adaptive QoS policy group to assign for volumes created. Choose one of qosPolicy or adaptiveQosPolicy per storage pool/backend.  Not supported by ontap-nas-economy.	""
snapshotReserve	Percentage of volume reserved for snapshots	"0" if snapshotPolicy is "none", otherwise ""
splitOnClone	Split a clone from its parent upon creation	"false"
encryption	Enable NetApp Volume Encryption (NVE) on the new volume; defaults to <code>false</code> . NVE must be licensed and enabled on the cluster to use this option.  If NAE is enabled on the backend, any volume provisioned in Trident will be NAE enabled.  For more information, refer to: <a href="#">How Trident works with NVE and NAE</a> .	"false"
tieringPolicy	Tiering policy to use "none"	"snapshot-only" for pre-ONTAP 9.5 SVM-DR configuration
unixPermissions	Mode for new volumes	"777" for NFS volumes; empty (not applicable) for SMB volumes
snapshotDir	Controls access to the <code>.snapshot</code> directory	"true" for NFSv4 "false" for NFSv3
exportPolicy	Export policy to use	"default"
securityStyle	Security style for new volumes.  NFS supports <code>mixed</code> and <code>unix</code> security styles.  SMB supports <code>mixed</code> and <code>ntfs</code> security styles.	NFS default is <code>unix</code> .  SMB default is <code>ntfs</code> .
nameTemplate	Template to create custom volume names.	""



Using QoS policy groups with Trident requires ONTAP 9.8 or later. You should use a non-shared QoS policy group and ensure the policy group is applied to each constituent individually. A shared QoS policy group enforces the ceiling for the total throughput of all workloads.

## Volume provisioning examples

Here's an example with defaults defined:

```

---
version: 1
storageDriverName: ontap-nas
backendName: customBackendName
managementLIF: 10.0.0.1
dataLIF: 10.0.0.2
labels:
  k8scluster: dev1
  backend: dev1-nasbackend
svm: trident_svm
username: cluster-admin
password: <password>
limitAggregateUsage: 80%
limitVolumeSize: 50Gi
nfsMountOptions: nfsvers=4
debugTraceFlags:
  api: false
  method: true
defaults:
  spaceReserve: volume
  qosPolicy: premium
  exportPolicy: myk8scluster
  snapshotPolicy: default
  snapshotReserve: '10'

```

For `ontap-nas` and `ontap-nas-flexgroups`, Trident now uses a new calculation to ensure that the FlexVol is sized correctly with the `snapshotReserve` percentage and PVC. When the user requests a PVC, Trident creates the original FlexVol with more space by using the new calculation. This calculation ensures that the user receives the writable space they requested for in the PVC, and not lesser space than what they requested. Before v21.07, when the user requests a PVC (for example, 5GiB), with the `snapshotReserve` to 50 percent, they get only 2.5GiB of writeable space. This is because what the user requested for is the whole volume and `snapshotReserve` is a percentage of that. With Trident 21.07, what the user requests for is the writeable space and Trident defines the `snapshotReserve` number as the percentage of the whole volume. This does not apply to `ontap-nas-economy`. See the following example to see how this works:

The calculation is as follows:

```

Total volume size = (PVC requested size) / (1 - (snapshotReserve
percentage) / 100)

```

For `snapshotReserve = 50%`, and `PVC request = 5GiB`, the total volume size is  $2/5 = 10\text{GiB}$  and the available size is  $5\text{GiB}$ , which is what the user requested in the PVC request. The `volume show` command should show results similar to this example:

Vserver	Volume	Aggregate	State	Type	Size	Available	Used%
	_pvc_89f1c156_3801_4de4_9f9d_034d54c395f4		online	RW	10GB	5.00GB	0%
	_pvc_e8372153_9ad9_474a_951a_08ae15e1c0ba		online	RW	1GB	511.8MB	0%
2 entries were displayed.							

Existing backends from previous installs will provision volumes as explained above when upgrading Trident. For volumes that you created before upgrading, you should resize their volumes for the change to be observed. For example, a 2GiB PVC with `snapshotReserve=50` earlier resulted in a volume that provides 1GiB of writable space. Resizing the volume to 3GiB, for example, provides the application with 3GiB of writable space on a 6 GiB volume.

#### Minimal configuration examples

The following examples show basic configurations that leave most parameters to default. This is the easiest way to define a backend.



If you are using Amazon FSx on NetApp ONTAP with Trident, the recommendation is to specify DNS names for LIFs instead of IP addresses.

#### ONTAP NAS economy example

```
---
version: 1
storageDriverName: ontap-nas-economy
managementLIF: 10.0.0.1
dataLIF: 10.0.0.2
svm: svm_nfs
username: vsadmin
password: password
```

#### ONTAP NAS Flexgroup example

```
---
version: 1
storageDriverName: ontap-nas-flexgroup
managementLIF: 10.0.0.1
dataLIF: 10.0.0.2
svm: svm_nfs
username: vsadmin
password: password
```

## MetroCluster example

You can configure the backend to avoid having to manually update the backend definition after switchover and switchback during [SVM replication and recovery](#).

For seamless switchover and switchback, specify the SVM using `managementLIF` and omit the `dataLIF` and `svm` parameters. For example:

```
---  
version: 1  
storageDriverName: ontap-nas  
managementLIF: 192.168.1.66  
username: vsadmin  
password: password
```

## SMB volumes example

```
---  
version: 1  
backendName: ExampleBackend  
storageDriverName: ontap-nas  
managementLIF: 10.0.0.1  
nasType: smb  
securityStyle: ntfs  
unixPermissions: ""  
dataLIF: 10.0.0.2  
svm: svm_nfs  
username: vsadmin  
password: password
```

## Certificate-based authentication example

This is a minimal backend configuration example. `clientCertificate`, `clientPrivateKey`, and `trustedCACertificate` (optional, if using trusted CA) are populated in `backend.json` and take the base64-encoded values of the client certificate, private key, and trusted CA certificate, respectively.

```
---  
version: 1  
backendName: DefaultNASBackend  
storageDriverName: ontap-nas  
managementLIF: 10.0.0.1  
dataLIF: 10.0.0.15  
svm: nfs_svm  
clientCertificate: ZXROZXJwYXB...ICMgJ3BhcGVyc2  
clientPrivateKey: vciwKIyAgZG...0cnksIGRlc2NyaX  
trustedCACertificate: zcyBbaG...b3Igb3duIGNsYXNz  
storagePrefix: myPrefix_
```

## Auto export policy example

This example shows you how you can instruct Trident to use dynamic export policies to create and manage the export policy automatically. This works the same for the `ontap-nas-economy` and `ontap-nas-flexgroup` drivers.

```
---  
version: 1  
storageDriverName: ontap-nas  
managementLIF: 10.0.0.1  
dataLIF: 10.0.0.2  
svm: svm_nfs  
labels:  
  k8scluster: test-cluster-east-1a  
  backend: test1-nasbackend  
autoExportPolicy: true  
autoExportCIDRs:  
- 10.0.0.0/24  
username: admin  
password: password  
nfsMountOptions: nfsvers=4
```

## IPv6 addresses example

This example shows managementLIF using an IPv6 address.

```
---  
version: 1  
storageDriverName: ontap-nas  
backendName: nas_ipv6_backend  
managementLIF: "[5c5d:5edf:8f:7657:bef8:109b:1b41:d491]"  
labels:  
  k8scluster: test-cluster-east-1a  
  backend: test1-ontap-ipv6  
svm: nas_ipv6_svm  
username: vsadmin  
password: password
```

## Amazon FSx for ONTAP using SMB volumes example

The smbShare parameter is required for FSx for ONTAP using SMB volumes.

```
---  
version: 1  
backendName: SMBBackend  
storageDriverName: ontap-nas  
managementLIF: example.mgmt.fqdn.aws.com  
nasType: smb  
dataLIF: 10.0.0.15  
svm: nfs_svm  
smbShare: smb-share  
clientCertificate: ZXR0ZXJwYXB...ICMgJ3BhcGVyc2  
clientPrivateKey: vciwKIyAgZG...0cnksIGRlc2NyaX  
trustedCACertificate: zcyBbaG...b3Igb3duIGNsYXNz  
storagePrefix: myPrefix_
```

## Backend configuration example with nameTemplate

```
---
version: 1
storageDriverName: ontap-nas
backendName: ontap-nas-backend
managementLIF: <ip address>
svm: svm0
username: <admin>
password: <password>
defaults: {
    "nameTemplate":
"{{.volume.Name}}_{{.labels.cluster}}_{{.volume.Namespace}}_{{.volume.RequestName}}"
},
"labels": {"cluster": "ClusterA", "PVC":
"{{.volume.Namespace}}_{{.volume.RequestName}}"
}
```

### Examples of backends with virtual pools

In the sample backend definition files shown below, specific defaults are set for all storage pools, such as `spaceReserve` at `none`, `spaceAllocation` at `false`, and `encryption` at `false`. The virtual pools are defined in the storage section.

Trident sets provisioning labels in the "Comments" field. Comments are set on FlexVol for `ontap-nas` or `FlexGroup` for `ontap-nas-flexgroup`. Trident copies all labels present on a virtual pool to the storage volume at provisioning. For convenience, storage administrators can define labels per virtual pool and group volumes by label.

In these examples, some of the storage pools set their own `spaceReserve`, `spaceAllocation`, and `encryption` values, and some pools override the default values.

## ONTAP NAS example

```
---  
version: 1  
storageDriverName: ontap-nas  
managementLIF: 10.0.0.1  
svm: svm_nfs  
username: admin  
password: <password>  
nfsMountOptions: nfsvers=4  
defaults:  
  spaceReserve: none  
  encryption: 'false'  
  qosPolicy: standard  
labels:  
  store: nas_store  
  k8scluster: prod-cluster-1  
region: us_east_1  
storage:  
- labels:  
  app: msoffice  
  cost: '100'  
  zone: us_east_1a  
  defaults:  
    spaceReserve: volume  
    encryption: 'true'  
    unixPermissions: '0755'  
    adaptiveQosPolicy: adaptive-premium  
- labels:  
  app: slack  
  cost: '75'  
  zone: us_east_1b  
  defaults:  
    spaceReserve: none  
    encryption: 'true'  
    unixPermissions: '0755'  
- labels:  
  department: legal  
  creditpoints: '5000'  
  zone: us_east_1b  
  defaults:  
    spaceReserve: none  
    encryption: 'true'  
    unixPermissions: '0755'  
- labels:  
  app: wordpress
```

```
cost: '50'
zone: us_east_1c
defaults:
  spaceReserve: none
  encryption: 'true'
  unixPermissions: '0775'
- labels:
  app: mysql
  cost: '25'
  zone: us_east_1d
  defaults:
    spaceReserve: volume
    encryption: 'false'
    unixPermissions: '0775'
```

## ONTAP NAS FlexGroup example

```
---  
version: 1  
storageDriverName: ontap-nas-flexgroup  
managementLIF: 10.0.0.1  
svm: svm_nfs  
username: vsadmin  
password: <password>  
defaults:  
  spaceReserve: none  
  encryption: 'false'  
labels:  
  store: flexgroup_store  
  k8scluster: prod-cluster-1  
region: us_east_1  
storage:  
- labels:  
  protection: gold  
  creditpoints: '50000'  
  zone: us_east_1a  
  defaults:  
    spaceReserve: volume  
    encryption: 'true'  
    unixPermissions: '0755'  
- labels:  
  protection: gold  
  creditpoints: '30000'  
  zone: us_east_1b  
  defaults:  
    spaceReserve: none  
    encryption: 'true'  
    unixPermissions: '0755'  
- labels:  
  protection: silver  
  creditpoints: '20000'  
  zone: us_east_1c  
  defaults:  
    spaceReserve: none  
    encryption: 'true'  
    unixPermissions: '0775'  
- labels:  
  protection: bronze  
  creditpoints: '10000'  
  zone: us_east_1d  
  defaults:
```

```
spaceReserve: volume
encryption: 'false'
unixPermissions: '0775'
```

## ONTAP NAS economy example

```
---  
version: 1  
storageDriverName: ontap-nas-economy  
managementLIF: 10.0.0.1  
svm: svm_nfs  
username: vsadmin  
password: <password>  
defaults:  
  spaceReserve: none  
  encryption: 'false'  
labels:  
  store: nas_economy_store  
region: us_east_1  
storage:  
- labels:  
  department: finance  
  creditpoints: '6000'  
  zone: us_east_1a  
  defaults:  
    spaceReserve: volume  
    encryption: 'true'  
    unixPermissions: '0755'  
- labels:  
  protection: bronze  
  creditpoints: '5000'  
  zone: us_east_1b  
  defaults:  
    spaceReserve: none  
    encryption: 'true'  
    unixPermissions: '0755'  
- labels:  
  department: engineering  
  creditpoints: '3000'  
  zone: us_east_1c  
  defaults:  
    spaceReserve: none  
    encryption: 'true'  
    unixPermissions: '0775'  
- labels:  
  department: humanresource  
  creditpoints: '2000'  
  zone: us_east_1d  
  defaults:  
    spaceReserve: volume
```

```
  encryption: 'false'  
  unixPermissions: '0775'
```

## Map backends to StorageClasses

The following StorageClass definitions refer to [Examples of backends with virtual pools](#). Using the `parameters.selector` field, each StorageClass calls out which virtual pools can be used to host a volume. The volume will have the aspects defined in the chosen virtual pool.

- The `protection-gold` StorageClass will map to the first and second virtual pool in the `ontap-nas-flexgroup` backend. These are the only pools offering gold level protection.

```
apiVersion: storage.k8s.io/v1  
kind: StorageClass  
metadata:  
  name: protection-gold  
provisioner: csi.trident.netapp.io  
parameters:  
  selector: "protection=gold"  
  fsType: "ext4"
```

- The `protection-not-gold` StorageClass will map to the third and fourth virtual pool in the `ontap-nas-flexgroup` backend. These are the only pools offering protection level other than gold.

```
apiVersion: storage.k8s.io/v1  
kind: StorageClass  
metadata:  
  name: protection-not-gold  
provisioner: csi.trident.netapp.io  
parameters:  
  selector: "protection!=gold"  
  fsType: "ext4"
```

- The `app-mysqldb` StorageClass will map to the fourth virtual pool in the `ontap-nas` backend. This is the only pool offering storage pool configuration for `mysqldb` type app.

```

apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: app-mysqldb
provisioner: csi.trident.netapp.io
parameters:
  selector: "app=mysqldb"
  fsType: "ext4"

```

- The protection-silver-creditpoints-20k StorageClass will map to the third virtual pool in the ontap-nas-flexgroup backend. This is the only pool offering silver-level protection and 20000 creditpoints.

```

apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: protection-silver-creditpoints-20k
provisioner: csi.trident.netapp.io
parameters:
  selector: "protection=silver; creditpoints=20000"
  fsType: "ext4"

```

- The creditpoints-5k StorageClass will map to the third virtual pool in the ontap-nas backend and the second virtual pool in the ontap-nas-economy backend. These are the only pool offerings with 5000 creditpoints.

```

apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: creditpoints-5k
provisioner: csi.trident.netapp.io
parameters:
  selector: "creditpoints=5000"
  fsType: "ext4"

```

Trident will decide which virtual pool is selected and ensures the storage requirement is met.

#### **Update dataLIF after initial configuration**

You can change the data LIF after initial configuration by running the following command to provide the new backend JSON file with updated data LIF.

```
tridentctl update backend <backend-name> -f <path-to-backend-json-file-with-updated-dataLIF>
```



If PVCs are attached to one or multiple pods, you must bring down all corresponding pods and then bring them back up in order for the new data LIF to take effect.

## Amazon FSx for NetApp ONTAP

### Use Trident with Amazon FSx for NetApp ONTAP

[Amazon FSx for NetApp ONTAP](#) is a fully managed AWS service that enables customers to launch and run file systems powered by the NetApp ONTAP storage operating system. FSx for ONTAP enables you to leverage NetApp features, performance, and administrative capabilities you are familiar with, while taking advantage of the simplicity, agility, security, and scalability of storing data on AWS. FSx for ONTAP supports ONTAP file system features and administration APIs.

You can integrate your Amazon FSx for NetApp ONTAP file system with Trident to ensure Kubernetes clusters running in Amazon Elastic Kubernetes Service (EKS) can provision block and file persistent volumes backed by ONTAP.

A file system is the primary resource in Amazon FSx, analogous to an ONTAP cluster on premises. Within each SVM you can create one or multiple volumes, which are data containers that store the files and folders in your file system. With Amazon FSx for NetApp ONTAP, Data ONTAP will be provided as a managed file system in the cloud. The new file system type is called **NetApp ONTAP**.

Using Trident with Amazon FSx for NetApp ONTAP, you can ensure Kubernetes clusters running in Amazon Elastic Kubernetes Service (EKS) can provision block and file persistent volumes backed by ONTAP.

### Requirements

In addition to [Trident requirements](#), to integrate FSx for ONTAP with Trident, you need:

- An existing Amazon EKS cluster or self-managed Kubernetes cluster with `kubectl` installed.
- An existing Amazon FSx for NetApp ONTAP file system and storage virtual machine (SVM) that is reachable from your cluster's worker nodes.
- Worker nodes that are prepared for [NFS](#) or [iSCSI](#).



Ensure you follow the node preparation steps required for Amazon Linux and Ubuntu [Amazon Machine Images](#) (AMIs) depending on your EKS AMI type.

### Considerations

- SMB volumes:
  - SMB volumes are supported using the `ontap-nas` driver only.
  - SMB volumes are not supported with Trident EKS add-on.
  - Trident supports SMB volumes mounted to pods running on Windows nodes only. Refer to [Prepare to](#)

[provision SMB volumes](#) for details.

- Prior to Trident 24.02, volumes created on Amazon FSx file systems that have automatic backups enabled, could not be deleted by Trident. To prevent this issue in Trident 24.02 or later, specify the `fsxFilesystemID`, `AWS apiRegion`, `AWS apiKey`, and `AWS secretKey` in the backend configuration file for AWS FSx for ONTAP.



If you are specifying an IAM role to Trident, then you can omit specifying the `apiRegion`, `apiKey`, and `secretKey` fields to Trident explicitly. For more information, refer to [FSx for ONTAP configuration options and examples](#).

## Authentication

Trident offers two modes of authentication.

- Credential-based(Recommended): Stores credentials securely in AWS Secrets Manager. You can use the `fsxadmin` user for your file system or the `vsadmin` user configured for your SVM.



Trident expects to be run as a `vsadmin` SVM user or as a user with a different name that has the same role. Amazon FSx for NetApp ONTAP has an `fsxadmin` user that is a limited replacement of the ONTAP `admin` cluster user. We strongly recommend using `vsadmin` with Trident.

- Certificate-based: Trident will communicate with the SVM on your FSx file system using a certificate installed on your SVM.

For details on enabling authentication, refer to the authentication for your driver type:

- [ONTAP NAS authentication](#)
- [ONTAP SAN authentication](#)

## Tested Amazon Machine Images (AMIs)

EKS cluster supports various operating systems, but AWS has optimized certain Amazon Machine Images (AMIs) for containers and EKS. The following AMIs have been tested with Trident 24.10.

AMI	NAS	NAS-economy	SAN	SAN-economy
AL2023_x86_64_STANDARD	Yes	Yes	Yes	Yes
AL2_x86_64	Yes	Yes	Yes**	Yes**
BOTTLEROCKET_x86_64	Yes*	Yes	N/A	N/A
AL2023_ARM_64_STANDARD	Yes	Yes	Yes	Yes
AL2_ARM_64	Yes	Yes	Yes**	Yes**
BOTTLEROCKET_ARM_64	Yes*	Yes	N/A	N/A

- \*Must use “nolock” in mount options.

- \*\* Unable to delete the PV without restarting the node



If your desired AMI is not listed here, it does not mean that it is not supported; it simply means it has not been tested. This list serves as a guide for AMIs known to work.

### Tests performed with:

- EKS version: 1.30
- Installation Method: Helm and as an AWS add-On
- For NAS both NFSv3 and NFSv4.1 were tested.
- For SAN only iSCSI was tested, not NVMe-oF.

### Tests performed:

- Create: Storage Class, pvc, pod
- Delete: pod, pvc (regular, qtree/lun – economy, NAS with AWS backup)

### Find more information

- [Amazon FSx for NetApp ONTAP documentation](#)
- [Blog post on Amazon FSx for NetApp ONTAP](#)

### Create an IAM role and AWS Secret

You can configure Kubernetes pods to access AWS resources by authenticating as an AWS IAM role instead of by providing explicit AWS credentials.



To authenticate using an AWS IAM role, you must have a Kubernetes cluster deployed using EKS.

#### Create AWS Secret Manager secret

This example creates an AWS Secret Manager secret to store Trident CSI credentials:

```
aws secretsmanager create-secret --name trident-secret --description "Trident CSI credentials" \
--secret-string "{\"username\":\"vsadmin\", \"password\":\"<svmpassword>\"}"
```

#### Create IAM Policy

The following examples creates an IAM policy using the AWS CLI:

```
aws iam create-policy --policy-name AmazonFSxNCSIDriverPolicy --policy
--document file://policy.json
--description "This policy grants access to Trident CSI to FSxN and
Secret manager"
```

### Policy JSON file:

```
policy.json:
{
  "Statement": [
    {
      "Action": [
        "fsx:DescribeFileSystems",
        "fsx:DescribeVolumes",
        "fsx>CreateVolume",
        "fsx:RestoreVolumeFromSnapshot",
        "fsx:DescribeStorageVirtualMachines",
        "fsx:UntagResource",
        "fsx:UpdateVolume",
        "fsx:TagResource",
        "fsx:DeleteVolume"
      ],
      "Effect": "Allow",
      "Resource": "*"
    },
    {
      "Action": "secretsmanager:GetSecretValue",
      "Effect": "Allow",
      "Resource": "arn:aws:secretsmanager:<aws-region>:<aws-account-
id>:secret:<aws-secret-manager-name>*"
    }
  ],
  "Version": "2012-10-17"
}
```

### Create an IAM role for the service account

## AWS CLI

```
aws iam create-role --role-name trident-controller \
--assume-role-policy-document file://trust-relationship.json
```

### trust-relationship.json file:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Principal": {
        "Federated": "arn:aws:iam::<account_id>:oidc-provider/<oidc_provider>"
      },
      "Action": "sts:AssumeRoleWithWebIdentity",
      "Condition": {
        "StringEquals": {
          "<oidc_provider>:aud": "sts.amazonaws.com",
          "<oidc_provider>:sub": "system:serviceaccount:trident:trident-controller"
        }
      }
    }
  ]
}
```

Update the following values in the `trust-relationship.json` file:

- `<account_id>` - Your AWS account ID
- `<oidc_provider>` - The OIDC of your EKS cluster. You can obtain the `oidc_provider` by running:

```
aws eks describe-cluster --name my-cluster --query
"cluster.identity.oidc.issuer"\n
--output text | sed -e "s/^https://\//\//\//\//"
```

### Attach the IAM role with the IAM policy:

Once the role has been created, attach the policy (that was created in the step above) to the role using this command:

```
aws iam attach-role-policy --role-name my-role --policy-arn <IAM policy ARN>
```

## Verify OIDC provider is associated:

Verify that your OIDC provider is associated with your cluster. You can verify it using this command:

```
aws iam list-open-id-connect-providers | grep $oidc_id | cut -d "/" -f4
```

Use the following command to associate IAM OIDC to your cluster:

```
eksctl utils associate-iam-oidc-provider --cluster $cluster_name  
--approve
```

## eksctl

The following example creates an IAM role for service account in EKS:

```
eksctl create iamserviceaccount --name trident-controller --namespace  
trident \  
--cluster <my-cluster> --role-name <AmazonEKS_FSxN_CSI_DriverRole>  
--role-only \  
--attach-policy-arn <IAM-Policy ARN> --approve
```

## Install Trident

Trident streamlines Amazon FSx for NetApp ONTAP storage management in Kubernetes to enable your developers and administrators focus on application deployment.

You can install Trident using one of the following methods:

- Helm
- EKS add-on

If you want to make use of the snapshot functionality, install the CSI snapshot controller add-on. Refer to [Enable snapshot functionality for CSI volumes](#) for more information.

### Install Trident via helm

#### 1. Download the Trident installer package

The Trident installer package contains everything you need to deploy the Trident operator and install Trident. Download and extract the latest version of the Trident installer from the Assets section on GitHub.

```
wget https://github.com/NetApp/trident/releases/download/v24.10.0/trident-  
installer-24.10.0.tar.gz  
tar -xf trident-installer-24.10.0.tar.gz  
cd trident-installer/helm
```

#### 2. Set the values for **cloud provider** and **cloud identity** flags using the following environment variables:

The following example installs Trident and sets the `cloud-provider` flag to `$CP`, and `cloud-identity` to `$CI`:

```
helm install trident trident-operator-100.2410.0.tgz --set
cloudProvider="AWS" \
--set cloudIdentity="'eks.amazonaws.com/role-arn:
arn:aws:iam::<accountID>:role/<AmazonEKS_FSxN_CSI_DriverRole>'" \
--namespace trident --create-namespace
```

You can use the `helm list` command to review installation details such as name, namespace, chart, status, app version, and revision number.

```
helm list -n trident
```

NAME	NAMESPACE	REVISION	UPDATED
STATUS	CHART		APP VERSION
trident-operator	trident	1	2024-10-14 14:31:22.463122
+0300 IDT	deployed	trident-operator-100.2410.0	24.10.0

### Install Trident via the EKS add-on

The Trident EKS add-on includes the latest security patches, bug fixes, and is validated by AWS to work with Amazon EKS. The EKS add-on enables you to consistently ensure that your Amazon EKS clusters are secure and stable and reduce the amount of work that you need to do in order to install, configure, and update add-ons.

### Prerequisites

Ensure that you have the following before configuring the Trident add-on for AWS EKS:

- An Amazon EKS cluster account with add-on subscription
- AWS permissions to the AWS marketplace:  
"aws-marketplace:ViewSubscriptions",  
"aws-marketplace:Subscribe",  
"aws-marketplace:Unsubscribe"
- AMI type: Amazon Linux 2 (AL2\_x86\_64) or Amazon Linux 2 Arm(AL2\_ARM\_64)
- Node type: AMD or ARM
- An existing Amazon FSx for NetApp ONTAP file system

### Enable the Trident add-on for AWS

## eksctl

The following example commands install the Trident EKS add-on:

```
eksctl create addon --name netapp_trident-operator --cluster
<cluster_name> \
    --service-account-role-arn
arn:aws:iam::<account_id>:role/<role_name> --force
```

## Management console

1. Open the Amazon EKS console at <https://console.aws.amazon.com/eks/home#/clusters>.
2. On the left navigation pane, click **Clusters**.
3. Click the name of the cluster that you want to configure the NetApp Trident CSI add-on for.
4. Click **Add-ons** and then click **Get more add-ons**.
5. On the **Select add-ons** page, do the following:
  - a. In the AWS Marketplace EKS-addons section, select the **Trident by NetApp** check box.
  - b. Click **Next**.
6. On the **Configure selected add-ons** settings page, do the following:
  - a. Select the **Version** you would like to use.
  - b. For **Select IAM role**, leave at **Not set**.
  - c. Expand the **Optional configuration settings**, follow the **Add-on configuration schema** and set the configurationValues parameter on the **Configuration values** section to the role-arn you created on the previous step (value should be in the following format:  
eks.amazonaws.com/role-arn:  
arn:aws:iam::464262061435:role/AmazonEKS\_FSXN\_CSI\_DriverRole). If you select **Override** for the Conflict resolution method, one or more of the settings for the existing add-on can be overwritten with the Amazon EKS add-on settings. If you don't enable this option and there's a conflict with your existing settings, the operation fails. You can use the resulting error message to troubleshoot the conflict. Before selecting this option, make sure that the Amazon EKS add-on doesn't manage settings that you need to self-manage.
7. Choose **Next**.
8. On the **Review and add** page, choose **Create**.

After the add-on installation is complete, you see your installed add-on.

## AWS CLI

1. Create the add-on.json file:

```
add-on.json
{
  "clusterName": "<eks-cluster>",
  "addonName": "netapp_trident-operator",
  "addonVersion": "v24.10.0-eksbuild.1",
  "serviceAccountRoleArn": "<arn:aws:iam::123456:role/astratrident-role>",
  "configurationValues": "{\"cloudIdentity\":\n    \"'eks.amazonaws.com/role-arn:\n    <arn:aws:iam::123456:role/astratrident-role>'\"},\n  \"cloudProvider\": \"AWS\"}"
}
```

## 2. Install the Trident EKS add-on

```
aws eks create-addon --cli-input-json file://add-on.json
```

## Update the Trident EKS add-on

## eksctl

- Check the current version of your FSxN Trident CSI add-on. Replace `my-cluster` with your cluster name.

```
eksctl get addon --name netapp_trident-operator --cluster my-cluster
```

### Example output:

NAME	VERSION	STATUS	ISSUES
IAMROLE	UPDATE AVAILABLE CONFIGURATION VALUES		
netapp_trident-operator	v24.10.0-eksbuild.1	ACTIVE	0
	{"cloudIdentity": "'eks.amazonaws.com/role-arn': 'arn:aws:iam::139763910815:role/AmazonEKS_FSXN_CSI_DriverRole'"}		

- Update the add-on to the version returned under UPDATE AVAILABLE in the output of the previous step.

```
eksctl update addon --name netapp_trident-operator --version v24.10.0-eksbuild.1 --cluster my-cluster --force
```

If you remove the `--force` option and any of the Amazon EKS add-on settings conflict with your existing settings, then updating the Amazon EKS add-on fails; you receive an error message to help you resolve the conflict. Before specifying this option, make sure that the Amazon EKS add-on does not manage settings that you need to manage, because those settings are overwritten with this option.

For more information about other options for this setting, see [Addons](#).

For more information about Amazon EKS Kubernetes field management, see [Kubernetes field management](#).

## Management console

1. Open the Amazon EKS console <https://console.aws.amazon.com/eks/home#/clusters>.
2. On the left navigation pane, click **Clusters**.
3. Click the name of the cluster that you want to update the NetApp Trident CSI add-on for.
4. Click the **Add-ons** tab.
5. Click **Trident by NetApp** and then click **Edit**.
6. On the **Configure Trident by NetApp** page, do the following:
  - a. Select the **Version** you would like to use.
  - b. Expand the **Optional configuration settings** and modify as needed.
  - c. Click **Save changes**.

## AWS CLI

The following example updates the EKS add-on:

```
aws eks update-addon --cluster-name my-cluster netapp_trident-operator
vpc-cni --addon-version v24.6.1-eksbuild.1 \
--service-account-role-arn arn:aws:iam::111122223333:role/role-name
--configuration-values '{}' --resolve-conflicts --preserve
```

## Uninstall/remove the Trident EKS add-on

You have two options for removing an Amazon EKS add-on:

- **Preserve add-on software on your cluster** – This option removes Amazon EKS management of any settings. It also removes the ability for Amazon EKS to notify you of updates and automatically update the Amazon EKS add-on after you initiate an update. However, it preserves the add-on software on your cluster. This option makes the add-on a self-managed installation, rather than an Amazon EKS add-on. With this option, there's no downtime for the add-on. Retain the `--preserve` option in the command to preserve the add-on.
- **Remove add-on software entirely from your cluster** – We recommend that you remove the Amazon EKS add-on from your cluster only if there are no resources on your cluster that are dependent on it. Remove the `--preserve` option from the `delete` command to remove the add-on.



If the add-on has an IAM account associated with it, the IAM account is not removed.

### eksctl

The following command uninstalls the Trident EKS add-on:

```
eksctl delete addon --cluster K8s-arm --name netapp_trident-operator
```

### Management console

1. Open the Amazon EKS console at <https://console.aws.amazon.com/eks/home#/clusters>.
2. In the left navigation pane, click **Clusters**.
3. Click the name of the cluster that you want to remove the NetApp Trident CSI add-on for.
4. Click the **Add-ons** tab and then click **Trident by NetApp**.\*
5. Click **Remove**.
6. In the **Remove netapp\_trident-operator confirmation** dialog, do the following:
  - a. If you want Amazon EKS to stop managing settings for the add-on, select **Preserve on cluster**. Do this if you want to retain the add-on software on your cluster so that you can manage all of the settings of the add-on on your own.
  - b. Enter **netapp\_trident-operator**.
  - c. Click **Remove**.

### AWS CLI

Replace `my-cluster` with the name of your cluster, and then run the following command.

```
aws eks delete-addon --cluster-name my-cluster --addon-name netapp_trident-
operator --preserve
```

## Configure the Storage Backend

### ONTAP SAN and NAS driver integration

To create a storage backend, you need to create a configuration file in either JSON or YAML format. The file needs to specify the type of storage you want (NAS or SAN), the file system, and SVM to get it from and how to authenticate with it. The following example shows how to define NAS-based storage and using an AWS secret to store the credentials to the SVM you want to use:

## YAML

```
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-ontap-nas
  namespace: trident
spec:
  version: 1
  storageDriverName: ontap-nas
  backendName: tbc-ontap-nas
  svm: svm-name
  aws:
    fsxFilesystemID: fs-xxxxxxxxxx
  credentials:
    name: "arn:aws:secretsmanager:us-west-2:xxxxxxxx:secret:secret-
name"
    type: awsarn
```

## JSON

```
{
  "apiVersion": "trident.netapp.io/v1",
  "kind": "TridentBackendConfig",
  "metadata": {
    "name": "backend-tbc-ontap-nas",
    "namespace": "trident"
  },
  "spec": {
    "version": 1,
    "storageDriverName": "ontap-nas",
    "backendName": "tbc-ontap-nas",
    "svm": "svm-name",
    "aws": {
      "fsxFilesystemID": "fs-xxxxxxxxxx"
    },
    "managementLIF": null,
    "credentials": {
      "name": "arn:aws:secretsmanager:us-west-2:xxxxxxxx:secret:secret-
name",
      "type": "awsarn"
    }
  }
}
```

Run the following commands to create and validate the Trident Backend Configuration (TBC):

- Create trident backend configuration (TBC) from yaml file and run the following command:

```
kubectl create -f backendconfig.yaml -n trident
```

```
tridentbackendconfig.trident.netapp.io/backend-tbc-ontap-nas created
```

- Validate the trident backend configuration (TBC) was created successfully:

```
Kubectl get tbc -n trident
```

NAME	PHASE	STATUS	BACKEND NAME	BACKEND UUID
backend-tbc-ontap-nas	b9ff-f96d916ac5e9	Bound	tbc-ontap-nas	933e0071-66ce-4324-

#### FSx for ONTAP driver details

You can integrate Trident with Amazon FSx for NetApp ONTAP using the following drivers:

- `ontap-san`: Each PV provisioned is a LUN within its own Amazon FSx for NetApp ONTAP volume. Recommended for block storage.
- `ontap-nas`: Each PV provisioned is a full Amazon FSx for NetApp ONTAP volume. Recommended for NFS and SMB.
- `ontap-san-economy`: Each PV provisioned is a LUN with a configurable number of LUNs per Amazon FSx for NetApp ONTAP volume.
- `ontap-nas-economy`: Each PV provisioned is a qtree, with a configurable number of qtrees per Amazon FSx for NetApp ONTAP volume.
- `ontap-nas-flexgroup`: Each PV provisioned is a full Amazon FSx for NetApp ONTAP FlexGroup volume.

For driver details, refer to [NAS drivers](#) and [SAN drivers](#).

Once the configuration file has been created, run this command to create it within your EKS:

```
kubectl create -f configuration_file
```

To verify the status, run this command:

```
kubectl get tbc -n trident
```

NAME	BACKEND NAME	BACKEND UUID
PHASE	STATUS	
backend-fsx-ontap-nas	backend-fsx-ontap-nas	7a551921-997c-4c37-a1d1-
f2f4c87fa629	Bound	Success

### Backend advanced configuration and examples

See the following table for the backend configuration options:

Parameter	Description	Example
version		Always 1
storageDriverName	Name of the storage driver	ontap-nas, ontap-nas-economy, ontap-nas-flexgroup, ontap-san, ontap-san-economy
backendName	Custom name or the storage backend	Driver name + “_” + dataLIF
managementLIF	<p>IP address of a cluster or SVM management LIF</p> <p>A fully-qualified domain name (FQDN) can be specified.</p> <p>Can be set to use IPv6 addresses if Trident was installed using the IPv6 flag. IPv6 addresses must be defined in square brackets, such as [28e8:d9fb:a825:b7bf:69a8:d02f:9e7b:3555].</p> <p>If you provide the <code>fsxFilesystemID</code> under the <code>aws</code> field, you need not to provide the <code>managementLIF</code> because Trident retrieves the SVM <code>managementLIF</code> information from AWS. So, you must provide credentials for a user under the SVM (For example: <code>vsadmin</code>) and the user must have the <code>vsadmin</code> role.</p>	“10.0.0.1”, “[2001:1234:abcd::fefe]”

Parameter	Description	Example
dataLIF	<p>IP address of protocol LIF.</p> <p><b>ONTAP NAS drivers:</b> We recommend specifying dataLIF. If not provided, Trident fetches data LIFs from the SVM. You can specify a fully-qualified domain name (FQDN) to be used for the NFS mount operations, allowing you to create a round-robin DNS to load-balance across multiple data LIFs. Can be changed after initial setting. Refer to <a href="#">Update dataLIF after initial configuration</a>.</p> <p><b>ONTAP SAN drivers:</b> Do not specify for iSCSI. Trident uses ONTAP Selective LUN Map to discover the iSCSI LIFs needed to establish a multi path session. A warning is generated if dataLIF is explicitly defined.</p> <p>Can be set to use IPv6 addresses if Trident was installed using the IPv6 flag. IPv6 addresses must be defined in square brackets, such as [28e8:d9fb:a825:b7bf:69a8:d02f:9e7b:3555].</p>	
autoExportPolicy	<p>Enable automatic export policy creation and updating [Boolean].</p> <p>Using the <code>autoExportPolicy</code> and <code>autoExportCIDRs</code> options, Trident can manage export policies automatically.</p>	false
autoExportCIDRs	<p>List of CIDRs to filter Kubernetes' node IPs against when <code>autoExportPolicy</code> is enabled.</p> <p>Using the <code>autoExportPolicy</code> and <code>autoExportCIDRs</code> options, Trident can manage export policies automatically.</p>	["0.0.0.0/0", "::/0"]
labels	Set of arbitrary JSON-formatted labels to apply on volumes	""
clientCertificate	Base64-encoded value of client certificate. Used for certificate-based auth	""

Parameter	Description	Example
clientPrivateKey	Base64-encoded value of client private key. Used for certificate-based auth	""
trustedCACertificate	Base64-encoded value of trusted CA certificate. Optional. Used for certificate-based authentication.	""
username	Username to connect to the cluster or SVM. Used for credential-based authentication. For example, vsadmin.	
password	Password to connect to the cluster or SVM. Used for credential-based authentication.	
svm	Storage virtual machine to use	Derived if an SVM managementLIF is specified.
storagePrefix	Prefix used when provisioning new volumes in the SVM.  Cannot be modified after creation. To update this parameter, you will need to create a new backend.	trident
limitAggregateUsage	<b>Do not specify for Amazon FSx for NetApp ONTAP.</b>  The provided fsxadmin and vsadmin do not contain the permissions required to retrieve aggregate usage and limit it using Trident.	Do not use.
limitVolumeSize	Fail provisioning if requested volume size is above this value.  Also restricts the maximum size of the volumes it manages for qtrees and LUNs, and the qtreesPerFlexvol option allows customizing the maximum number of qtrees per FlexVol.	"" (not enforced by default)
lunsPerFlexvol	Maximum LUNs per Flexvol, must be in range [50, 200].  SAN only.	"100"

Parameter	Description	Example
debugTraceFlags	<p>Debug flags to use when troubleshooting. Example, <code>{"api":false, "method":true}</code></p> <p><b>Do not use debugTraceFlags unless you are troubleshooting and require a detailed log dump.</b></p>	null
nfsMountOptions	<p>Comma-separated list of NFS mount options.</p> <p>The mount options for Kubernetes-persistent volumes are normally specified in storage classes, but if no mount options are specified in a storage class, Trident will fall back to using the mount options specified in the storage backend's configuration file.</p> <p>If no mount options are specified in the storage class or the configuration file, Trident will not set any mount options on an associated persistent volume.</p>	""
nasType	<p>Configure NFS or SMB volumes creation.</p> <p>Options are <code>nfs</code>, <code>smb</code>, or <code>null</code>.</p> <p><b>Must set to <code>smb</code> for SMB volumes.</b> Setting to <code>null</code> defaults to NFS volumes.</p>	<code>nfs</code>
qtreesPerFlexvol	Maximum Qtrees per FlexVol, must be in range [50, 300]	<code>"200"</code>
smbShare	<p>You can specify one of the following: the name of an SMB share created using the Microsoft Management Console or ONTAP CLI or a name to allow Trident to create the SMB share.</p> <p>This parameter is required for Amazon FSx for ONTAP backends.</p>	<code>smb-share</code>

Parameter	Description	Example
useREST	<p>Boolean parameter to use ONTAP REST APIs. <b>Tech preview</b></p> <p>useREST is provided as a <b>tech preview</b> that is recommended for test environments and not for production workloads. When set to true, Trident will use ONTAP REST APIs to communicate with the backend.</p> <p>This feature requires ONTAP 9.11.1 and later. In addition, the ONTAP login role used must have access to the <code>ontap</code> application. This is satisfied by the pre-defined <code>vsadmin</code> and <code>cluster-admin</code> roles.</p>	false
aws	<p>You can specify the following in the configuration file for AWS FSx for ONTAP:</p> <ul style="list-style-type: none"> <li>- <code>fsxFilesystemID</code>: Specify the ID of the AWS FSx file system.</li> <li>- <code>apiRegion</code>: AWS API region name.</li> <li>- <code>apikey</code>: AWS API key.</li> <li>- <code>secretKey</code>: AWS secret key.</li> </ul>	"" "" ""
credentials	<p>Specify the FSx SVM credentials to store in AWS Secret Manager.</p> <ul style="list-style-type: none"> <li>- <code>name</code>: Amazon Resource Name (ARN) of the secret, which contains the credentials of SVM.</li> <li>- <code>type</code>: Set to <code>awsarn</code>. Refer to <a href="#">Create an AWS Secrets Manager secret</a> for more information.</li> </ul>	

#### Backend configuration options for provisioning volumes

You can control default provisioning using these options in the `defaults` section of the configuration. For an example, see the configuration examples below.

Parameter	Description	Default
<code>spaceAllocation</code>	Space-allocation for LUNs	true
<code>spaceReserve</code>	Space reservation mode; “none” (thin) or “volume” (thick)	none
<code>snapshotPolicy</code>	Snapshot policy to use	none

Parameter	Description	Default
qosPolicy	<p>QoS policy group to assign for volumes created. Choose one of qosPolicy or adaptiveQosPolicy per storage pool or backend.</p> <p>Using QoS policy groups with Trident requires ONTAP 9.8 or later.</p> <p>You should use a non-shared QoS policy group and ensuring the policy group is applied to each constituent individually. A shared QoS policy group enforces the ceiling for the total throughput of all workloads.</p>	""
adaptiveQosPolicy	<p>Adaptive QoS policy group to assign for volumes created. Choose one of qosPolicy or adaptiveQosPolicy per storage pool or backend.</p> <p>Not supported by ontap-nas-economy.</p>	""
snapshotReserve	Percentage of volume reserved for snapshots "0"	If snapshotPolicy is none, else ""
splitOnClone	Split a clone from its parent upon creation	false
encryption	<p>Enable NetApp Volume Encryption (NVE) on the new volume; defaults to false. NVE must be licensed and enabled on the cluster to use this option.</p> <p>If NAE is enabled on the backend, any volume provisioned in Trident will be NAE enabled.</p> <p>For more information, refer to: <a href="#">How Trident works with NVE and NAE</a>.</p>	false
luksEncryption	<p>Enable LUKS encryption. Refer to <a href="#">Use Linux Unified Key Setup (LUKS)</a>.</p> <p>SAN only.</p>	""
tieringPolicy	Tiering policy to use none	snapshot-only for pre-ONTAP 9.5 SVM-DR configuration

Parameter	Description	Default
unixPermissions	Mode for new volumes.  <b>Leave empty for SMB volumes.</b>	""
securityStyle	Security style for new volumes.  NFS supports <code>mixed</code> and <code>unix</code> security styles.  SMB supports <code>mixed</code> and <code>ntfs</code> security styles.	NFS default is <code>unix</code> .  SMB default is <code>ntfs</code> .

### Prepare to provision SMB volumes

You can provision SMB volumes using the `ontap-nas` driver. Before you complete [ONTAP SAN and NAS driver integration](#) complete the following steps.

#### Before you begin

Before you can provision SMB volumes using the `ontap-nas` driver, you must have the following.

- A Kubernetes cluster with a Linux controller node and at least one Windows worker node running Windows Server 2019. Trident supports SMB volumes mounted to pods running on Windows nodes only.
- At least one Trident secret containing your Active Directory credentials. To generate secret `smbcreds`:

```
kubectl create secret generic smbcreds --from-literal username=user
--from-literal password='password'
```

- A CSI proxy configured as a Windows service. To configure a `csi-proxy`, refer to [GitHub: CSI Proxy](#) or [GitHub: CSI Proxy for Windows](#) for Kubernetes nodes running on Windows.

#### Steps

1. Create SMB shares. You can create the SMB admin shares in one of two ways either using the [Microsoft Management Console Shared Folders](#) snap-in or using the ONTAP CLI. To create the SMB shares using the ONTAP CLI:

- a. If necessary, create the directory path structure for the share.

The `vserver cifs share create` command checks the path specified in the `-path` option during share creation. If the specified path does not exist, the command fails.

- b. Create an SMB share associated with the specified SVM:

```
vserver cifs share create -vserver vserver_name -share-name
share_name -path path [-share-properties share_properties,...]
[other_attributes] [-comment text]
```

- c. Verify that the share was created:

```
vserver cifs share show -share-name share_name
```



Refer to [Create an SMB share](#) for full details.

2. When creating the backend, you must configure the following to specify SMB volumes. For all FSx for ONTAP backend configuration options, refer to [FSx for ONTAP configuration options and examples](#).

Parameter	Description	Example
smbShare	<p>You can specify one of the following: the name of an SMB share created using the Microsoft Management Console or ONTAP CLI or a name to allow Trident to create the SMB share.</p> <p>This parameter is required for Amazon FSx for ONTAP backends.</p>	smb-share
nasType	<p><b>Must set to smb.</b> If null, defaults to nfs.</p>	smb
securityStyle	<p>Security style for new volumes.</p> <p><b>Must be set to ntfs or mixed for SMB volumes.</b></p>	ntfs or mixed for SMB volumes
unixPermissions	<p>Mode for new volumes. <b>Must be left empty for SMB volumes.</b></p>	""

## Configure a storage class and PVC

Configure a Kubernetes StorageClass object and create the storage class to instruct Trident how to provision volumes. Create a PersistentVolume (PV) and a PersistentVolumeClaim (PVC) that uses the configured Kubernetes StorageClass to request access to the PV. You can then mount the PV to a pod.

### Create a storage class

#### Configure a Kubernetes StorageClass object

The [Kubernetes StorageClass object](#) identifies Trident as the provisioner that is used for that class instructs Trident how to provision a volume. For example:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: ontap-gold
provisioner: csi.trident.netapp.io
parameters:
  backendType: "ontap-nas"
  media: "ssd"
  provisioningType: "thin"
  snapshots: "true"
```

Refer to [Kubernetes and Trident objects](#) for details on how storage classes interact with the `PersistentVolumeClaim` and parameters for controlling how Trident provisions volumes.

## Create a storage class

### Steps

1. This is a Kubernetes object, so use `kubectl` to create it in Kubernetes.

```
kubectl create -f storage-class-ontapnas.yaml
```

2. You should now see a **basic-csi** storage class in both Kubernetes and Trident, and Trident should have discovered the pools on the backend.

```
kubectl get sc basic-csi
NAME      PROVISIONER          AGE
basic-csi  csi.trident.netapp.io  15h
```

## Create the PV and PVC

A [PersistentVolume](#) (PV) is a physical storage resource provisioned by the cluster administrator on a Kubernetes cluster. The [PersistentVolumeClaim](#) (PVC) is a request for access to the PersistentVolume on the cluster.

The PVC can be configured to request storage of a certain size or access mode. Using the associated StorageClass, the cluster administrator can control more than PersistentVolume size and access mode—such as performance or service level.

After you create the PV and PVC, you can mount the volume in a pod.

## Sample manifests

## PersistentVolume sample manifest

This sample manifest shows a basic PV of 10Gi that is associated with StorageClass `basic-csi`.

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv-storage
  labels:
    type: local
spec:
  storageClassName: basic-csi
  capacity:
    storage: 10Gi
  accessModes:
    - ReadWriteMany
  hostPath:
    path: "/my/host/path"
```

## PersistentVolumeClaim sample manifests

These examples show basic PVC configuration options.

### PVC with RWX access

This example shows a basic PVC with RWX access that is associated with a StorageClass named basic-csi.

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

### PVC with NVMe/TCP

This example shows a basic PVC for NVMe/TCP with RWO access that is associated with a StorageClass named protection-gold.

```
---
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: pvc-san-nvme
spec:
  accessModes:
    - ReadWriteMany
  resources:
    requests:
      storage: 300Mi
  storageClassName: protection-gold
```

## Create the PV and PVC

### Steps

1. Create the PV.

```
kubectl create -f pv.yaml
```

2. Verify the PV status.

```
kubectl get pv
NAME          CAPACITY  ACCESS MODES  RECLAIM POLICY  STATUS     CLAIM
STORAGECLASS  REASON    AGE
pv-storage    4Gi       RWO          Retain        Available
7s
```

3. Create the PVC.

```
kubectl create -f pvc.yaml
```

4. Verify the PVC status.

```
kubectl get pvc
NAME          STATUS  VOLUME      CAPACITY  ACCESS MODES  STORAGECLASS  AGE
pvc-storage  Bound  pv-name  2Gi       RWO          5m
```

Refer to [Kubernetes and Trident objects](#) for details on how storage classes interact with the `PersistentVolumeClaim` and parameters for controlling how Trident provisions volumes.

#### Trident attributes

These parameters determine which Trident-managed storage pools should be utilized to provision volumes of a given type.

Attribute	Type	Values	Offer	Request	Supported by
media <sup>1</sup>	string	hdd, hybrid, ssd	Pool contains media of this type; hybrid means both	Media type specified	ontap-nas, ontap-nas-economy, ontap-nas-flexgroup, ontap-san, solidfire-san
provisioningType	string	thin, thick	Pool supports this provisioning method	Provisioning method specified	thick: all ontap; thin: all ontap & solidfire-san

Attribute	Type	Values	Offer	Request	Supported by
backendType	string	ontap-nas, ontap-nas-economy, ontap-nas-flexgroup, ontap-san, solidfire-san, gcp-cvs, azure-netapp-files, ontap-san-economy	Pool belongs to this type of backend	Backend specified	All drivers
snapshots	bool	true, false	Pool supports volumes with snapshots	Volume with snapshots enabled	ontap-nas, ontap-san, solidfire-san, gcp-cvs
clones	bool	true, false	Pool supports cloning volumes	Volume with clones enabled	ontap-nas, ontap-san, solidfire-san, gcp-cvs
encryption	bool	true, false	Pool supports encrypted volumes	Volume with encryption enabled	ontap-nas, ontap-nas-economy, ontap-nas-flexgroups, ontap-san
IOPS	int	positive integer	Pool is capable of guaranteeing IOPS in this range	Volume guaranteed these IOPS	solidfire-san

<sup>1</sup>: Not supported by ONTAP Select systems

## Deploy sample application

Deploy sample application.

### Steps

1. Mount the volume in a pod.

```
kubectl create -f pv-pod.yaml
```

These examples show basic configurations to attach the PVC to a pod:

#### Basic configuration:

```

kind: Pod
apiVersion: v1
metadata:
  name: pv-pod
spec:
  volumes:
    - name: pv-storage
      persistentVolumeClaim:
        claimName: basic
  containers:
    - name: pv-container
      image: nginx
      ports:
        - containerPort: 80
          name: "http-server"
      volumeMounts:
        - mountPath: "/my/mount/path"
          name: pv-storage

```



You can monitor the progress using `kubectl get pod --watch`.

2. Verify that the volume is mounted on `/my/mount/path`.

```
kubectl exec -it pv-pod -- df -h /my/mount/path
```

Filesystem	Size
Used Avail Use% Mounted on	
192.168.188.78:/trident_pvc_ae45ed05_3ace_4e7c_9080_d2a83ae03d06	1.1G
320K 1.0G 1% /my/mount/path	

You can now delete the Pod. The Pod application will no longer exist, but the volume will remain.

```
kubectl delete pod pv-pod
```

### Configure the Trident EKS add-on on an EKS cluster

NetApp Trident streamlines Amazon FSx for NetApp ONTAP storage management in Kubernetes to enable your developers and administrators focus on application deployment. The NetApp Trident EKS add-on includes the latest security patches, bug fixes, and is validated by AWS to work with Amazon EKS. The EKS add-on enables you to consistently ensure that your Amazon EKS clusters are secure and stable and reduce

the amount of work that you need to do in order to install, configure, and update add-ons.

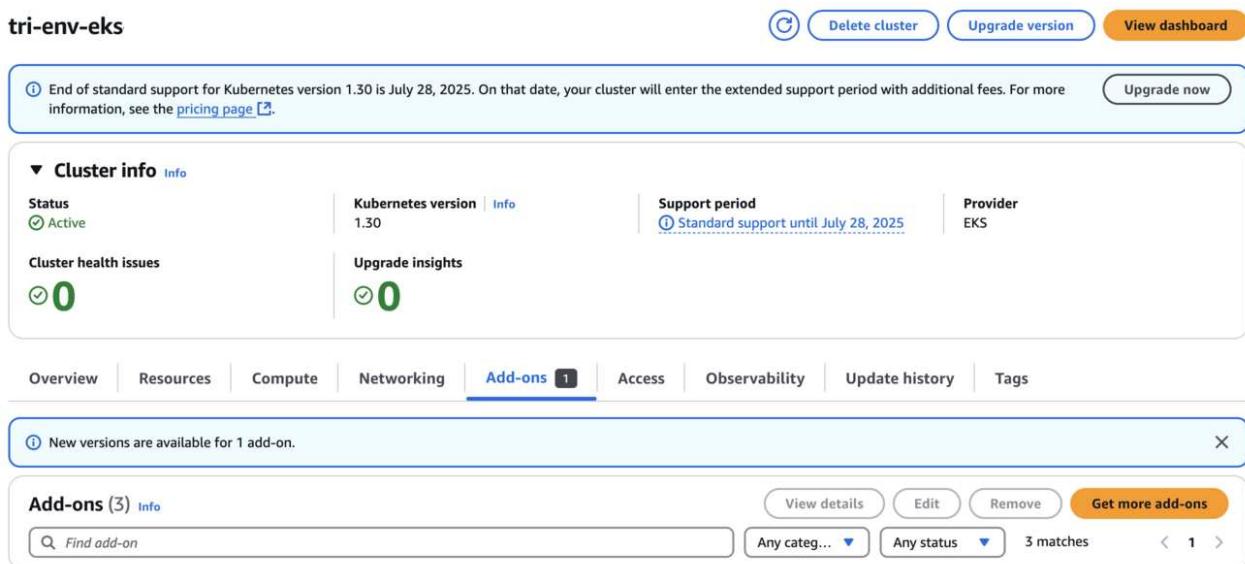
## Prerequisites

Ensure that you have the following before configuring the Trident add-on for AWS EKS:

- An Amazon EKS cluster account with permissions to work with add-ons. Refer to [Amazon EKS add-ons](#).
- AWS permissions to the AWS marketplace:  
"aws-marketplace:ViewSubscriptions",  
"aws-marketplace:Subscribe",  
"aws-marketplace:Unsubscribe"
- AMI type: Amazon Linux 2 (AL2\_x86\_64) or Amazon Linux 2 Arm(AL2\_ARM\_64)
- Node type: AMD or ARM
- An existing Amazon FSx for NetApp ONTAP file system

## Steps

1. Make sure to create IAM role and AWS secret to enable EKS pods to access AWS resources. For instructions, see [Create an IAM role and AWS Secret](#).
2. On your EKS Kubernetes cluster, navigate to the **Add-ons** tab.



The screenshot shows the AWS EKS Cluster Details page for a cluster named "tri-env-eks". The "Add-ons" tab is selected. A notification bar at the top right says "New versions are available for 1 add-on." The "Add-ons (3)" section includes a search bar, filter buttons for "Any category", "Any status", and "3 matches", and a "Get more add-ons" button. The "Cluster info" section shows the cluster is active, running Kubernetes version 1.30, with standard support until July 28, 2025, and is provided by EKS.

3. Go to **AWS Marketplace add-ons** and choose the *storage* category.

**AWS Marketplace add-ons (1)**

Discover, subscribe to and configure EKS add-ons to enhance your EKS clusters.

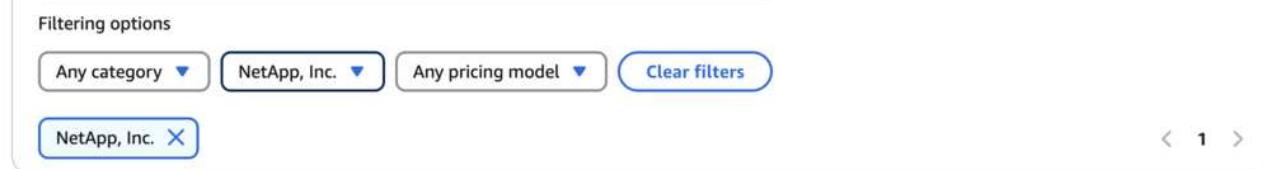
Find add-on

Filtering options

Any category  NetApp, Inc.  Any pricing model  Clear filters

NetApp, Inc.

<  1  >



### NetApp Trident

NetApp Trident streamlines Amazon FSx for NetApp ONTAP storage management in Kubernetes to let your developers and administrators focus on application deployment. FSx for ONTAP flexibility, scalability, and integration capabilities make it the ideal choice for organizations seeking efficient containerized storage workflows. [Product details](#)

Standard Contract

Category  
storage

Listed by  
[NetApp, Inc.](#)

Supported versions  
1.31, 1.30, 1.29, 1.28,  
1.27, 1.26, 1.25, 1.24,  
1.23

Pricing starting at  
[View pricing details](#)

[Cancel](#)

[Next](#)

4. Locate **NetApp Trident** and select the checkbox for the Trident add-on, and click **Next**.
5. Choose the desired version of the add-on.

**NetApp Trident**

[Remove add-on](#)

Listed by  NetApp	Category storage	Status  Ready to install
---	---------------------	---

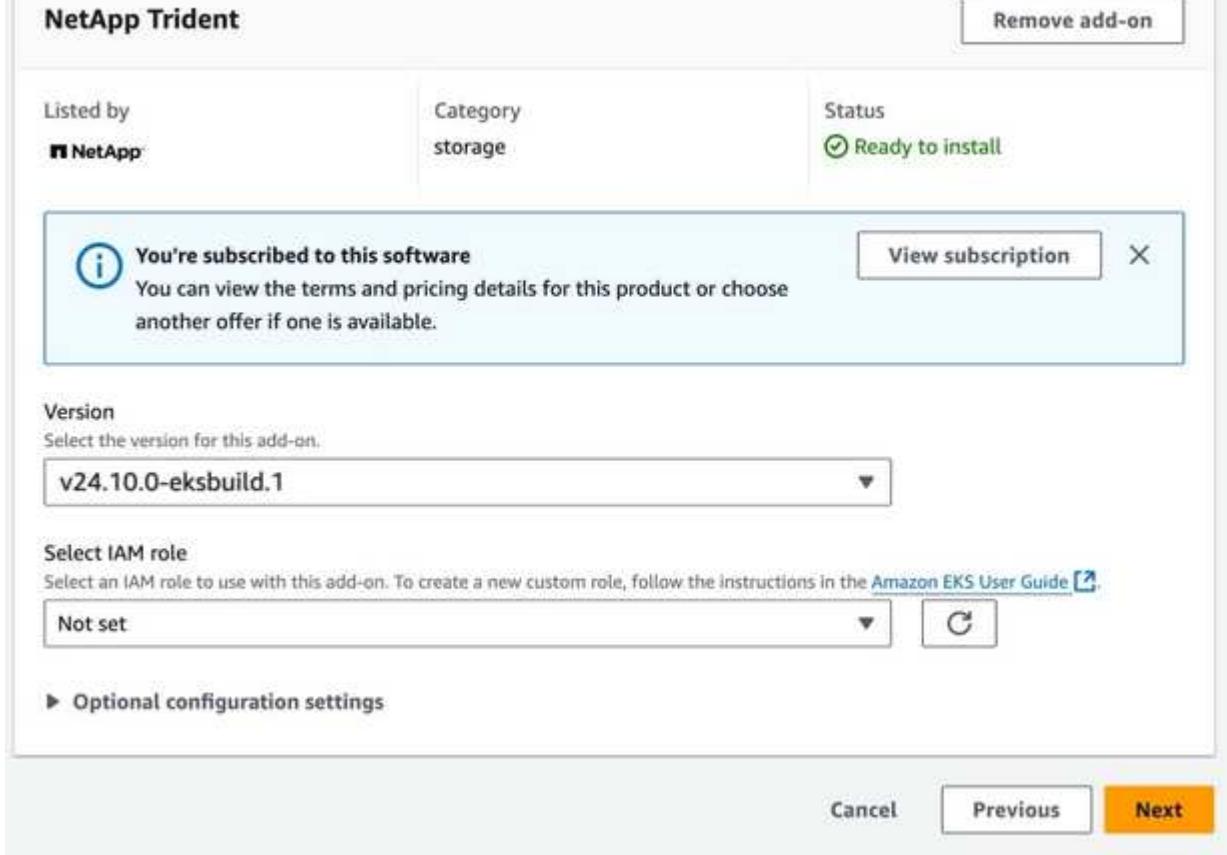
**i** You're subscribed to this software  
You can view the terms and pricing details for this product or choose another offer if one is available. [View subscription](#) [X](#)

**Version**  
Select the version for this add-on.

**Select IAM role**  
Select an IAM role to use with this add-on. To create a new custom role, follow the instructions in the [Amazon EKS User Guide](#).  [C](#)

**Optional configuration settings**

[Cancel](#) [Previous](#) [Next](#)



6. Select the IAM role option to inherit from the node.

## Review and add

### Step 1: Select add-ons

Edit

#### Selected add-ons (1)

Find add-on

< 1 >

Add-on name	Type	Status
netapp_trident-operator	storage	Ready to install

### Step 2: Configure selected add-ons settings

Edit

#### Selected add-ons version (1)

< 1 >

Add-on name	Version	IAM role for service account (IRSA)
netapp_trident-operator	v24.10.0-eksbuild.1	Not set

#### EKS Pod Identity (0)

< 1 >

Add-on name	IAM role	Service account
No Pod Identity associations		

None of the selected add-on(s) have Pod Identity associations.

Cancel

Previous

Create

7. Configure any Optional configuration settings as required and select **Next**.

Follow the **Add-on configuration schema** and set the Configuration Values parameter on the **Configuration values** section to the role-arn you created on the previous step(Step 1) (value should be in the following format: `eks.amazonaws.com/role-arn`:

`arn:aws:iam::464262061435:role/AmazonEKS_FSXN_CSI_DriverRole`).

NOTE: If you select **Override** for the Conflict resolution method, one or more of the settings for the existing add-on can be overwritten with the Amazon EKS add-on settings. If you don't enable this option and there's a conflict with your existing settings, the operation fails. You can use the resulting error message to troubleshoot the conflict. Before selecting this option, make sure that the Amazon EKS add-on doesn't manage settings that you need to self-manage.

## ▼ Optional configuration settings

### Add-on configuration schema

Refer to the JSON schema below. The configuration values entered in the code editor will be validated against this schema.

```
        "default": "",  
        "examples": [  
            {  
                "cloudIdentity": ""  
            }  
        ],  
        "properties": {  
            "cloudIdentity": {  
                "default": "",  
                "examples": [  
                    ""  
                ],  
                "title": "The cloudIdentity Schema",  
                "type": "string"  
            }  
        }  
    }  
}
```

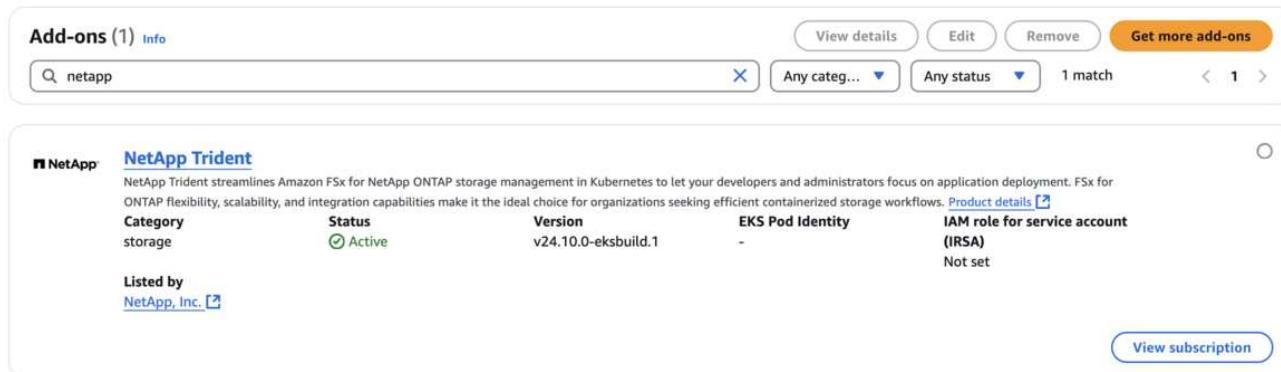
### Configuration values [Info](#)

Specify any additional JSON or YAML configurations that should be applied to the add-on.

```
1 ▼ {  
2     "cloudIdentity": "eks.amazonaws.com/role-arn: arn:aws:iam  
        ::186785786363:role/tri-env-eks-trident-controller-role"  
3 }
```

8. Select **Create**.

9. Verify that the status of the add-on is *Active*.



The screenshot shows the AWS EKS Add-ons console. A search bar at the top contains the text "netapp". Below the search bar, a table displays the "NetApp Trident" add-on. The table columns are: Category (storage), Status (Active), Version (v24.10.0-eksbuild.1), EKS Pod Identity (-), and IAM role for service account (IRSA, Not set). The "Listed by" section shows "NetApp, Inc." with a link. At the bottom right of the card, there is a "View subscription" button.

Category	Status	Version	EKS Pod Identity	IAM role for service account
storage	Active	v24.10.0-eksbuild.1	-	IRSA Not set

10. Run the following command to verify that Trident is properly installed on the cluster:

```
kubectl get pods -n trident
```

11. Continue the setup and configure the storage backend. For information, see [Configure the Storage Backend](#).

### Install/uninstall the Trident EKS add-on using CLI

#### Install the NetApp Trident EKS add-on using CLI:

The following example command installs the Trident EKS add-on:

```
eksctl create addon --name aws-ebs-csi-driver --cluster <cluster_name>
--service-account-role-arn arn:aws:iam::<account_id>:role/<role_name>
--force
```

### Uninstall the NetApp Trident EKS add-on using CLI:

The following command uninstalls the Trident EKS add-on:

```
eksctl delete addon --cluster K8s-arm --name netapp_trident-operator
```

## Create backends with kubectl

A backend defines the relationship between Trident and a storage system. It tells Trident how to communicate with that storage system and how Trident should provision volumes from it. After Trident is installed, the next step is to create a backend. The `TridentBackendConfig` Custom Resource Definition (CRD) enables you to create and manage Trident backends directly through the Kubernetes interface. You can do this by using `kubectl` or the equivalent CLI tool for your Kubernetes distribution.

### TridentBackendConfig

`TridentBackendConfig` (`tbc`, `tbconfig`, `tbackendconfig`) is a frontend, namespaced CRD that enables you to manage Trident backends using `kubectl`. Kubernetes and storage admins can now create and manage backends directly through the Kubernetes CLI without requiring a dedicated command-line utility (`tridentctl`).

Upon the creation of a `TridentBackendConfig` object, the following happens:

- A backend is created automatically by Trident based on the configuration you provide. This is represented internally as a `TridentBackend` (`tbe`, `tridentbackend`) CR.
- The `TridentBackendConfig` is uniquely bound to a `TridentBackend` that was created by Trident.

Each `TridentBackendConfig` maintains a one-to-one mapping with a `TridentBackend`. The former is the interface provided to the user to design and configure backends; the latter is how Trident represents the actual backend object.



TridentBackend CRs are created automatically by Trident. You **should not** modify them. If you want to make updates to backends, do this by modifying the `TridentBackendConfig` object.

See the following example for the format of the `TridentBackendConfig` CR:

```

apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-ontap-san
spec:
  version: 1
  backendName: ontap-san-backend
  storageDriverName: ontap-san
  managementLIF: 10.0.0.1
  dataLIF: 10.0.0.2
  svm: trident_svm
  credentials:
    name: backend-tbc-ontap-san-secret

```

You can also take a look at the examples in the [trident-installer](#) directory for sample configurations for the desired storage platform/service.

The `spec` takes backend-specific configuration parameters. In this example, the backend uses the `ontap-san` storage driver and uses the configuration parameters that are tabulated here. For the list of configuration options for your desired storage driver, refer to the [backend configuration information for your storage driver](#).

The `spec` section also includes `credentials` and `deletionPolicy` fields, which are newly introduced in the `TridentBackendConfig` CR:

- `credentials`: This parameter is a required field and contains the credentials used to authenticate with the storage system/service. This is set to a user-created Kubernetes Secret. The credentials cannot be passed in plain text and will result in an error.
- `deletionPolicy`: This field defines what should happen when the `TridentBackendConfig` is deleted. It can take one of two possible values:
  - `delete`: This results in the deletion of both `TridentBackendConfig` CR and the associated backend. This is the default value.
  - `retain`: When a `TridentBackendConfig` CR is deleted, the backend definition will still be present and can be managed with `tridentctl`. Setting the deletion policy to `retain` lets users downgrade to an earlier release (pre-21.04) and retain the created backends. The value for this field can be updated after a `TridentBackendConfig` is created.

 The name of a backend is set using `spec.backendName`. If unspecified, the name of the backend is set to the name of the `TridentBackendConfig` object (`metadata.name`). It is recommended to explicitly set backend names using `spec.backendName`.

 Backends that were created with `tridentctl` do not have an associated `TridentBackendConfig` object. You can choose to manage such backends with `kubectl` by creating a `TridentBackendConfig` CR. Care must be taken to specify identical config parameters (such as `spec.backendName`, `spec.storagePrefix`, `spec.storageDriverName`, and so on). Trident will automatically bind the newly-created `TridentBackendConfig` with the pre-existing backend.

## Steps overview

To create a new backend by using `kubectl`, you should do the following:

1. Create a [Kubernetes Secret](#). The secret contains the credentials Trident needs to communicate with the storage cluster/service.
2. Create a `TridentBackendConfig` object. This contains specifics about the storage cluster/service and references the secret created in the previous step.

After you create a backend, you can observe its status by using `kubectl get tbc <tbc-name> -n <trident-namespace>` and gather additional details.

### Step 1: Create a Kubernetes Secret

Create a Secret that contains the access credentials for the backend. This is unique to each storage service/platform. Here's an example:

```
kubectl -n trident create -f backend-tbc-ontap-san-secret.yaml
apiVersion: v1
kind: Secret
metadata:
  name: backend-tbc-ontap-san-secret
type: Opaque
stringData:
  username: cluster-admin
  password: password
```

This table summarizes the fields that must be included in the Secret for each storage platform:

Storage platform Secret Fields description	Secret	Fields description
Azure NetApp Files	clientID	The client ID from an app registration
Cloud Volumes Service for GCP	private_key_id	ID of the private key. Part of API key for GCP Service Account with CVS admin role
Cloud Volumes Service for GCP	private_key	Private key. Part of API key for GCP Service Account with CVS admin role
Element (NetApp HCI/SolidFire)	Endpoint	MVIP for the SolidFire cluster with tenant credentials

Storage platform Secret Fields description	Secret	Fields description
ONTAP	username	Username to connect to the cluster/SVM. Used for credential-based authentication
ONTAP	password	Password to connect to the cluster/SVM. Used for credential-based authentication
ONTAP	clientPrivateKey	Base64-encoded value of client private key. Used for certificate-based authentication
ONTAP	chapUsername	Inbound username. Required if useCHAP=true. For <code>ontap-san</code> and <code>ontap-san-economy</code>
ONTAP	chapInitiatorSecret	CHAP initiator secret. Required if useCHAP=true. For <code>ontap-san</code> and <code>ontap-san-economy</code>
ONTAP	chapTargetUsername	Target username. Required if useCHAP=true. For <code>ontap-san</code> and <code>ontap-san-economy</code>
ONTAP	chapTargetInitiatorSecret	CHAP target initiator secret. Required if useCHAP=true. For <code>ontap-san</code> and <code>ontap-san-economy</code>

The Secret created in this step will be referenced in the `spec.credentials` field of the `TridentBackendConfig` object that is created in the next step.

## Step 2: Create the `TridentBackendConfig` CR

You are now ready to create your `TridentBackendConfig` CR. In this example, a backend that uses the `ontap-san` driver is created by using the `TridentBackendConfig` object shown below:

```
kubectl -n trident create -f backend-tbc-ontap-san.yaml
```

```

apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: backend-tbc-ontap-san
spec:
  version: 1
  backendName: ontap-san-backend
  storageDriverName: ontap-san
  managementLIF: 10.0.0.1
  dataLIF: 10.0.0.2
  svm: trident_svm
  credentials:
    name: backend-tbc-ontap-san-secret

```

### Step 3: Verify the status of the TridentBackendConfig CR

Now that you created the TridentBackendConfig CR, you can verify the status. See the following example:

```

kubectl -n trident get tbc backend-tbc-ontap-san
NAME                  BACKEND NAME          BACKEND UUID
PHASE    STATUS
backend-tbc-ontap-san  ontap-san-backend  8d24fce7-6f60-4d4a-8ef6-
bab2699e6ab8    Bound      Success

```

A backend was successfully created and bound to the TridentBackendConfig CR.

Phase can take one of the following values:

- **Bound:** The TridentBackendConfig CR is associated with a backend, and that backend contains configRef set to the TridentBackendConfig CR's uid.
- **Unbound:** Represented using "". The TridentBackendConfig object is not bound to a backend. All newly created TridentBackendConfig CRs are in this phase by default. After the phase changes, it cannot revert to Unbound again.
- **Deleting:** The TridentBackendConfig CR's deletionPolicy was set to delete. When the TridentBackendConfig CR is deleted, it transitions to the Deleting state.
  - If no persistent volume claims (PVCs) exist on the backend, deleting the TridentBackendConfig will result in Trident deleting the backend as well as the TridentBackendConfig CR.
  - If one or more PVCs are present on the backend, it goes to a deleting state. The TridentBackendConfig CR subsequently also enters deleting phase. The backend and TridentBackendConfig are deleted only after all PVCs are deleted.
- **Lost:** The backend associated with the TridentBackendConfig CR was accidentally or deliberately deleted and the TridentBackendConfig CR still has a reference to the deleted backend. The TridentBackendConfig CR can still be deleted irrespective of the deletionPolicy value.

- Unknown: Trident is unable to determine the state or existence of the backend associated with the `TridentBackendConfig` CR. For example, if the API server is not responding or if the `tridentbackends.trident.netapp.io` CRD is missing. This might require intervention.

At this stage, a backend is successfully created! There are several operations that can additionally be handled, such as [backend updates](#) and [backend deletions](#).

#### (Optional) Step 4: Get more details

You can run the following command to get more information about your backend:

```
kubectl -n trident get tbc backend-tbc-ontap-san -o wide
```

NAME	BACKEND NAME	BACKEND UUID	
PHASE	STATUS	STORAGE DRIVER	DELETION POLICY
backend-tbc-ontap-san	Bound	ontap-san-backend	8d24fce7-6f60-4d4a-8ef6-bab2699e6ab8
		Success	ontap-san
			delete

In addition, you can also obtain a YAML/JSON dump of `TridentBackendConfig`.

```
kubectl -n trident get tbc backend-tbc-ontap-san -o yaml
```

```

apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  creationTimestamp: "2021-04-21T20:45:11Z"
  finalizers:
  - trident.netapp.io
  generation: 1
  name: backend-tbc-ontap-san
  namespace: trident
  resourceVersion: "947143"
  uid: 35b9d777-109f-43d5-8077-c74a4559d09c
spec:
  backendName: ontap-san-backend
  credentials:
    name: backend-tbc-ontap-san-secret
  managementLIF: 10.0.0.1
  dataLIF: 10.0.0.2
  storageDriverName: ontap-san
  svm: trident_svm
  version: 1
status:
  backendInfo:
    backendName: ontap-san-backend
    backendUUID: 8d24fce7-6f60-4d4a-8ef6-bab2699e6ab8
  deletionPolicy: delete
  lastOperationStatus: Success
  message: Backend 'ontap-san-backend' created
  phase: Bound

```

backendInfo contains the backendName and the backendUUID of the backend that got created in response to the TridentBackendConfig CR. The lastOperationStatus field represents the status of the last operation of the TridentBackendConfig CR, which can be user-triggered (for example, user changed something in spec) or triggered by Trident (for example, during Trident restarts). It can either be Success or Failed. phase represents the status of the relation between the TridentBackendConfig CR and the backend. In the example above, phase has the value Bound, which means that the TridentBackendConfig CR is associated with the backend.

You can run the `kubectl -n trident describe tbc <tbc-cr-name>` command to get details of the event logs.

 You cannot update or delete a backend which contains an associated TridentBackendConfig object using `tridentctl`. To understand the steps involved in switching between `tridentctl` and `TridentBackendConfig`, [see here](#).

## Manage backends

### Perform backend management with kubectl

Learn about how to perform backend management operations by using kubectl.

#### Delete a backend

By deleting a `TridentBackendConfig`, you instruct Trident to delete/retain backends (based on `deletionPolicy`). To delete a backend, ensure that `deletionPolicy` is set to `delete`. To delete just the `TridentBackendConfig`, ensure that `deletionPolicy` is set to `retain`. This ensures the backend is still present and can be managed by using `tridentctl`.

Run the following command:

```
kubectl delete tbc <tbc-name> -n trident
```

Trident does not delete the Kubernetes Secrets that were in use by `TridentBackendConfig`. The Kubernetes user is responsible for cleaning up secrets. Care must be taken when deleting secrets. You should delete secrets only if they are not in use by the backends.

#### View the existing backends

Run the following command:

```
kubectl get tbc -n trident
```

You can also run `tridentctl get backend -n trident` or `tridentctl get backend -o yaml -n trident` to obtain a list of all backends that exist. This list will also include backends that were created with `tridentctl`.

#### Update a backend

There can be multiple reasons to update a backend:

- Credentials to the storage system have changed. To update credentials, the Kubernetes Secret that is used in the `TridentBackendConfig` object must be updated. Trident will automatically update the backend with the latest credentials provided. Run the following command to update the Kubernetes Secret:

```
kubectl apply -f <updated-secret-file.yaml> -n trident
```

- Parameters (such as the name of the ONTAP SVM being used) need to be updated.
  - You can update `TridentBackendConfig` objects directly through Kubernetes using the following command:

```
kubectl apply -f <updated-backend-file.yaml>
```

- Alternatively, you can make changes to the existing `TridentBackendConfig` CR using the following command:

```
kubectl edit tbc <tbc-name> -n trident
```



- If a backend update fails, the backend continues to remain in its last known configuration. You can view the logs to determine the cause by running `kubectl get tbc <tbc-name> -o yaml -n trident` or `kubectl describe tbc <tbc-name> -n trident`.
- After you identify and correct the problem with the configuration file, you can re-run the update command.

## Perform backend management with `tridentctl`

Learn about how to perform backend management operations by using `tridentctl`.

### Create a backend

After you create a [backend configuration file](#), run the following command:

```
tridentctl create backend -f <backend-file> -n trident
```

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

```
tridentctl logs -n trident
```

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

### Delete a backend

To delete a backend from Trident, do the following:

1. Retrieve the backend name:

```
tridentctl get backend -n trident
```

2. Delete the backend:

```
tridentctl delete backend <backend-name> -n trident
```



If Trident has provisioned volumes and snapshots from this backend that still exist, deleting the backend prevents new volumes from being provisioned by it. The backend will continue to exist in a “Deleting” state and Trident will continue to manage those volumes and snapshots until they are deleted.

### **View the existing backends**

To view the backends that Trident knows about, do the following:

- To get a summary, run the following command:

```
tridentctl get backend -n trident
```

- To get all the details, run the following command:

```
tridentctl get backend -o json -n trident
```

### **Update a backend**

After you create a new backend configuration file, run the following command:

```
tridentctl update backend <backend-name> -f <backend-file> -n trident
```

If backend update fails, something was wrong with the backend configuration or you attempted an invalid update. You can view the logs to determine the cause by running the following command:

```
tridentctl logs -n trident
```

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

### **Identify the storage classes that use a backend**

This is an example of the kind of questions you can answer with the JSON that `tridentctl` outputs for backend objects. This uses the `jq` utility, which you need to install.

```
tridentctl get backend -o json | jq '[.items[] | {backend: .name, storageClasses: [.storage[].storageClasses]|unique}]'
```

This also applies for backends that were created by using `TridentBackendConfig`.

### **Move between backend management options**

Learn about the different ways of managing backends in Trident.

## Options for managing backends

With the introduction of `TridentBackendConfig`, administrators now have two unique ways of managing backends. This poses the following questions:

- Can backends created using `tridentctl` be managed with `TridentBackendConfig`?
- Can backends created using `TridentBackendConfig` be managed using `tridentctl`?

### Manage `tridentctl` backends using `TridentBackendConfig`

This section covers the steps required to manage backends that were created using `tridentctl` directly through the Kubernetes interface by creating `TridentBackendConfig` objects.

This will apply to the following scenarios:

- Pre-existing backends, that don't have a `TridentBackendConfig` because they were created with `tridentctl`.
- New backends that were created with `tridentctl`, while other `TridentBackendConfig` objects exist.

In both scenarios, backends will continue to be present, with Trident scheduling volumes and operating on them. Administrators have one of two choices here:

- Continue using `tridentctl` to manage backends that were created using it.
- Bind backends created using `tridentctl` to a new `TridentBackendConfig` object. Doing so would mean the backends will be managed using `kubectl` and not `tridentctl`.

To manage a pre-existing backend using `kubectl`, you will need to create a `TridentBackendConfig` that binds to the existing backend. Here is an overview of how that works:

1. Create a Kubernetes Secret. The secret contains the credentials Trident needs to communicate with the storage cluster/service.
2. Create a `TridentBackendConfig` object. This contains specifics about the storage cluster/service and references the secret created in the previous step. Care must be taken to specify identical config parameters (such as `spec.backendName`, `spec.storagePrefix`, `spec.storageDriverName`, and so on). `spec.backendName` must be set to the name of the existing backend.

### Step 0: Identify the backend

To create a `TridentBackendConfig` that binds to an existing backend, you will need to obtain the backend configuration. In this example, let us assume a backend was created using the following JSON definition:

```
tridentctl get backend ontap-nas-backend -n trident
+-----+-----+
+-----+-----+-----+
|       NAME       | STORAGE DRIVER |             UUID
| STATE | VOLUMES |             |
+-----+-----+
+-----+-----+-----+
| ontap-nas-backend | ontap-nas | 52f2eb10-e4c6-4160-99fc-
```

```

96b3be5ab5d7 | online |      25 |
+-----+-----+
+-----+-----+-----+
cat ontap-nas-backend.json

{
  "version": 1,
  "storageDriverName": "ontap-nas",
  "managementLIF": "10.10.10.1",
  "dataLIF": "10.10.10.2",
  "backendName": "ontap-nas-backend",
  "svm": "trident_svm",
  "username": "cluster-admin",
  "password": "admin-password",

  "defaults": {
    "spaceReserve": "none",
    "encryption": "false"
  },
  "labels": {"store": "nas_store"},
  "region": "us_east_1",
  "storage": [
    {
      "labels": {"app": "msoffice", "cost": "100"},
      "zone": "us_east_1a",
      "defaults": {
        "spaceReserve": "volume",
        "encryption": "true",
        "unixPermissions": "0755"
      }
    },
    {
      "labels": {"app": "mysqladb", "cost": "25"},
      "zone": "us_east_1d",
      "defaults": {
        "spaceReserve": "volume",
        "encryption": "false",
        "unixPermissions": "0775"
      }
    }
  ]
}

```

## Step 1: Create a Kubernetes Secret

Create a Secret that contains the credentials for the backend, as shown in this example:

```
cat tbc-ontap-nas-backend-secret.yaml

apiVersion: v1
kind: Secret
metadata:
  name: ontap-nas-backend-secret
type: Opaque
stringData:
  username: cluster-admin
  password: admin-password

kubectl create -f tbc-ontap-nas-backend-secret.yaml -n trident
secret/backend-tbc-ontap-san-secret created
```

## Step 2: Create a TridentBackendConfig CR

The next step is to create a TridentBackendConfig CR that will automatically bind to the pre-existing ontap-nas-backend (as in this example). Ensure the following requirements are met:

- The same backend name is defined in spec.backendName.
- Configuration parameters are identical to the original backend.
- Virtual pools (if present) must retain the same order as in the original backend.
- Credentials are provided through a Kubernetes Secret and not in plain text.

In this case, the TridentBackendConfig will look like this:

```

cat backend-tbc-ontap-nas.yaml
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: tbc-ontap-nas-backend
spec:
  version: 1
  storageDriverName: ontap-nas
  managementLIF: 10.10.10.1
  dataLIF: 10.10.10.2
  backendName: ontap-nas-backend
  svm: trident_svm
  credentials:
    name: mysecret
  defaults:
    spaceReserve: none
    encryption: 'false'
  labels:
    store: nas_store
  region: us_east_1
  storage:
    - labels:
        app: msoffice
        cost: '100'
        zone: us_east_1a
        defaults:
          spaceReserve: volume
          encryption: 'true'
          unixPermissions: '0755'
    - labels:
        app: mysqldb
        cost: '25'
        zone: us_east_1d
        defaults:
          spaceReserve: volume
          encryption: 'false'
          unixPermissions: '0775'

kubectl create -f backend-tbc-ontap-nas.yaml -n trident
tridentbackendconfig.trident.netapp.io/tbc-ontap-nas-backend created

```

### Step 3: Verify the status of the TridentBackendConfig CR

After the TridentBackendConfig has been created, its phase must be Bound. It should also reflect the same backend name and UUID as that of the existing backend.

```

kubectl get tbc tbc-ontap-nas-backend -n trident
NAME                  BACKEND NAME      BACKEND UUID
PHASE    STATUS
tbc-ontap-nas-backend  ontap-nas-backend  52f2eb10-e4c6-4160-99fc-
96b3be5ab5d7    Bound    Success

#confirm that no new backends were created (i.e., TridentBackendConfig did
#not end up creating a new backend)
tridentctl get backend -n trident
+-----+-----+
+-----+-----+-----+
|       NAME      | STORAGE DRIVER |          UUID
| STATE  | VOLUMES | 
+-----+-----+
+-----+-----+-----+
| ontap-nas-backend | ontap-nas      | 52f2eb10-e4c6-4160-99fc-
96b3be5ab5d7 | online |      25 |
+-----+-----+
+-----+-----+-----+

```

The backend will now be completely managed using the `tbc-ontap-nas-backend` TridentBackendConfig object.

#### Manage TridentBackendConfig backends using `tridentctl`

`tridentctl` can be used to list backends that were created using `TridentBackendConfig`. In addition, administrators can also choose to completely manage such backends through `tridentctl` by deleting `TridentBackendConfig` and making sure `spec.deletionPolicy` is set to `retain`.

#### Step 0: Identify the backend

For example, let us assume the following backend was created using `TridentBackendConfig`:

```

kubectl get tbc backend-tbc-ontap-san -n trident -o wide
NAME                  BACKEND NAME      BACKEND UUID
PHASE    STATUS      STORAGE DRIVER  DELETION POLICY
backend-tbc-ontap-san  ontap-san-backend  81abcb27-ea63-49bb-b606-
0a5315ac5f82    Bound    Success    ontap-san      delete

tridentctl get backend ontap-san-backend -n trident
+-----+-----+
+-----+-----+-----+
|      NAME      | STORAGE DRIVER |          UUID
| STATE | VOLUMES |          |
+-----+-----+
+-----+-----+-----+
| ontap-san-backend | ontap-san      | 81abcb27-ea63-49bb-b606-
0a5315ac5f82 | online |      33 |
+-----+-----+
+-----+-----+

```

From the output, it is seen that `TridentBackendConfig` was created successfully and is bound to a backend [observe the backend's UUID].

### Step 1: Confirm `deletionPolicy` is set to retain

Let us take a look at the value of `deletionPolicy`. This needs to be set to `retain`. This ensures that when a `TridentBackendConfig` CR is deleted, the backend definition will still be present and can be managed with `tridentctl`.

```

kubectl get tbc backend-tbc-ontap-san -n trident -o wide
NAME                  BACKEND NAME      BACKEND UUID
PHASE    STATUS      STORAGE DRIVER  DELETION POLICY
backend-tbc-ontap-san  ontap-san-backend  81abcb27-ea63-49bb-b606-
0a5315ac5f82    Bound    Success    ontap-san      delete

# Patch value of deletionPolicy to retain
kubectl patch tbc backend-tbc-ontap-san --type=merge -p
'{"spec":{"deletionPolicy":"retain"}}' -n trident
tridentbackendconfig.trident.netapp.io/backend-tbc-ontap-san patched

#Confirm the value of deletionPolicy
kubectl get tbc backend-tbc-ontap-san -n trident -o wide
NAME                  BACKEND NAME      BACKEND UUID
PHASE    STATUS      STORAGE DRIVER  DELETION POLICY
backend-tbc-ontap-san  ontap-san-backend  81abcb27-ea63-49bb-b606-
0a5315ac5f82    Bound    Success    ontap-san      retain

```



Do not proceed to the next step unless `deletionPolicy` is set to `retain`.

## Step 2: Delete the TridentBackendConfig CR

The final step is to delete the TridentBackendConfig CR. After confirming the `deletionPolicy` is set to `retain`, you can go ahead with the deletion:

```
kubectl delete tbc backend-tbc-ontap-san -n trident
tridentbackendconfig.trident.netapp.io "backend-tbc-ontap-san" deleted

tridentctl get backend ontap-san-backend -n trident
+-----+-----+
+-----+-----+-----+
|       NAME       | STORAGE DRIVER |           UUID
| STATE | VOLUMES |           |
+-----+-----+
+-----+-----+-----+
| ontap-san-backend | ontap-san       | 81abcb27-ea63-49bb-b606-
0a5315ac5f82 | online |      33 |
+-----+-----+
+-----+-----+
```

Upon the deletion of the TridentBackendConfig object, Trident simply removes it without actually deleting the backend itself.

# Create and manage storage classes

## Create a storage class

Configure a Kubernetes StorageClass object and create the storage class to instruct Trident how to provision volumes.

### Configure a Kubernetes StorageClass object

The [Kubernetes StorageClass object](#) identifies Trident as the provisioner that is used for that class and instructs Trident how to provision a volume. For example:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: <Name>
provisioner: csi.trident.netapp.io
mountOptions: <Mount Options>
parameters:
  <Trident Parameters>
allowVolumeExpansion: true
volumeBindingMode: Immediate
```

Refer to [Kubernetes and Trident objects](#) for details on how storage classes interact with the `PersistentVolumeClaim` and parameters for controlling how Trident provisions volumes.

## Create a storage class

After you create the `StorageClass` object, you can create the storage class. [Storage class samples](#) provides some basic samples you can use or modify.

### Steps

1. This is a Kubernetes object, so use `kubectl` to create it in Kubernetes.

```
kubectl create -f sample-input/storage-class-basic-csi.yaml
```

2. You should now see a **basic-csi** storage class in both Kubernetes and Trident, and Trident should have discovered the pools on the backend.

```

kubectl get sc basic-csi
NAME      PROVISIONER          AGE
basic-csi  csi.trident.netapp.io  15h

./tridentctl -n trident get storageclass basic-csi -o json
{
  "items": [
    {
      "Config": {
        "version": "1",
        "name": "basic-csi",
        "attributes": {
          "backendType": "ontap-nas"
        },
        "storagePools": null,
        "additionalStoragePools": null
      },
      "storage": {
        "ontapnas_10.0.0.1": [
          "aggr1",
          "aggr2",
          "aggr3",
          "aggr4"
        ]
      }
    }
  ]
}

```

## Storage class samples

Trident provides [simple storage class definitions for specific backends](#).

Alternatively, you can edit `sample-input/storage-class-csi.yaml.template` file that comes with the installer and replace `BACKEND_TYPE` with the storage driver name.

```

./tridentctl -n trident get backend
+-----+-----+
+-----+-----+
|     NAME      | STORAGE DRIVER |                         UUID          |
STATE  | VOLUMES  |
+-----+-----+
+-----+-----+
| nas-backend | ontap-nas      | 98e19b74-aec7-4a3d-8dcf-128e5033b214 |
online |          0 |
+-----+-----+
+-----+-----+
cp sample-input/storage-class-csi.yaml.template sample-input/storage-class-
basic-csi.yaml

# Modify __BACKEND_TYPE__ with the storage driver field above (e.g.,
ontap-nas)
vi sample-input/storage-class-basic-csi.yaml

```

## Manage storage classes

You can view existing storage classes, set a default storage class, identify the storage class backend, and delete storage classes.

### View the existing storage classes

- To view existing Kubernetes storage classes, run the following command:

```
kubectl get storageclass
```

- To view Kubernetes storage class detail, run the following command:

```
kubectl get storageclass <storage-class> -o json
```

- To view Trident's synchronized storage classes, run the following command:

```
tridentctl get storageclass
```

- To view Trident's synchronized storage class detail, run the following command:

```
tridentctl get storageclass <storage-class> -o json
```

## Set a default storage class

Kubernetes 1.6 added the ability to set a default storage class. This is the storage class that will be used to provision a Persistent Volume if a user does not specify one in a Persistent Volume Claim (PVC).

- Define a default storage class by setting the annotation `storageclass.kubernetes.io/is-default-class` to true in the storage class definition. According to the specification, any other value or absence of the annotation is interpreted as false.
- You can configure an existing storage class to be the default storage class by using the following command:

```
kubectl patch storageclass <storage-class-name> -p '{"metadata": {"annotations":{"storageclass.kubernetes.io/is-default-class":"true"}}}'
```

- Similarly, you can remove the default storage class annotation by using the following command:

```
kubectl patch storageclass <storage-class-name> -p '{"metadata": {"annotations":{"storageclass.kubernetes.io/is-default-class":"false"}}}'
```

There are also examples in the Trident installer bundle that include this annotation.



There should be only one default storage class in your cluster at a time. Kubernetes does not technically prevent you from having more than one, but it will behave as if there is no default storage class at all.

## Identify the backend for a storage class

This is an example of the kind of questions you can answer with the JSON that `tridentctl` outputs for Trident backend objects. This uses the `jq` utility, which you may need to install first.

```
tridentctl get storageclass -o json | jq '[.items[] | {storageClass: .Config.name, backends: [.storage] | unique}]'
```

## Delete a storage class

To delete a storage class from Kubernetes, run the following command:

```
kubectl delete storageclass <storage-class>
```

`<storage-class>` should be replaced with your storage class.

Any persistent volumes that were created through this storage class will remain untouched, and Trident will continue to manage them.



Trident enforces a blank `fsType` for the volumes it creates. For iSCSI backends, it is recommended to enforce `parameters.fsType` in the `StorageClass`. You should delete existing `StorageClasses` and re-create them with `parameters.fsType` specified.

# Provision and manage volumes

## Provision a volume

Create a `PersistentVolume` (PV) and a `PersistentVolumeClaim` (PVC) that uses the configured Kubernetes `StorageClass` to request access to the PV. You can then mount the PV to a pod.

### Overview

A `PersistentVolume` (PV) is a physical storage resource provisioned by the cluster administrator on a Kubernetes cluster. The `PersistentVolumeClaim` (PVC) is a request for access to the PersistentVolume on the cluster.

The PVC can be configured to request storage of a certain size or access mode. Using the associated `StorageClass`, the cluster administrator can control more than PersistentVolume size and access mode—such as performance or service level.

After you create the PV and PVC, you can mount the volume in a pod.

### Sample manifests

#### `PersistentVolume` sample manifest

This sample manifest shows a basic PV of 10Gi that is associated with `StorageClass` `basic-csi`.

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv-storage
  labels:
    type: local
spec:
  storageClassName: basic-csi
  capacity:
    storage: 10Gi
  accessModes:
    - ReadWriteOnce
  hostPath:
    path: "/my/host/path"
```

## PersistentVolumeClaim sample manifests

These examples show basic PVC configuration options.

### PVC with RWO access

This example shows a basic PVC with RWO access that is associated with a StorageClass named basic-csi.

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: pvc-storage
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi
  storageClassName: basic-csi
```

### PVC with NVMe/TCP

This example shows a basic PVC for NVMe/TCP with RWO access that is associated with a StorageClass named protection-gold.

```
---
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: pvc-san-nvme
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 300Mi
  storageClassName: protection-gold
```

## Pod manifest samples

These examples show basic configurations to attach the PVC to a pod.

### Basic configuration

```
kind: Pod
apiVersion: v1
metadata:
  name: pv-pod
spec:
  volumes:
    - name: pv-storage
      persistentVolumeClaim:
        claimName: basic
  containers:
    - name: pv-container
      image: nginx
      ports:
        - containerPort: 80
          name: "http-server"
  volumeMounts:
    - mountPath: "/my/mount/path"
      name: pv-storage
```

## Basic NVMe/TCP configuration

```
---
apiVersion: v1
kind: Pod
metadata:
  creationTimestamp: null
  labels:
    run: nginx
    name: nginx
spec:
  containers:
    - image: nginx
      name: nginx
      resources: {}
  volumeMounts:
    - mountPath: "/usr/share/nginx/html"
      name: task-pv-storage
  dnsPolicy: ClusterFirst
  restartPolicy: Always
  volumes:
    - name: task-pv-storage
      persistentVolumeClaim:
        claimName: pvc-san-nvme
```

## Create the PV and PVC

### Steps

1. Create the PV.

```
kubectl create -f pv.yaml
```

2. Verify the PV status.

```
kubectl get pv
NAME      CAPACITY  ACCESS MODES  RECLAIM POLICY  STATUS      CLAIM
STORAGECLASS  REASON  AGE
pv-storage  4Gi      RWO          Retain        Available
7s
```

3. Create the PVC.

```
kubectl create -f pvc.yaml
```

4. Verify the PVC status.

```
kubectl get pvc
NAME      STATUS  VOLUME      CAPACITY  ACCESS MODES  STORAGECLASS  AGE
pvc-storage  Bound  pv-name  2Gi        RWO          5m
```

5. Mount the volume in a pod.

```
kubectl create -f pv-pod.yaml
```



You can monitor the progress using `kubectl get pod --watch`.

6. Verify that the volume is mounted on `/my/mount/path`.

```
kubectl exec -it task-pv-pod -- df -h /my/mount/path
```

7. You can now delete the Pod. The Pod application will no longer exist, but the volume will remain.

```
kubectl delete pod pv-pod
```

Refer to [Kubernetes and Trident objects](#) for details on how storage classes interact with the `PersistentVolumeClaim` and parameters for controlling how Trident provisions volumes.

## Expand volumes

Trident provides Kubernetes users the ability to expand their volumes after they are created. Find information about the configurations required to expand iSCSI and NFS volumes.

### Expand an iSCSI volume

You can expand an iSCSI Persistent Volume (PV) by using the CSI provisioner.



iSCSI volume expansion is supported by the `ontap-san`, `ontap-san-economy`, `solidfire-san` drivers and requires Kubernetes 1.16 and later.

#### Step 1: Configure the StorageClass to support volume expansion

Edit the StorageClass definition to set the `allowVolumeExpansion` field to `true`.

```
cat storageclass-ontapsan.yaml
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: ontap-san
provisioner: csi.trident.netapp.io
parameters:
  backendType: "ontap-san"
allowVolumeExpansion: True
```

For an already existing StorageClass, edit it to include the `allowVolumeExpansion` parameter.

#### Step 2: Create a PVC with the StorageClass you created

Edit the PVC definition and update the `spec.resources.requests.storage` to reflect the newly desired size, which must be greater than the original size.

```
cat pvc-ontapsan.yaml
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: san-pvc
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi
  storageClassName: ontap-san
```

Trident creates a Persistent Volume (PV) and associates it with this Persistent Volume Claim (PVC).

```

kubectl get pvc
NAME      STATUS      VOLUME                                     CAPACITY
ACCESS MODES      STORAGECLASS      AGE
san-pvc    Bound      pvc-8a814d62-bd58-4253-b0d1-82f2885db671   1Gi
RWO          ontap-san      8s

kubectl get pv
NAME                                         CAPACITY      ACCESS MODES
RECLAIM POLICY      STATUS      CLAIM      STORAGECLASS      REASON      AGE
pvc-8a814d62-bd58-4253-b0d1-82f2885db671   1Gi          RWO
Delete          Bound      default/san-pvc      ontap-san      10s

```

### Step 3: Define a pod that attaches the PVC

Attach the PV to a pod for it to be resized. There are two scenarios when resizing an iSCSI PV:

- If the PV is attached to a pod, Trident expands the volume on the storage backend, rescans the device, and resizes the filesystem.
- When attempting to resize an unattached PV, Trident expands the volume on the storage backend. After the PVC is bound to a pod, Trident rescans the device and resizes the filesystem. Kubernetes then updates the PVC size after the expand operation has successfully completed.

In this example, a pod is created that uses the san-pvc.

```

kubectl get pod
NAME      READY      STATUS      RESTARTS      AGE
ubuntu-pod  1/1      Running      0          65s

kubectl describe pvc san-pvc
Name:          san-pvc
Namespace:     default
StorageClass:  ontap-san
Status:        Bound
Volume:        pvc-8a814d62-bd58-4253-b0d1-82f2885db671
Labels:        <none>
Annotations:   pv.kubernetes.io/bind-completed: yes
                  pv.kubernetes.io/bound-by-controller: yes
                  volume.beta.kubernetes.io/storage-provisioner:
csi.trident.netapp.io
Finalizers:    [kubernetes.io/pvc-protection]
Capacity:      1Gi
Access Modes:  RWO
VolumeMode:    Filesystem
Mounted By:   ubuntu-pod

```

#### Step 4: Expand the PV

To resize the PV that has been created from 1Gi to 2Gi, edit the PVC definition and update the `spec.resources.requests.storage` to 2Gi.

```
kubectl edit pvc san-pvc
# Please edit the object below. Lines beginning with a '#' will be
ignored,
# and an empty file will abort the edit. If an error occurs while saving
this file will be
# reopened with the relevant failures.
#
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  annotations:
    pv.kubernetes.io/bind-completed: "yes"
    pv.kubernetes.io/bound-by-controller: "yes"
    volume.beta.kubernetes.io/storage-provisioner: csi.trident.netapp.io
  creationTimestamp: "2019-10-10T17:32:29Z"
  finalizers:
  - kubernetes.io/pvc-protection
  name: san-pvc
  namespace: default
  resourceVersion: "16609"
  selfLink: /api/v1/namespaces/default/persistentvolumeclaims/san-pvc
  uid: 8a814d62-bd58-4253-b0d1-82f2885db671
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 2Gi
  ...
```

#### Step 5: Validate the expansion

You can validate the expansion worked correctly by checking the size of the PVC, PV, and the Trident volume:

```

kubectl get pvc san-pvc
NAME      STATUS      VOLUME                                     CAPACITY
ACCESS MODES  STORAGECLASS  AGE
san-pvc    Bound      pvc-8a814d62-bd58-4253-b0d1-82f2885db671  2Gi
RWO          ontap-san   11m

kubectl get pv
NAME                                     CAPACITY  ACCESS MODES
RECLAIM POLICY  STATUS      CLAIM      STORAGECLASS  REASON  AGE
pvc-8a814d62-bd58-4253-b0d1-82f2885db671  2Gi      RWO
Delete        Bound      default/san-pvc  ontap-san           12m

tridentctl get volumes -n trident
+-----+-----+-----+
+-----+-----+-----+
|           NAME           |  SIZE  | STORAGE CLASS |
PROTOCOL |           BACKEND UUID           | STATE | MANAGED |
+-----+-----+-----+
+-----+-----+-----+
| pvc-8a814d62-bd58-4253-b0d1-82f2885db671 | 2.0 GiB | ontap-san    |
block     | a9b7bfff-0505-4e31-b6c5-59f492e02d33 | online | true      |
+-----+-----+-----+
+-----+-----+-----+

```

## Expand an NFS volume

Trident supports volume expansion for NFS PVs provisioned on `ontap-nas`, `ontap-nas-economy`, `ontap-nas-flexgroup`, `gcp-cvs`, and `azure-netapp-files` backends.

### Step 1: Configure the StorageClass to support volume expansion

To resize an NFS PV, the admin first needs to configure the storage class to allow volume expansion by setting the `allowVolumeExpansion` field to `true`:

```

cat storageclass-ontapnas.yaml
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: ontapnas
provisioner: csi.trident.netapp.io
parameters:
  backendType: ontap-nas
allowVolumeExpansion: true

```

If you have already created a storage class without this option, you can simply edit the existing storage class by using `kubectl edit storageclass` to allow volume expansion.

## Step 2: Create a PVC with the StorageClass you created

```
cat pvc-ontapnas.yaml
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: ontapnas20mb
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 20Mi
  storageClassName: ontapnas
```

Trident should create a 20MiB NFS PV for this PVC:

```
kubectl get pvc
NAME           STATUS    VOLUME
CAPACITY      ACCESS MODES  STORAGECLASS      AGE
ontapnas20mb  Bound     pvc-08f3d561-b199-11e9-8d9f-5254004dfdb7  20Mi
RWO           ontapnas   9s

kubectl get pv pvc-08f3d561-b199-11e9-8d9f-5254004dfdb7
NAME
RECLAIM POLICY  STATUS    CLAIM           CAPACITY  ACCESS MODES
AGE
pvc-08f3d561-b199-11e9-8d9f-5254004dfdb7  20Mi      RWO
Delete        Bound     default/ontapnas20mb  ontapnas
2m42s
```

## Step 3: Expand the PV

To resize the newly created 20MiB PV to 1GiB, edit the PVC and set `spec.resources.requests.storage` to 1GiB:

```
kubectl edit pvc ontapnas20mb
# Please edit the object below. Lines beginning with a '#' will be
ignored,
# and an empty file will abort the edit. If an error occurs while saving
this file will be
# reopened with the relevant failures.
#
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  annotations:
    pv.kubernetes.io/bind-completed: "yes"
    pv.kubernetes.io/bound-by-controller: "yes"
    volume.beta.kubernetes.io/storage-provisioner: csi.trident.netapp.io
  creationTimestamp: 2018-08-21T18:26:44Z
  finalizers:
  - kubernetes.io/pvc-protection
  name: ontapnas20mb
  namespace: default
  resourceVersion: "1958015"
  selfLink: /api/v1/namespaces/default/persistentvolumeclaims/ontapnas20mb
  uid: c1bd7fa5-a56f-11e8-b8d7-fa163e59eaab
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi
...

```

#### Step 4: Validate the expansion

You can validate the resize worked correctly by checking the size of the PVC, PV, and the Trident volume:

```

kubectl get pvc ontapnas20mb
NAME           STATUS  VOLUME
CAPACITY      ACCESS MODES  STORAGECLASS      AGE
ontapnas20mb  Bound    pvc-08f3d561-b199-11e9-8d9f-5254004dfdb7  1Gi
RWO           ontapnas  4m44s

kubectl get pv pvc-08f3d561-b199-11e9-8d9f-5254004dfdb7
NAME
RECLAIM POLICY  STATUS  CLAIM
AGE
pvc-08f3d561-b199-11e9-8d9f-5254004dfdb7  1Gi      RWO
Delete        Bound    default/ontapnas20mb  ontapnas
5m35s

tridentctl get volume pvc-08f3d561-b199-11e9-8d9f-5254004dfdb7 -n trident
+-----+-----+-----+
+-----+-----+-----+-----+
|           NAME           |  SIZE  | STORAGE CLASS | 
PROTOCOL |           BACKEND UUID           | STATE | MANAGED | 
+-----+-----+-----+-----+
+-----+-----+-----+-----+
| pvc-08f3d561-b199-11e9-8d9f-5254004dfdb7 | 1.0 GiB | ontapnas      | 
file     | c5a6f6a4-b052-423b-80d4-8fb491a14a22 | online | true      | 
+-----+-----+-----+-----+
+-----+-----+-----+-----+

```

## Import volumes

You can import existing storage volumes as a Kubernetes PV using `tridentctl import`.

### Overview and considerations

You might import a volume into Trident to:

- Containerize an application and reuse its existing data set
- Use a clone of a data set for an ephemeral application
- Rebuild a failed Kubernetes cluster
- Migrate application data during disaster recovery

### Considerations

Before importing a volume, review the following considerations.

- Trident can import RW (read-write) type ONTAP volumes only. DP (data protection) type volumes are SnapMirror destination volumes. You should break the mirror relationship before importing the volume into Trident.

- We suggest importing volumes without active connections. To import an actively-used volume, clone the volume and then perform the import.



This is especially important for block volumes as Kubernetes would be unaware of the previous connection and could easily attach an active volume to a pod. This can result in data corruption.

- Though `StorageClass` must be specified on a PVC, Trident does not use this parameter during import. Storage classes are used during volume creation to select from available pools based on storage characteristics. Because the volume already exists, no pool selection is required during import. Therefore, the import will not fail even if the volume exists on a backend or pool that does not match the storage class specified in the PVC.
- The existing volume size is determined and set in the PVC. After the volume is imported by the storage driver, the PV is created with a `ClaimRef` to the PVC.
  - The reclaim policy is initially set to `retain` in the PV. After Kubernetes successfully binds the PVC and PV, the reclaim policy is updated to match the reclaim policy of the Storage Class.
  - If the reclaim policy of the Storage Class is `delete`, the storage volume will be deleted when the PV is deleted.
- By default, Trident manages the PVC and renames the FlexVol and LUN on the backend. You can pass the `--no-manage` flag to import an unmanaged volume. If you use `--no-manage`, Trident does not perform any additional operations on the PVC or PV for the lifecycle of the objects. The storage volume is not deleted when the PV is deleted and other operations such as volume clone and volume resize are also ignored.



This option is useful if you want to use Kubernetes for containerized workloads but otherwise want to manage the lifecycle of the storage volume outside of Kubernetes.

- An annotation is added to the PVC and PV that serves a dual purpose of indicating that the volume was imported and if the PVC and PV are managed. This annotation should not be modified or removed.

## Import a volume

You can use `tridentctl import` to import a volume.

### Steps

1. Create the Persistent Volume Claim (PVC) file (for example, `pvc.yaml`) that will be used to create the PVC. The PVC file should include `name`, `namespace`, `accessModes`, and `storageClassName`. Optionally, you can specify `unixPermissions` in your PVC definition.

The following is an example of a minimum specification:

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: my_claim
  namespace: my_namespace
spec:
  accessModes:
    - ReadWriteOnce
  storageClassName: my_storage_class
```



Don't include additional parameters such as PV name or volume size. This can cause the import command to fail.

2. Use the `tridentctl import` command to specify the name of the Trident backend containing the volume and the name that uniquely identifies the volume on the storage (for example: ONTAP FlexVol, Element Volume, Cloud Volumes Service path). The `-f` argument is required to specify the path to the PVC file.

```
tridentctl import volume <backendName> <volumeName> -f <path-to-pvc-file>
```

## Examples

Review the following volume import examples for supported drivers.

### ONTAP NAS and ONTAP NAS FlexGroup

Trident supports volume import using the `ontap-nas` and `ontap-nas-flexgroup` drivers.



- The `ontap-nas-economy` driver cannot import and manage qtrees.
- The `ontap-nas` and `ontap-nas-flexgroup` drivers do not allow duplicate volume names.

Each volume created with the `ontap-nas` driver is a FlexVol on the ONTAP cluster. Importing FlexVols with the `ontap-nas` driver works the same. A FlexVol that already exists on an ONTAP cluster can be imported as a `ontap-nas` PVC. Similarly, FlexGroup vols can be imported as `ontap-nas-flexgroup` PVCs.

### ONTAP NAS examples

The following show an example of a managed volume and an unmanaged volume import.

## Managed volume

The following example imports a volume named `managed_volume` on a backend named `ontap_nas`:

```
tridentctl import volume ontap_nas managed_volume -f <path-to-pvc-file>

+-----+-----+-----+
+-----+-----+-----+
|           NAME           |  SIZE   | STORAGE CLASS |
PROTOCOL |           BACKEND UUID           |  STATE  |  MANAGED  |
+-----+-----+-----+
+-----+-----+-----+
| pvc-bf5ad463-afbb-11e9-8d9f-5254004dfdb7 | 1.0 GiB | standard   |
file      | c5a6f6a4-b052-423b-80d4-8fb491a14a22 | online   | true      |
+-----+-----+-----+
+-----+-----+-----+
```

## Unmanaged volume

When using the `--no-manage` argument, Trident does not rename the volume.

The following example imports `unmanaged_volume` on the `ontap_nas` backend:

```
tridentctl import volume nas_blog unmanaged_volume -f <path-to-pvc-
file> --no-manage

+-----+-----+-----+
+-----+-----+-----+
|           NAME           |  SIZE   | STORAGE CLASS |
PROTOCOL |           BACKEND UUID           |  STATE  |  MANAGED  |
+-----+-----+-----+
+-----+-----+-----+
| pvc-df07d542-afbc-11e9-8d9f-5254004dfdb7 | 1.0 GiB | standard   |
file      | c5a6f6a4-b052-423b-80d4-8fb491a14a22 | online   | false     |
+-----+-----+-----+
+-----+-----+-----+
```

## ONTAP SAN

Trident supports volume import using the `ontap-san` and `ontap-san-economy` drivers.

Trident can import ONTAP SAN FlexVols that contain a single LUN. This is consistent with the `ontap-san` driver, which creates a FlexVol for each PVC and a LUN within the FlexVol. Trident imports the FlexVol and associates it with the PVC definition.

## ONTAP SAN examples

The following show an example of a managed volume and an unmanaged volume import.

## Managed volume

For managed volumes, Trident renames the FlexVol to the `pvc-<uuid>` format and the LUN within the FlexVol to `lun0`.

The following example imports the `ontap-san-managed` FlexVol that is present on the `ontap_san_default` backend:

```
tridentctl import volume ontapsan_default ontap-san-managed -f pvc-basic-import.yaml -n trident -d

+-----+-----+-----+
|           NAME           |  SIZE  | STORAGE CLASS |
| PROTOCOL | BACKEND UUID      | STATE  | MANAGED   |
+-----+-----+-----+
+-----+-----+-----+
| pvc-d6ee4f54-4e40-4454-92fd-d00fc228d74a | 20 MiB | basic      |
block    | cd394786-ddd5-4470-adc3-10c5ce4ca757 | online  | true      |
+-----+-----+-----+
+-----+-----+-----+
```

## Unmanaged volume

The following example imports `unmanaged_example_volume` on the `ontap_san` backend:

```
tridentctl import volume -n trident san_blog unmanaged_example_volume
-f pvc-import.yaml --no-manage

+-----+-----+-----+
|           NAME           |  SIZE  | STORAGE CLASS |
| PROTOCOL | BACKEND UUID      | STATE  | MANAGED   |
+-----+-----+-----+
+-----+-----+-----+
| pvc-1fc999c9-ce8c-459c-82e4-ed4380a4b228 | 1.0 GiB | san-blog      |
block    | e3275890-7d80-4af6-90cc-c7a0759f555a | online  | false      |
+-----+-----+-----+
+-----+-----+-----+
```

If you have LUNS mapped to igroups that share an IQN with a Kubernetes node IQN, as shown in the following example, you will receive the error: LUN already mapped to initiator(s) in this group. You will need to remove the initiator or unmap the LUN to import the volume.



Vserver	Igroup	Protocol	OS	Type	Initiators
svm0	k8s-nodename.example.com-fe5d36f2-cded-4f38-9eb0-c7719fc2f9f3	iscsi	linux	iqn.1994-05.com.redhat:4c2e1cf35e0	
svm0	unmanaged-example-igroup	mixed	linux	iqn.1994-05.com.redhat:4c2e1cf35e0	

## Element

Trident supports NetApp Element software and NetApp HCI volume import using the `solidfire-san` driver.



The Element driver supports duplicate volume names. However, Trident returns an error if there are duplicate volume names. As a workaround, clone the volume, provide a unique volume name, and import the cloned volume.

## Element example

The following example imports an element-managed volume on backend `element_default`.

```
tridentctl import volume element_default element-managed -f pvc-basic-import.yaml -n trident -d

+-----+-----+-----+
+-----+-----+-----+
|           NAME           |   SIZE   | STORAGE CLASS |
PROTOCOL |           BACKEND UUID           | STATE   | MANAGED |
+-----+-----+-----+
+-----+-----+-----+
| pvc-970ce1ca-2096-4ecd-8545-ac7edc24a8fe | 10 GiB | basic-element |
block    | d3ba047a-ea0b-43f9-9c42-e38e58301c49 | online | true   |
+-----+-----+-----+
+-----+-----+-----+
```

## Google Cloud Platform

Trident supports volume import using the `gcp-cvs` driver.



To import a volume backed by the NetApp Cloud Volumes Service in Google Cloud Platform, identify the volume by its volume path. The volume path is the portion of the volume's export path after the `:`. For example, if the export path is `10.0.0.1:/adroit-jolly-swift`, the volume path is `adroit-jolly-swift`.

## Google Cloud Platform example

The following example imports a `gcp-cvs` volume on backend `gpcvss_YEppr` with the volume path of `adroit-jolly-swift`.

```
tridentctl import volume gpcvss_YEppr adroit-jolly-swift -f <path-to-pvc-file> -n trident

+-----+-----+-----+
+-----+-----+-----+
|           NAME           |  SIZE  | STORAGE CLASS  |
PROTOCOL |           BACKEND UUID           | STATE  | MANAGED  |
+-----+-----+-----+
+-----+-----+-----+
| pvc-a46ccab7-44aa-4433-94b1-e47fc8c0fa55 | 93 GiB | gcp-storage  | file
| e1a6e65b-299e-4568-ad05-4f0a105c888f | online | true      |
+-----+-----+-----+
+-----+-----+-----+
```

## Azure NetApp Files

Trident supports volume import using the `azure-netapp-files` driver.



To import an Azure NetApp Files volume, identify the volume by its volume path. The volume path is the portion of the volume's export path after the `:/`. For example, if the mount path is `10.0.0.2:/importvol1`, the volume path is `importvol1`.

## Azure NetApp Files example

The following example imports an `azure-netapp-files` volume on backend `azurenappfiles_40517` with the volume path `importvol1`.

```
tridentctl import volume azurenappfiles_40517 importvol1 -f <path-to-pvc-file> -n trident

+-----+-----+-----+
+-----+-----+-----+
|           NAME           |  SIZE  | STORAGE CLASS  |
PROTOCOL |           BACKEND UUID           | STATE  | MANAGED  |
+-----+-----+-----+
+-----+-----+-----+
| pvc-0ee95d60-fd5c-448d-b505-b72901b3a4ab | 100 GiB | anf-storage  |
file      | 1c01274f-d94b-44a3-98a3-04c953c9a51e | online | true      |
+-----+-----+-----+
+-----+-----+-----+
```

## Customize volume names and labels

With Trident, you can assign meaningful names and labels to volumes you create. This helps you identify and easily map volumes to their respective Kubernetes resources (PVCs). You can also define templates at the backend level for creating custom volume names and custom labels; any volumes that you create, import, or clone will adhere to the templates.

### Before you begin

Customizable volume names and labels support:

1. Volume create, import, and clone operations.
2. In the case of ontap-nas-economy driver, only the name of the Qtree volume complies with the name template.
3. In the case of ontap-san-economy driver, only the LUN name complies with the name template.

### Limitations

1. Customizable volume names are compatible with ONTAP on-premises drivers only.
2. Customizable volume names do not apply to existing volumes.

### Key behaviors of customizable volume names

1. If a failure occurs due to invalid syntax in a name template, the backend creation fails. However, if the template application fails, the volume will be named according to existing naming convention.
2. Storage prefix is not applicable when a volume is named using a name template from the backend configuration. Any desired prefix value may be directly added to the template.

### Backend configuration examples with name template and labels

Custom name templates can be defined at the root and/or pool level.

## Root level example

```
{  
  "version": 1,  
  "storageDriverName": "ontap-nas",  
  "backendName": "ontap-nfs-backend",  
  "managementLIF": "<ip address>",  
  "svm": "svm0",  
  "username": "<admin>",  
  "password": "<password>",  
  "defaults": {  
    "nameTemplate":  
      "{{.volume.Name}}_{{.labels.cluster}}_{{.volume.Namespace}}_{{.volume.RequestName}}"  
  },  
  "labels": {"cluster": "ClusterA", "PVC":  
    "{{.volume.Namespace}}_{{.volume.RequestName}}"}  
}
```

## Pool level example

```
{  
  "version": 1,  
  "storageDriverName": "ontap-nas",  
  "backendName": "ontap-nfs-backend",  
  "managementLIF": "<ip address>",  
  "svm": "svm0",  
  "username": "<admin>",  
  "password": "<password>",  
  "useREST": true,  
  "storage": [  
    {  
      "labels": {"labelname": "label1", "name": "{{ .volume.Name }}"},  
      "defaults": {  
        "nameTemplate": "pool01_{{ .volume.Name }}_{{ .labels.cluster }}_{{ .volume.Namespace }}_{{ .volume.RequestName }}"  
      }  
    },  
    {  
      "labels": {"cluster": "label2", "name": "{{ .volume.Name }}"},  
      "defaults": {  
        "nameTemplate": "pool02_{{ .volume.Name }}_{{ .labels.cluster }}_{{ .volume.Namespace }}_{{ .volume.RequestName }}"  
      }  
    }  
  ]  
}
```

## Name template examples

### Example 1:

```
"nameTemplate": "{{ .config.StoragePrefix }}_{{ .volume.Name }}_{{ .config.BackendName }}"
```

### Example 2:

```
"nameTemplate": "pool_{{ .config.StoragePrefix }}_{{ .volume.Name }}_{{ slice .volume.RequestName 1 5 }}""
```

## Points to consider

1. In the case of volume imports, the labels are updated only if the existing volume has labels in a specific format. For example: `{"provisioning": {"Cluster": "ClusterA", "PVC": "pvcname"}}`.
2. In the case of managed volume imports, the volume name follows the name template defined at the root level in the backend definition.
3. Trident does not support the use of a slice operator with the storage prefix.
4. If the templates do not result in unique volume names, Trident will append a few random characters to create unique volume names.
5. If the custom name for a NAS economy volume exceeds 64 characters in length, Trident will name the volumes according to the existing naming convention. For all other ONTAP drivers, if the volume name exceeds the name limit, the volume creation process fails.

## Share an NFS volume across namespaces

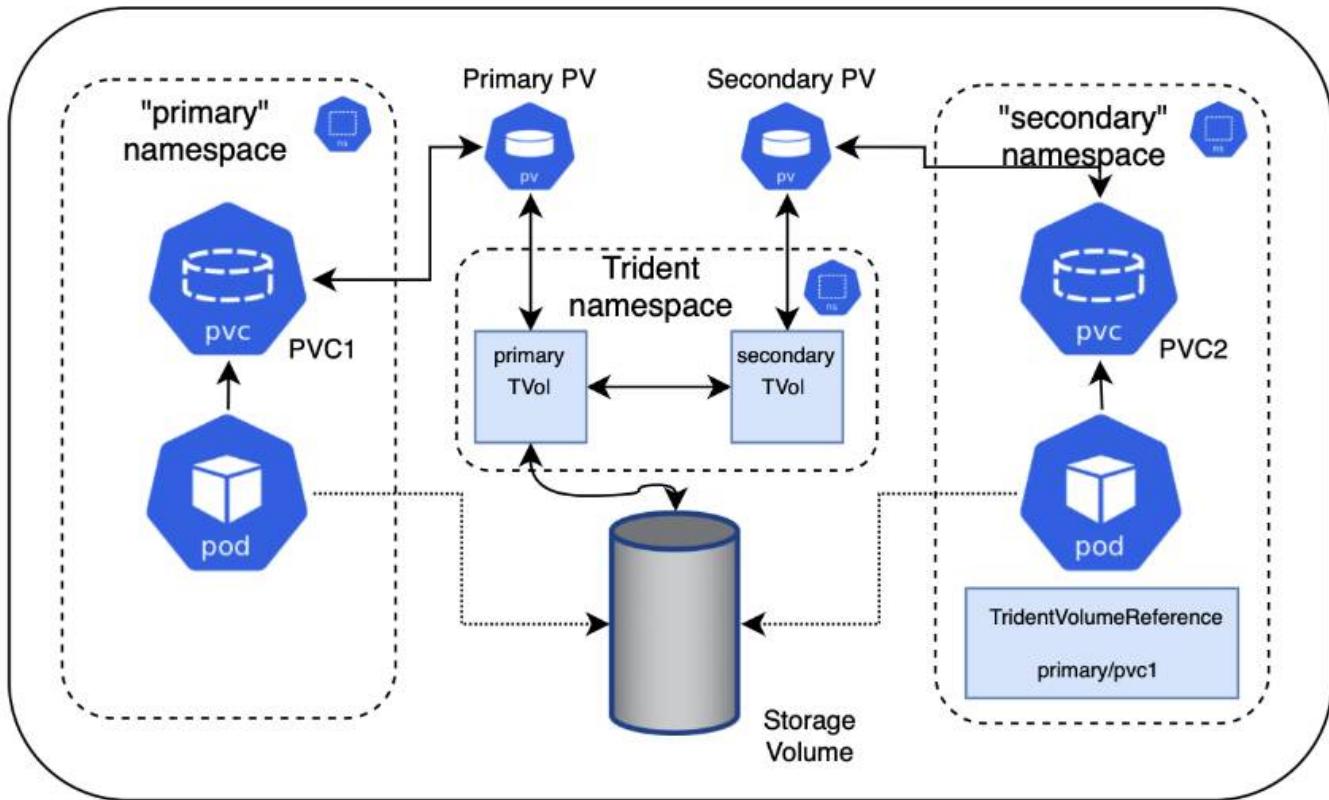
Using Trident, you can create a volume in a primary namespace and share it in one or more secondary namespaces.

### Features

The TridentVolumeReference CR allows you to securely share ReadWriteMany (RWX) NFS volumes across one or more Kubernetes namespaces. This Kubernetes-native solution has the following benefits:

- Multiple levels of access control to ensure security
- Works with all Trident NFS volume drivers
- No reliance on `tridentctl` or any other non-native Kubernetes feature

This diagram illustrates NFS volume sharing across two Kubernetes namespaces.



## Quick start

You can set up NFS volume sharing in just a few steps.

1

### Configure source PVC to share the volume

The source namespace owner grants permission to access the data in the source PVC.

2

### Grant permission to create a CR in the destination namespace

The cluster administrator grants permission to the owner of the destination namespace to create the TridentVolumeReference CR.

3

### Create TridentVolumeReference in the destination namespace

The owner of the destination namespace creates the TridentVolumeReference CR to refer to the source PVC.

4

### Create the subordinate PVC in the destination namespace

The owner of the destination namespace creates the subordinate PVC to use the data source from the source PVC.

## Configure the source and destination namespaces

To ensure security, cross namespace sharing requires collaboration and action by the source namespace

owner, cluster administrator, and destination namespace owner. The user role is designated in each step.

## Steps

1. **Source namespace owner:** Create the PVC (pvc1) in the source namespace that grants permission to share with the destination namespace (namespace2) using the `shareToNamespace` annotation.

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: pvc1
  namespace: namespace1
  annotations:
    trident.netapp.io/shareToNamespace: namespace2
spec:
  accessModes:
    - ReadWriteMany
  storageClassName: trident-csi
  resources:
    requests:
      storage: 100Gi
```

Trident creates the PV and its backend NFS storage volume.

- You can share the PVC to multiple namespaces using a comma-delimited list. For example, `trident.netapp.io/shareToNamespace: namespace2, namespace3, namespace4`.
- You can share to all namespaces using `*`. For example, `trident.netapp.io/shareToNamespace: *`
- You can update the PVC to include the `shareToNamespace` annotation at any time.



2. **Cluster admin:** Create the custom role and kubeconfig to grant permission to the destination namespace owner to create the TridentVolumeReference CR in the destination namespace.
3. **Destination namespace owner:** Create a TridentVolumeReference CR in the destination namespace that refers to the source namespace pvc1.

```
apiVersion: trident.netapp.io/v1
kind: TridentVolumeReference
metadata:
  name: my-first-tvr
  namespace: namespace2
spec:
  pvcName: pvc1
  pvcNamespace: namespace1
```

4. **Destination namespace owner:** Create a PVC (`pvc2`) in destination namespace (`namespace2`) using the `shareFromPVC` annotation to designate the source PVC.

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  annotations:
    trident.netapp.io/shareFromPVC: namespace1/pvc1
  name: pvc2
  namespace: namespace2
spec:
  accessModes:
    - ReadWriteMany
  storageClassName: trident-csi
  resources:
    requests:
      storage: 100Gi
```



The size of the destination PVC must be less than or equal than the source PVC.

## Results

Trident reads the `shareFromPVC` annotation on the destination PVC and creates the destination PV as a subordinate volume with no storage resource of its own that points to the source PV and shares the source PV storage resource. The destination PVC and PV appear bound as normal.

## Delete a shared volume

You can delete a volume that is shared across multiple namespaces. Trident will remove access to the volume on the source namespace and maintain access for other namespaces that share the volume. When all namespaces that reference the volume are removed, Trident deletes the volume.

### Use `tridentctl get` to query subordinate volumes

Using the `tridentctl` utility, you can run the `get` command to get subordinate volumes. For more information, refer to [tridentctl commands and options](#).

```
Usage:
  tridentctl get [option]
```

Flags:

- `-h, --help`: Help for volumes.
- `--parentOfSubordinate string`: Limit query to subordinate source volume.
- `--subordinateOf string`: Limit query to subordinates of volume.

## Limitations

- Trident cannot prevent destination namespaces from writing to the shared volume. You should use file locking or other processes to prevent overwriting shared volume data.
- You cannot revoke access to the source PVC by removing the `shareToNamespace` or `shareFromNamespace` annotations or deleting the `TridentVolumeReference` CR. To revoke access, you must delete the subordinate PVC.
- Snapshots, clones, and mirroring are not possible on subordinate volumes.

## For more information

To learn more about cross-namespace volume access:

- Visit [Sharing volumes between namespaces: Say hello to cross-namespace volume access](#).
- Watch the demo on [NetAppTV](#).

## Replicate volumes using SnapMirror

Trident supports 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

- **Trident:** Trident version 22.10 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.

- **Trident and SVM:** The peered remote SVMs must be available to Trident 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
```

Trident 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"
```

Trident 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
```

Trident will check for the TridentMirrorRelationship CRD and fail to create the volume if the relationship

does not exist. If the relationship exists, Trident 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 Trident 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

Trident 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 flexvols 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)

Trident 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 Trident 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 Trident 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 Trident 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*.

## Use CSI Topology

Trident can selectively create and attach volumes to nodes present in a Kubernetes cluster by making use of the [CSI Topology feature](#).

### Overview

Using the CSI Topology feature, access to volumes can be limited to a subset of nodes, based on regions and availability zones. Cloud providers today enable Kubernetes administrators to spawn nodes that are zone based. Nodes can be located in different availability zones within a region, or across various regions. To facilitate the provisioning of volumes for workloads in a multi-zone architecture, Trident uses CSI Topology.



Learn more about the CSI Topology feature [here](#).

Kubernetes provides two unique volume binding modes:

- With `VolumeBindingMode` set to `Immediate`, Trident creates the volume without any topology awareness. Volume binding and dynamic provisioning are handled when the PVC is created. This is the default `VolumeBindingMode` and is suited for clusters that do not enforce topology constraints. Persistent Volumes are created without having any dependency on the requesting pod's scheduling requirements.
- With `VolumeBindingMode` set to `WaitForFirstConsumer`, the creation and binding of a Persistent Volume for a PVC is delayed until a pod that uses the PVC is scheduled and created. This way, volumes are created to meet the scheduling constraints that are enforced by topology requirements.



The `WaitForFirstConsumer` binding mode does not require topology labels. This can be used independent of the CSI Topology feature.

### What you'll need

To make use of CSI Topology, you need the following:

- A Kubernetes cluster running a [supported Kubernetes version](#)

```

kubectl version
Client Version: version.Info{Major:"1", Minor:"19",
GitVersion:"v1.19.3",
GitCommit:"1e11e4a2108024935ecfcb2912226cedead99df",
GitTreeState:"clean", BuildDate:"2020-10-14T12:50:19Z",
GoVersion:"go1.15.2", Compiler:"gc", Platform:"linux/amd64"}
Server Version: version.Info{Major:"1", Minor:"19",
GitVersion:"v1.19.3",
GitCommit:"1e11e4a2108024935ecfcb2912226cedead99df",
GitTreeState:"clean", BuildDate:"2020-10-14T12:41:49Z",
GoVersion:"go1.15.2", Compiler:"gc", Platform:"linux/amd64"}

```

- Nodes in the cluster should have labels that introduce topology awareness (`topology.kubernetes.io/region` and `topology.kubernetes.io/zone`). These labels **should be present on nodes in the cluster** before Trident is installed for Trident to be topology aware.

```

kubectl get nodes -o=jsonpath='{range .items[*]}{{.metadata.name},\n{.metadata.labels}}{"\n"}{end}' | grep --color "topology.kubernetes.io"
[node1,
{"beta.kubernetes.io/arch":"amd64","beta.kubernetes.io/os":"linux","kubernetes.io/arch":"amd64","kubernetes.io/hostname":"node1","kubernetes.io/os":"linux","node-
role.kubernetes.io/master":"","topology.kubernetes.io/region":"us-
east1","topology.kubernetes.io/zone":"us-east1-a"}]
[node2,
{"beta.kubernetes.io/arch":"amd64","beta.kubernetes.io/os":"linux","kubernetes.io/arch":"amd64","kubernetes.io/hostname":"node2","kubernetes.io/os":"linux","node-
role.kubernetes.io/worker":"","topology.kubernetes.io/region":"us-
east1","topology.kubernetes.io/zone":"us-east1-b"}]
[node3,
{"beta.kubernetes.io/arch":"amd64","beta.kubernetes.io/os":"linux","kubernetes.io/arch":"amd64","kubernetes.io/hostname":"node3","kubernetes.io/os":"linux","node-
role.kubernetes.io/worker":"","topology.kubernetes.io/region":"us-
east1","topology.kubernetes.io/zone":"us-east1-c"}]

```

## Step 1: Create a topology-aware backend

Trident storage backends can be designed to selectively provision volumes based on availability zones. Each backend can carry an optional `supportedTopologies` block that represents a list of zones and regions that are supported. For StorageClasses that make use of such a backend, a volume would only be created if requested by an application that is scheduled in a supported region/zone.

Here is an example backend definition:

## YAML

```
---
version: 1
storageDriverName: ontap-san
backendName: san-backend-us-east1
managementLIF: 192.168.27.5
svm: iscsi_svm
username: admin
password: password
supportedTopologies:
- topology.kubernetes.io/region: us-east1
  topology.kubernetes.io/zone: us-east1-a
- topology.kubernetes.io/region: us-east1
  topology.kubernetes.io/zone: us-east1-b
```

## JSON

```
{
  "version": 1,
  "storageDriverName": "ontap-san",
  "backendName": "san-backend-us-east1",
  "managementLIF": "192.168.27.5",
  "svm": "iscsi_svm",
  "username": "admin",
  "password": "password",
  "supportedTopologies": [
    {"topology.kubernetes.io/region": "us-east1",
     "topology.kubernetes.io/zone": "us-east1-a"},
    {"topology.kubernetes.io/region": "us-east1",
     "topology.kubernetes.io/zone": "us-east1-b"}
  ]
}
```

 `supportedTopologies` is used to provide a list of regions and zones per backend. These regions and zones represent the list of permissible values that can be provided in a `StorageClass`. For `StorageClasses` that contain a subset of the regions and zones provided in a backend, Trident creates a volume on the backend.

You can define `supportedTopologies` per storage pool as well. See the following example:

```
---
version: 1
storageDriverName: ontap-nas
backendName: nas-backend-us-central1
managementLIF: 172.16.238.5
svm: nfs_svm
username: admin
password: password
supportedTopologies:
- topology.kubernetes.io/region: us-central1
  topology.kubernetes.io/zone: us-central1-a
- topology.kubernetes.io/region: us-central1
  topology.kubernetes.io/zone: us-central1-b
storage:
- labels:
  workload: production
  supportedTopologies:
  - topology.kubernetes.io/region: us-central1
    topology.kubernetes.io/zone: us-central1-a
- labels:
  workload: dev
  supportedTopologies:
  - topology.kubernetes.io/region: us-central1
    topology.kubernetes.io/zone: us-central1-b
```

In this example, the `region` and `zone` labels stand for the location of the storage pool. `topology.kubernetes.io/region` and `topology.kubernetes.io/zone` dictate where the storage pools can be consumed from.

## Step 2: Define StorageClasses that are topology aware

Based on the topology labels that are provided to the nodes in the cluster, StorageClasses can be defined to contain topology information. This will determine the storage pools that serve as candidates for PVC requests made, and the subset of nodes that can make use of the volumes provisioned by Trident.

See the following example:

```

apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: netapp-san-us-east1
  provisioner: csi.trident.netapp.io
  volumeBindingMode: WaitForFirstConsumer
  allowedTopologies:
    - matchLabelExpressions:
    - key: topology.kubernetes.io/zone
      values:
        - us-east1-a
        - us-east1-b
    - key: topology.kubernetes.io/region
      values:
        - us-east1
  parameters:
    fsType: "ext4"

```

In the StorageClass definition provided above, `volumeBindingMode` is set to `WaitForFirstConsumer`. PVCs that are requested with this StorageClass will not be acted upon until they are referenced in a pod. And, `allowedTopologies` provides the zones and region to be used. The `netapp-san-us-east1` StorageClass creates PVCs on the `san-backend-us-east1` backend defined above.

### Step 3: Create and use a PVC

With the StorageClass created and mapped to a backend, you can now create PVCs.

See the example spec below:

```

---
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: pvc-san
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 300Mi
  storageClassName: netapp-san-us-east1

```

Creating a PVC using this manifest would result in the following:

```

kubectl create -f pvc.yaml
persistentvolumeclaim/pvc-san created
kubectl get pvc
NAME      STATUS      VOLUME      CAPACITY      ACCESS MODES      STORAGECLASS
AGE
pvc-san   Pending          2s          netapp-san-us-east1

kubectl describe pvc
Name:            pvc-san
Namespace:       default
StorageClass:    netapp-san-us-east1
Status:          Pending
Volume:
Labels:          <none>
Annotations:    <none>
Finalizers:     [kubernetes.io/pvc-protection]
Capacity:
Access Modes:
VolumeMode:     Filesystem
Mounted By:    <none>
Events:
  Type  Reason          Age      From          Message
  ----  ----          ----      ----          -----
  Normal  WaitForFirstConsumer  6s      persistentvolume-controller  waiting
for first consumer to be created before binding

```

For Trident to create a volume and bind it to the PVC, use the PVC in a pod. See the following example:

```

apiVersion: v1
kind: Pod
metadata:
  name: app-pod-1
spec:
  affinity:
    nodeAffinity:
      requiredDuringSchedulingIgnoredDuringExecution:
        nodeSelectorTerms:
        - matchExpressions:
          - key: topology.kubernetes.io/region
            operator: In
            values:
            - us-east1
      preferredDuringSchedulingIgnoredDuringExecution:
      - weight: 1
        preference:
          matchExpressions:
          - key: topology.kubernetes.io/zone
            operator: In
            values:
            - us-east1-a
            - us-east1-b
  securityContext:
    runAsUser: 1000
    runAsGroup: 3000
    fsGroup: 2000
  volumes:
  - name: vol1
    persistentVolumeClaim:
      claimName: pvc-san
  containers:
  - name: sec-ctx-demo
    image: busybox
    command: [ "sh", "-c", "sleep 1h" ]
    volumeMounts:
    - name: vol1
      mountPath: /data/demo
    securityContext:
      allowPrivilegeEscalation: false

```

This podSpec instructs Kubernetes to schedule the pod on nodes that are present in the us-east1 region, and choose from any node that is present in the us-east1-a or us-east1-b zones.

See the following output:

```

kubectl get pods -o wide
NAME        READY   STATUS    RESTARTS   AGE   IP           NODE
NOMINATED NODE   READINESS GATES
app-pod-1   1/1     Running   0          19s   192.168.25.131   node2
<none>          <none>
kubectl get pvc -o wide
NAME        STATUS    VOLUME
ACCESS MODES   STORAGECLASS   AGE   VOLUMEMODE
pvc-san     Bound     pvc-ecb1e1a0-840c-463b-8b65-b3d033e2e62b   300Mi
RWO          netapp-san-us-east1   48s   Filesystem

```

## Update backends to include `supportedTopologies`

Pre-existing backends can be updated to include a list of `supportedTopologies` using `tridentctl backend update`. This will not affect volumes that have already been provisioned, and will only be used for subsequent PVCs.

## Find more information

- [Manage resources for containers](#)
- [nodeSelector](#)
- [Affinity and anti-affinity](#)
- [Taints and Tolerations](#)

## Work with snapshots

Kubernetes volume snapshots of Persistent Volumes (PVs) enable point-in-time copies of volumes. You can create a snapshot of a volume created using Trident, import a snapshot created outside of Trident, create a new volume from an existing snapshot, and recover volume data from snapshots.

### Overview

Volume snapshot is supported by `ontap-nas`, `ontap-nas-flexgroup`, `ontap-san`, `ontap-san-economy`, `solidfire-san`, `gcp-cvs`, and `azure-netapp-files` drivers.

### Before you begin

You must have an external snapshot controller and Custom Resource Definitions (CRDs) to work with snapshots. This is the responsibility of the Kubernetes orchestrator (for example: Kubeadm, GKE, OpenShift).

If your Kubernetes distribution does not include the snapshot controller and CRDs, refer to [Deploy a volume snapshot controller](#).



Don't create a snapshot controller if creating on-demand volume snapshots in a GKE environment. GKE uses a built-in, hidden snapshot controller.

## Create a volume snapshot

### Steps

1. Create a `VolumeSnapshotClass`. For more information, refer to [VolumeSnapshotClass](#).
  - The `driver` points to the Trident CSI driver.
  - `deletionPolicy` can be `Delete` or `Retain`. When set to `Retain`, the underlying physical snapshot on the storage cluster is retained even when the `VolumeSnapshot` object is deleted.

### Example

```
cat snap-sc.yaml
apiVersion: snapshot.storage.k8s.io/v1
kind: VolumeSnapshotClass
metadata:
  name: csi-snapclass
driver: csi.trident.netapp.io
deletionPolicy: Delete
```

2. Create a snapshot of an existing PVC.

### Examples

- This example creates a snapshot of an existing PVC.

```
cat snap.yaml
apiVersion: snapshot.storage.k8s.io/v1
kind: VolumeSnapshot
metadata:
  name: pvc1-snap
spec:
  volumeSnapshotClassName: csi-snapclass
  source:
    persistentVolumeClaimName: pvc1
```

- This example creates a volume snapshot object for a PVC named `pvc1` and the name of the snapshot is set to `pvc1-snap`. A `VolumeSnapshot` is analogous to a PVC and is associated with a `VolumeSnapshotContent` object that represents the actual snapshot.

```
kubectl create -f snap.yaml
volumesnapshot.snapshot.storage.k8s.io/pvc1-snap created

kubectl get volumesnapshots
NAME          AGE
pvc1-snap    50s
```

- You can identify the `VolumeSnapshotContent` object for the `pvc1-snap` `VolumeSnapshot` by

describing it. The Snapshot Content Name identifies the VolumeSnapshotContent object which serves this snapshot. The Ready To Use parameter indicates that the snapshot can be used to create a new PVC.

```
kubectl describe volumesnapshots pvc1-snap
Name:          pvc1-snap
Namespace:     default
.
.
.
Spec:
  Snapshot Class Name:    pvc1-snap
  Snapshot Content Name:  snapcontent-e8d8a0ca-9826-11e9-9807-
  525400f3f660
  Source:
    API Group:   PersistentVolumeClaim
    Kind:        PersistentVolumeClaim
    Name:        pvc1
Status:
  Creation Time: 2019-06-26T15:27:29Z
  Ready To Use:  true
  Restore Size:  3Gi
.
```

## Create a PVC from a volume snapshot

You can use `dataSource` to create a PVC using a VolumeSnapshot named `<pvc-name>` as the source of the data. After the PVC is created, it can be attached to a pod and used just like any other PVC.



The PVC will be created in the same backend as the source volume. Refer to [KB: Creating a PVC from a Trident PVC Snapshot cannot be created in an alternate backend](#).

The following example creates the PVC using `pvc1-snap` as the data source.

```
cat pvc-from-snap.yaml
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-from-snap
spec:
  accessModes:
    - ReadWriteOnce
  storageClassName: golden
  resources:
    requests:
      storage: 3Gi
  dataSource:
    name: pvcl-snap
    kind: VolumeSnapshot
    apiGroup: snapshot.storage.k8s.io
```

## Import a volume snapshot

Trident supports the [Kubernetes pre-provisioned snapshot process](#) to enable the cluster administrator to create a `VolumeSnapshotContent` object and import snapshots created outside of Trident.

### Before you begin

Trident must have created or imported the snapshot's parent volume.

### Steps

1. **Cluster admin:** Create a `VolumeSnapshotContent` object that references the backend snapshot. This initiates the snapshot workflow in Trident.
  - Specify the name of the backend snapshot in annotations as `trident.netapp.io/internalSnapshotName: <"backend-snapshot-name">`.
  - Specify `<name-of-parent-volume-in-trident>/<volume-snapshot-content-name>` in `snapshotHandle`. This is the only information provided to Trident by the external snapshotter in the `ListSnapshots` call.



The `<volumeSnapshotContentName>` cannot always match the backend snapshot name due to CR naming constraints.

### Example

The following example creates a `VolumeSnapshotContent` object that references backend snapshot `snap-01`.

```

apiVersion: snapshot.storage.k8s.io/v1
kind: VolumeSnapshotContent
metadata:
  name: import-snap-content
  annotations:
    trident.netapp.io/internalSnapshotName: "snap-01" # This is the
    name of the snapshot on the backend
spec:
  deletionPolicy: Retain
  driver: csi.trident.netapp.io
  source:
    snapshotHandle: pvc-f71223b5-23b9-4235-bbfe-e269ac7b84b0/import-
    snap-content # <import PV name or source PV name>/<volume-snapshot-
    content-name>
    volumeSnapshotRef:
      name: import-snap
      namespace: default

```

2. **Cluster admin:** Create the VolumeSnapshot CR that references the VolumeSnapshotContent object. This requests access to use the VolumeSnapshot in a given namespace.

#### Example

The following example creates a VolumeSnapshot CR named import-snap that references the VolumeSnapshotContent named import-snap-content.

```

apiVersion: snapshot.storage.k8s.io/v1
kind: VolumeSnapshot
metadata:
  name: import-snap
spec:
  # volumeSnapshotClassName: csi-snapclass (not required for pre-
  # provisioned or imported snapshots)
  source:
    volumeSnapshotContentName: import-snap-content

```

3. **Internal processing (no action required):** The external snapshotter recognizes the newly created VolumeSnapshotContent and runs the ListSnapshots call. Trident creates the TridentSnapshot.

- The external snapshotter sets the VolumeSnapshotContent to readyToUse and the VolumeSnapshot to true.
- Trident returns readyToUse=true.

4. **Any user:** Create a PersistentVolumeClaim to reference the new VolumeSnapshot, where the spec.dataSource (or spec.dataSourceRef) name is the VolumeSnapshot name.

#### Example

The following example creates a PVC referencing the VolumeSnapshot named `import-snap`.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-from-snap
spec:
  accessModes:
    - ReadWriteOnce
  storageClassName: simple-sc
  resources:
    requests:
      storage: 1Gi
  dataSource:
    name: import-snap
    kind: VolumeSnapshot
  apiGroup: snapshot.storage.k8s.io
```

## Recover volume data using snapshots

The snapshot directory is hidden by default to facilitate maximum compatibility of volumes provisioned using the `ontap-nas` and `ontap-nas-economy` drivers. Enable the `.snapshot` directory to recover data from snapshots directly.

Use the volume snapshot restore ONTAP CLI to to restore a volume to a state recorded in a prior snapshot.

```
cluster1::*> volume snapshot restore -vserver vs0 -volume vol3 -snapshot
vol3_snap_archive
```



When you restore a snapshot copy, the existing volume configuration is overwritten. Changes made to volume data after the snapshot copy was created are lost.

## In-place volume restoration from a snapshot

Trident 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.

Trident supports snapshot restore on the `ontap-san`, `ontap-san-economy`, `ontap-nas`, `ontap-nas-flexgroup`, `azure-netapp-files`, `gcp-cvs`, `google-cloud-netapp-volumes`, 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.



The TASR CR must be in a namespace where the PVC & VS exist.

```
cat tasr-pvc1-snapshot.yaml

apiVersion: trident.netapp.io/v1
kind: TridentActionSnapshotRestore
metadata:
  name: trident-snap
  namespace: trident
spec:
  pvcName: pvc1
  volumeSnapshotName: pvc1-snapshot
```

1. 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/trident-snap created
```

## Results

Trident restores the data from the snapshot. You can verify the snapshot restore status.

```

kubectl get tasr -o yaml

apiVersion: trident.netapp.io/v1
items:
- apiVersion: trident.netapp.io/v1
  kind: TridentActionSnapshotRestore
  metadata:
    creationTimestamp: "2023-04-14T00:20:33Z"
    generation: 3
    name: trident-snap
    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, Trident 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.

## Delete a PV with associated snapshots

When deleting a Persistent Volume with associated snapshots, the corresponding Trident volume is updated to a “Deleting state”. Remove the volume snapshots to delete the Trident volume.

## Deploy a volume snapshot controller

If your Kubernetes distribution does not include the snapshot controller and CRDs, you can deploy them as follows.

### Steps

1. Create volume snapshot CRDs.

```
cat snapshot-setup.sh
#!/bin/bash
# Create volume snapshot CRDs
kubectl apply -f https://raw.githubusercontent.com/kubernetes-
csi/external-snapshotter/release-
6.1/client/config/crd/snapshot.storage.k8s.io_volumesnapshotclasses.yaml
kubectl apply -f https://raw.githubusercontent.com/kubernetes-
csi/external-snapshotter/release-
6.1/client/config/crd/snapshot.storage.k8s.io_volumesnapshotcontents.yaml
1
kubectl apply -f https://raw.githubusercontent.com/kubernetes-
csi/external-snapshotter/release-
6.1/client/config/crd/snapshot.storage.k8s.io_volumesnapshots.yaml
```

## 2. Create the snapshot controller.

```
kubectl apply -f https://raw.githubusercontent.com/kubernetes-
csi/external-snapshotter/release-6.1/deploy/kubernetes/snapshot-
controller/rbac-snapshot-controller.yaml
kubectl apply -f https://raw.githubusercontent.com/kubernetes-
csi/external-snapshotter/release-6.1/deploy/kubernetes/snapshot-
controller/setup-snapshot-controller.yaml
```



If necessary, open `deploy/kubernetes/snapshot-controller/rbac-snapshot-
controller.yaml` and update namespace to your namespace.

## Related links

- [Volume snapshots](#)
- [VolumeSnapshotClass](#)

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