



# **On-Premises**

## **NetApp Solutions**

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# NetApp Hybrid Multicloud solutions for Red Hat OpenShift Container workloads

## Overview

NetApp is seeing a significant increase in customers modernizing their legacy enterprise applications and building new applications using containers and orchestration platforms built around Kubernetes. Red Hat OpenShift Container Platform is one example that we see adopted by many of our customers.

As more and more customers begin adopting containers within their enterprises, NetApp is perfectly positioned to help serve the persistent storage needs of their stateful applications and classic data management needs such as data protection, data security, and data migration. However, these needs are met using different strategies, tools, and methods.

**NetApp ONTAP** based storage options listed below, deliver security, data protection, reliability, and flexibility for containers and Kubernetes deployments.

- Self-managed storage in on-premises:
  - NetApp Fabric Attached Storage (FAS), NetApp All Flash FAS Arrays (AFF), NetApp All SAN Array (ASA) and ONTAP Select
- Provider-managed storage in on-premises:
  - NetApp Keystone provides Storage as a Service (STaaS)
- Self-managed storage in the cloud:
  - NetApp Cloud Volumes ONTAP(CVO) provide self managed storage in the hyperscalers
- Provider-managed storage in the cloud:
  - Cloud Volumes Service for Google Cloud (CVS), Azure NetApp Files (ANF), Amazon FSx for NetApp ONTAP offer fully managed storage in the hyperscalers

## ONTAP feature highlights



### Storage Administration

- Multi-tenancy
- FlexVol & FlexGroup
- LUN
- Quotas
- ONTAP CLI & API
- System Manager & BlueXP

### Performance & Scalability

- FlexCache
- FlexClone
- nconnect, session trunking, multipathing
- Scale-out clusters

### Availability & Resilience

- Multi-AZ HA deployment (MetroCluster)
- SnapShot & SnapRestore
- SnapMirror
- SnapMirror Business Continuity
- SnapMirror Cloud

### Access Protocols

- NFS –v3, v4, v4.1, v4.2
- SMB – v2, v3
- iSCSI
- Multi-protocol access

### Storage Efficiency

- Deduplication & Compression
- Compaction
- Thin provisioning
- Data Tiering (Fabric Pool)

### Security & Compliance

- Fpolicy & Vscan
- Active Directory integration
- LDAP & Kerberos
- Certificate based authentication

**NetApp BlueXP** enables you to manage all of your storage and data assets from a single control plane/interface.

You can use BlueXP to create and administer cloud storage (for example, Cloud Volumes ONTAP and Azure NetApp Files), to move, protect, and analyze data, and to control many on-prem and edge storage devices.

**NetApp Astra Trident** is a CSI Compliant Storage Orchestrator that enable quick and easy consumption of persistent storage backed by a variety of the above-mentioned NetApp storage options. It is an open-source software maintained and supported by NetApp.

### Astra Trident CSI feature highlights



<b>CSI specific</b> <ul style="list-style-type: none"><li>• CSI NetApp® Snapshot™ copies and volume creation from CSI Snapshot copies</li><li>• CSI topology</li><li>• Volume expansion</li></ul>	<b>Security</b> <ul style="list-style-type: none"><li>• Dynamic-export policy management</li><li>• iSCSI initiator-groups dynamic management</li><li>• iSCSI bidirectional CHAP</li></ul>
<b>Control</b> <ul style="list-style-type: none"><li>• Storage and performance consumption</li><li>• Monitoring</li><li>• Volume Import</li><li>• Cross Namespace Volume Access</li></ul>	<b>Installation methods</b> <ul style="list-style-type: none"><li>• Binary</li><li>• Helm chart</li><li>• Operator</li><li>• GitOps</li></ul>
<b>Choose your access mode</b> <ul style="list-style-type: none"><li>• RWO (ReadWriteOnce, i.e 1↔1)</li><li>• RWX (ReadWriteMany, i.e 1↔n)</li><li>• ROX (ReadOnlyMany)</li><li>• RWOP (ReadWriteOnce POD)</li></ul>	<b>Choose your protocol</b> <ul style="list-style-type: none"><li>• NFS</li><li>• SMB</li><li>• iSCSI</li></ul>

Business critical container workloads need more than just persistent volumes. Their data management requirements require protection and migration of the application kubernetes objects as well.



- Application data includes kubernetes objects in addition to the user data: Some examples are as follows:
- kubernetes objects such as pods specs, PVCs, deployments, services
  - custom config objects such as config maps and secrets
  - persistent data such as Snapshot copies, backups, clones
  - custom resources such as CRs and CRDs

**NetApp Astra Control**, available as both fully-managed and self-managed software, provides orchestration for robust application data management. Refer to the [Astra documentation](#) for additional details on the Astra family of products.

This reference documentation provides validation of migration and protection of container-based applications, deployed on RedHat OpenShift container platform, using NetApp Astra Control Center. In addition, the solution provides high-level details for the deployment and the use of Red Hat Advanced Cluster Management (ACM) for managing the container platforms. The document also highlights the details for the integration of NetApp storage with Red Hat OpenShift container platforms using Astra Trident CSI provisioner. Astra Control Center is deployed on the hub cluster and is used to manage the container applications and their persistent storage lifecycle. Finally, it provides a solution for replication and failover and fail-back for container workloads on managed Red Hat OpenShift clusters in AWS (ROSA) using Amazon FSx for NetApp ONTAP (FSxN) as

persistent storage.

## NetApp Solution with Red Hat OpenShift Container platform workloads on VMware

If customers have a need to run their modern containerized applications on infrastructure in their private data centers, they can do so. They should plan and deploy the Red Hat OpenShift container platform (OCP) for a successful production-ready environment for deploying their container workloads. Their OCP clusters can be deployed on VMware or bare metal.

NetApp ONTAP storage delivers data protection, reliability, and flexibility for container deployments. Astra Trident serves as the dynamic storage provisioner to consume persistent ONTAP storage for customers' stateful applications. Astra Control Center can be used to orchestrate the many data management requirements of stateful applications such as data protection, migration, and business continuity.

With VMware vSphere, NetApp ONTAP tools provides a vCenter Plugin which can be utilized to provision datastores. Apply tags and use it with OpenShift for storing the node configuration and data. NVMe based storage provides lower latency and high performance.

This solution provides details for data protection and migration of container workloads using Astra Control Center. For this solution, the container workloads are deployed on Red Hat OpenShift clusters on vSphere within the on-premises environment.

NOTE: We will provide a solution for container workloads on OpenShift clusters on bare metal in the future.

### Data protection and migration solution for OpenShift Container workloads using Astra Control Center



# Deploy and configure the Red Hat OpenShift Container platform on VMware

This section describes a high-level workflow of how to set up and manage OpenShift clusters and manage stateful applications on them. It shows the use of NetApp ONTAP storage arrays with the help of Astra Trident to provide persistent volumes. Details are provided about the use of Astra Control Center to perform data protection and migration activities for the stateful applications.



There are several ways of deploying Red Hat OpenShift Container platform clusters. This high-level description of the setup provides documentation links for the specific method that was used. You can refer to the other methods in the relevant links provided in the [resources section](#).

Here is a diagram that depicts the clusters deployed on VMware in a data center.



The setup process can be broken down into the following steps:

## Deploy and configure a CentOS VM

- It is deployed in the VMware vSphere environment.
- This VM is used for deploying some components such as NetApp Astra Trident and NetApp Astra Control Center for the solution.
- A root user is configured on this VM during installation.

## Deploy and configure an OpenShift Container Platform cluster on VMware vSphere (Hub Cluster)

Refer to the instructions for the [Assisted deployment](#) method to deploy an OCP cluster.



Remember the following:

- Create ssh public and private key to provide to the installer. These keys will be used to login to the master and worker nodes if needed.
- Download the installer program from the assisted installer. This program is used to boot the VMs that you create in the VMware vSphere environment for the master and worker nodes.
- VMs should have the minimum CPU, memory, and hard disk requirement. (Refer to the vm create commands on [this](#) page for the master and the worker nodes which provide this information)
- The diskUUID should be enabled on all VMs.
- Create a minimum of 3 nodes for master and 3 nodes for worker.
- Once they are discovered by the installer, turn on the VMware vSphere integration toggle button.

### Install Advanced Cluster Management on the Hub cluster

This is installed using the Advanced Cluster Management Operator on the Hub Cluster.  
Refer to the instructions [here](#).

### Install an internal Red Hat Quay registry on the Hub Cluster.

- An internal registry is required to push the Astra image. A Quay internal registry is installed using the Operator in the Hub cluster.
- Refer to the instructions [here](#)

### Install two additional OCP clusters (Source and Destination)

- The additional clusters can be deployed using the ACM on the Hub Cluster.
- Refer to the instructions [here](#).

### Configure NetApp ONTAP storage

- Install an ONTAP cluster with connectivity to the OCP VMs in VMWare environment.
- Create an SVM.
- Configure NAS data lif to access the storage in SVM.

## Install NetApp Trident on the OCP clusters

- Install NetApp Trident on all three clusters: Hub, source, and destination clusters
- Refer to the instructions [here](#).
- Create a storage backend for ontap-nas .
- Create a storage class for ontap-nas.
- Refer to instructions [here](#).

## Install NetApp Astra Control Center

- NetApp Astra Control Center is installed using the Astra Operator on the Hub Cluster.
- Refer to the instructions [here](#).

Points to remember:

- \* Download NetApp Astra Control Center image from the support site.
- \* Push the image to an internal registry.
- \* Refer to instructions [here](#).

## Deploy an Application on Source Cluster

Use OpenShift GitOps to deploy an application. (eg. Postgres, Ghost)

## Add the Source and Destination clusters into Astra Control Center.

After you add a cluster to Astra Control management, you can install apps on the cluster (outside of Astra Control) and then go to the Applications page in Astra Control to define the apps and their resources. Refer to [Start managing apps section of Astra Control Center](#).

The next step is to use the Astra Control Center for Data protection and Data migration from the source to the destination cluster.

# Data protection using Astra

This page shows the data protection options for Red Hat OpenShift Container based applications running on VMware vSphere using Astra Control Center (ACC).

As users take their journey of modernizing their applications with Red Hat OpenShift, a data protection strategy should be in place to protect them from accidental deletion or any other human errors. Often a protection strategy is also required for regulatory or compliance purposes to protect their data from a disaster.

The requirements of data protection varies from reverting back to a point in time copy to automatically failing over to a different fault domain without any human intervention. Many customers pick ONTAP as their preferred storage platform for their Kubernetes applications because of its rich features like multitenancy, multi-protocol, high performance and capacity offerings, replication and caching for multi-site locations, security and flexibility.

Data protection in ONTAP can be achieved using ad-hoc or policy controlled

### - Snapshot



## - backup and restore

Both Snapshot copies and backups protect the following types of data:

- The application metadata that represents the state of the application
- Any persistent data volumes associated with the application
- Any resource artifacts belonging to the application

## Snapshot with ACC

A point in time copy of data can be captured using Snapshot with ACC. Protection policy defines the number of Snapshot copies to keep. Minimum schedule option available is hourly. Manual, on-demand Snapshot copies can be taken at any time and at shorter intervals than scheduled Snapshot copies. Snapshot copies are stored on the same provisioned volume as the app.

## Configuring Snapshot with ACC

The screenshot shows the Astra dashboard for a 'ghost' application. The 'Data protection' tab is selected, showing a table of snapshot configurations. The table has columns for Name, State, Hook state, On-Schedule / On-Demand, Created, and Actions. There are four entries in the table, all with a 'Healthy' state.

Name	State	Hook state	On-Schedule / On-Demand	Created	Actions
replication-schedule-wddw-50aug	Healthy	Healthy	On-Schedule	2023/04/26 19:50 UTC	
ghost-snapshot-20230426155028	Healthy	Healthy	On-Schedule	2023/04/26 15:50 UTC	
ghost-snapshot-20230426145026	Healthy	Healthy	On-Schedule	2023/04/26 14:50 UTC	
ghost-snapshot-20230416182551	Healthy	Healthy	On-Demand	2023/04/16 18:25 UTC	

## Backup and Restore with ACC

A backup is based on a Snapshot. ACC can take Snapshot copies using CSI and perform backup using the point in time Snapshot copy. The backup is stored in an external object store (any s3 compatible including ONTAP S3 at a different location). Protection policy can be configured for scheduled backups and the number of backup versions to keep. The minimum RPO is one hour.

## Restoring an application from a backup using ACC

ACC restores application from the S3 bucket where the backups are store.

The screenshot shows the Astra dashboard for a 'ghost' application. The 'Data protection' tab is selected, showing a table of backup configurations. The table has columns for Name, State, Hook state, On-Schedule / On-Demand, Bucket, Created, and Actions. There is one entry in the table, with a 'Healthy' state.

Name	State	Hook state	On-Schedule / On-Demand	Bucket	Created	Actions
hourly-backup-bpc7m	Healthy	Healthy	On-Schedule	astra	2023/04/26 15:50 UTC	<div>Restore application Delete backup</div>

## Application specific execution hooks

In addition, execution hooks can be configured to run in conjunction with a data protection operation of a managed app. Even though storage array level data protection features are available, often additional steps are needed to make backups and restores, application consistent. The app-specific additional steps could be:

- before or after a Snapshot copy is created.
- before or after a backup is created.
- after restoring from a Snapshot copy or backup.

Astra Control can execute these app-specific steps coded as custom scripts called execution hooks.

[NetApp Verda GitHub project](#) provides execution hooks for popular cloud-native applications to make protecting applications straightforward, robust, and easy to orchestrate. Feel free to contribute to that project if you have enough information for an application that is not in the repository.

## Sample execution hook for pre-Snapshot of a redis application.

Edit execution hook

HOOK DETAILS ?

Operation

Pre-snapshot

Hook arguments (optional)

1 pre X

Enter hook arguments

Hook name

redis-pre-snapshot

CONTAINER IMAGES ?

☐ Apply to all container images

Use a regular expression to target container images for the hook.

Container image names to match

redis

SCRIPT ?

+ Add

Search

Name ↓

☐ mariadb\_mysql.sh

☐ postgresql.sh

☒ redis\_hook.sh

EXECUTION HOOKS

Execution hooks allow Astra Control to execute your own custom scripts before or after a snapshot.

Read more in [Manage application execution hooks](#)

Cancel

Save ✓

## Replication with ACC

For regional protection or for a low RPO and RTO solution, an application can be replicated to another Kubernetes instance running at a different site, preferably in another region. ACC utilizes ONTAP async SnapMirror with RPO as low as 5 minutes. Replication is done by replicating to ONTAP and then a fail over

creates the Kubernetes resources in the destination cluster.



Note that replication is different from the backup and restore where the backup goes to S3 and restore is performed from S3. Refer [xref:./rhhc/on-premises/ here](#) to get additional details about the differences between the two types of data protection.

Refer [here](#) for SnapMirror setup instructions.

## SnapMirror with ACC



san-economy and nas-economy storage drivers do not support replication feature. Refer [here](#) for additional details.

## Demo video:

[Demonstration video of disaster recovery with Astra Control Center](#)

## Business Continuity with MetroCluster

Most of our hardware platform for ONTAP has high availability features to protect from device failures avoiding the need to perform disaster recovery. But to protect from fire or any other disaster and to continue the business with zero RPO and low RTO, often a MetroCluster solution is used.

Customers who currently have an ONTAP system can extend to MetroCluster by adding supported ONTAP systems within the distance limitations for providing zone level disaster recovery.

Astra Trident, the CSI (Container Storage Interface) supports NetApp ONTAP including MetroCluster configuration as well as other options like Cloud Volumes ONTAP, Azure NetApp Files, AWS FSx for NetApp ONTAP, etc. Astra Trident provides five storage driver options for ONTAP and all are supported for MetroCluster configuration. Refer [here](#) for additional details about ONTAP storage drivers supported by Astra Trident.

The MetroCluster solution requires layer 2 network extension or capability to access the same network address from both fault domains. Once MetroCluster configuration is in place, the solution is transparent to application owners as all the volumes in the MetroCluster svm are protected and get the benefits of SyncMirror (zero RPO).



For Trident Backend Configuration (TBC), do not specify the dataLIF and SVM when using MetroCluster configuration. Specify SVM management IP for managementLIF and use vsadmin role credentials.

Details on Astra Control Center Data Protection features are available [here](#)

## Data migration using Astra Control Center

This page shows the data migration options for container workloads on Red Hat OpenShift clusters with Astra Control Center (ACC).

Kubernetes Applications are often required to be moved from one environment to another. To migrate an application along with its persistent data, NetApp ACC can be utilized.

### Data Migration between different Kubernetes environment

ACC supports various Kubernetes flavors including Google Anthos, Red Hat OpenShift, Tanzu Kubernetes Grid, Rancher Kubernetes Engine, Upstream Kubernetes, etc. For additional details, refer [here](#).

To migrate application from one cluster to another, you can use one of the following features of ACC:

- replication
- backup and restore
- clone

Refer to the [data protection section](#) for the **replication and backup and restore** options.  
Refer [here](#) for additional details about **cloning**.



Astra Replication feature is only supported with Trident Container Storage Interface (CSI).  
However, replication is not supported by nas-economy & san-economy drivers.

## Performing data replication using ACC

The screenshot displays the Astra management console interface for configuring data replication. The left sidebar contains navigation links: Dashboard, Applications, Clusters, Cloud instances, Backends, Buckets, Account, Activity, and Support.

The main content area is titled "ghost" and shows the "APPLICATION STATUS" as "Healthy". Below this, the "Definition" is "ghost-zonea" and the "Cluster" is "ocp-cluster5". The "APPLICATION PROTECTION" section indicates "Fully protected" with three status indicators: "Protection policy configured", "Replication policy configured", and "Replication policy configured".

The "Data protection" tab is selected, showing a "Configure" button. The "Replication" sub-tab is active, displaying a "Replication relationship" summary. The summary includes:

- STATUS:** Healthy | Established
- SCHEDULE:** Replicate snapshot every 5 minutes to [ocp-cluster7](#)
- LAST SYNC:** 2023/04/26 19:16 UTC, Sync duration: 30 seconds

The diagram illustrates the replication relationship between two clusters. The "Source" cluster is "ghost" (Healthy) with "ocp-cluster5" and "ghost-zonea". The "Destination" cluster is "ghost" (Healthy) with "ocp-cluster7" and "blog-zoneb". An arrow points from the Source to the Destination, indicating the direction of replication.

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