Red Hat OpenShift Virtualization with NetApp ONTAP

NetApp Solutions

NetApp

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Red Hat OpenShift Virtualization with NetApp ONTAP

Depending on the specific use case, both containers and virtual machines (VMs) can serve as optimal platforms for different types of applications. Therefore, many organizations run some of their workloads on containers and some on VMs. Often, this leads organizations to face additional challenges by having to manage separate platforms: a hypervisor for VMs and a container orchestrator for applications.

To address this challenge, Red Hat introduced OpenShift Virtualization (formerly known as Container Native Virtualization) starting from OpenShift version 4.6. The OpenShift Virtualization feature enables you to run and manage virtual machines alongside containers on the same OpenShift Container Platform installation, providing hybrid management capability to automate deployment and management of VMs through operators. In addition to creating VMs in OpenShift, with OpenShift Virtualization, Red Hat also supports importing VMs from VMware vSphere, Red Hat Virtualization, and Red Hat OpenStack Platform deployments.

Certain features like live VM migration, VM disk cloning, VM snapshots and so on are also supported by OpenShift Virtualization with assistance from Astra Trident when backed by NetApp ONTAP. Examples of each of these workflows are discussed later in this document in their respective sections.

To learn more about Red Hat OpenShift Virtualization, see the documentation here.

Deployment for OpenShift Virtualization

Deploy Red Hat OpenShift Virtualization with NetApp ONTAP

Prerequisites

- A Red Hat OpenShift cluster (later than version 4.6) installed on bare-metal infrastructure with RHCOS worker nodes
- The OpenShift cluster must be installed via installer provisioned infrastructure (IPI)
- Deploy Machine Health Checks to maintain HA for VMs
• A NetApp ONTAP cluster
• Astra Trident installed on the OpenShift cluster
• A Trident backend configured with an SVM on ONTAP cluster
• A StorageClass configured on the OpenShift cluster with Astra Trident as the provisioner
• Cluster-admin access to Red Hat OpenShift cluster
• Admin access to NetApp ONTAP cluster
• An admin workstation with tridentctl and oc tools installed and added to $PATH

Because OpenShift Virtualization is managed by an operator installed on the OpenShift cluster, it imposes additional overhead on memory, CPU, and storage, which must be accounted for while planning the hardware requirements for the cluster. See the documentation [here](#) for more details.

Optionally, you can also specify a subset of the OpenShift cluster nodes to host the OpenShift Virtualization operators, controllers, and VMs by configuring node placement rules. To configure node placement rules for OpenShift Virtualization, follow the documentation [here](#).

For the storage backing OpenShift Virtualization, NetApp recommends having a dedicated StorageClass that requests storage from a particular Trident backend, which in turn is backed by a dedicated SVM. This maintains a level of multitenancy with regard to the data being served for VM-based workloads on the OpenShift cluster.

**Deploy Red Hat OpenShift Virtualization with NetApp ONTAP**

To install OpenShift Virtualization, complete the following steps:

1. Log into the Red Hat OpenShift bare-metal cluster with cluster-admin access.
2. Select Administrator from the Perspective drop down.
4. Select the OpenShift Virtualization tile and click Install.

**OpenShift Virtualization**

2.6.2 provided by Red Hat

![Install button]

**Requirements**

Your cluster must be installed on bare metal infrastructure with Red Hat Enterprise Linux CoreOS workers.

**Details**

OpenShift Virtualization extends Red Hat OpenShift Container Platform, allowing you to host and manage virtualized workloads on the same platform as container-based workloads. From the OpenShift Container Platform web console, you can import a VMware virtual machine from vSphere, create new or clone existing VMs, perform live migrations between nodes, and more. You can use OpenShift Virtualization to manage both Linux and Windows VMs.

The technology behind OpenShift Virtualization is developed in the KubeVirt open source community. The KubeVirt project extends Kubernetes by adding additional virtualization resource types through Custom Resource Definitions (CRDs). Administrators can use Custom Resource Definitions to manage `VirtualMachine` resources alongside all other resources that Kubernetes provides.

5. On the Install Operator screen, leave all default parameters and click Install.
6. Wait for the operator installation to complete.

OpenShift Virtualization
2.6.2 provided by Red Hat

Installing Operator

The Operator is being installed. This may take a few minutes.

View installed Operators in Namespace openshift-cnv

7. After the operator has installed, click Create HyperConverged.
8. On the Create HyperConverged screen, click Create, accepting all default parameters. This step starts the installation of OpenShift Virtualization.
9. After all the pods move to the Running state in the openshift-cnv namespace and the OpenShift Virtualization operator is in the Succeeded state, the operator is ready to use. VMs can now be created on the OpenShift cluster.

Project: openshift-cnv

Installed Operators

Installed Operators are represented by ClusterServiceVersions within this Namespace. For more information, see the Understanding Operators documentation. Or create an Operator and ClusterServiceVersion using the Operator SDK.

<table>
<thead>
<tr>
<th>Name</th>
<th>Managed Namespaces</th>
<th>Status</th>
<th>Last updated</th>
<th>Provided APIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>OpenShift Virtualization</td>
<td>openshift-cnv</td>
<td>Succeeded</td>
<td>May 18, 8:02 pm</td>
<td>OpenShift Virtualization Deployment, HostPath/Provisioner deployment</td>
</tr>
</tbody>
</table>

Workflows

**Workflows: Red Hat OpenShift Virtualization with NetApp ONTAP**

**Create VM**

VMs are stateful deployments that require volumes to host the operating system and data. With CNV, because
the VMs are run as pods, the VMs are backed by PVs hosted on NetApp ONTAP through Trident. These volumes are attached as disks and store the entire filesystem including the boot source of the VM.

To create a virtual machine on the OpenShift cluster, complete the following steps:

1. Navigate to Workloads > Virtualization > Virtual Machines and click Create > With Wizard.
2. Select the desired the operating system and click Next.
3. If the selected operating system has no boot source configured, you must configure it. For Boot Source, select whether you want to import the OS image from an URL or from a registry and provide the corresponding details. Expand Advanced and select the Trident-backed StorageClass. Then click Next.
4. If the selected operating system already has a boot source configured, the previous step can be skipped.

5. In the Review and Create pane, select the project you want to create the VM in and furnish the VM details. Make sure that the boot source is selected to be Clone and boot from CD-ROM with the appropriate PVC assigned for the selected OS.
6. If you wish to customize the virtual machine, click Customize Virtual Machine and modify the required parameters.

7. Click Create Virtual Machine to create the virtual machine; this spins up a corresponding pod in the background.

When a boot source is configured for a template or an operating system from an URL or from a registry, it creates a PVC in the openshift-virtualization-os-images project and downloads the KVM guest image to the PVC. You must make sure that template PVCs have enough provisioned space to accommodate the KVM guest image for the corresponding OS. These PVCs are then cloned and attached as rootdisks to virtual machines when they are created using the respective templates in any project.

**Workflows: Red Hat OpenShift Virtualization with NetApp ONTAP**

**VM Live Migration**

Live Migration is a process of migrating a VM instance from one node to another in an OpenShift cluster with no downtime. For live migration to work in an OpenShift cluster, VMs must be bound to PVCs with shared ReadWriteMany access mode. Astra Trident backend configured with an SVM on a NetApp ONTAP cluster that is enabled for NFS protocol supports shared ReadWriteMany access for PVCs. Therefore, the VMs with PVCs that are requested from StorageClasses provisioned by Trident from NFS-enabled SVM can be migrated with no downtime.
To create a VM bound to PVCs with shared ReadWriteMany access:

1. Navigate to Workloads > Virtualization > Virtual Machines and click Create > With Wizard.
2. Select the desired the operating system and click Next. Let us assume the selected OS already had a boot source configured with it.
3. In the Review and Create pane, select the project you want to create the VM in and furnish the VM details. Make sure that the boot source is selected to be Clone and boot from CD-ROM with the appropriate PVC assigned for the selected OS.
4. Click Customize Virtual Machine and then click Storage.
5. Click the ellipsis next to rootdisk, and make sure that the storageclass provisioned using Trident is selected. Expand Advanced and select Shared Access (RWX) for Access Mode. Then click Save.
6. Click Review and confirm and then click Create Virtual Machine.

To manually migrate a VM to another node in the OpenShift cluster, complete the following steps.

1. Navigate to Workloads > Virtualization > Virtual Machines.
2. For the VM you wish to migrate, click the ellipsis, and then click Migrate the Virtual Machine.
3. Click Migrate when the message pops up to confirm.

A VM instance in an OpenShift cluster automatically migrates to another node when the original node is placed into maintenance mode if the evictionStrategy is set to LiveMigrate.

**Workflows: Red Hat OpenShift Virtualization with NetApp ONTAP**

**VM cloning**

Cloning an existing VM in OpenShift is achieved with the support of Astra Trident’s Volume CSI cloning feature. CSI volume cloning allows for creation of a new PVC using an existing PVC as the data source by duplicating its PV. After the new PVC is created, it functions as a separate entity and without any link to or dependency on the source PVC.

There are certain restrictions with CSI volume cloning to consider:

1. Source PVC and destination PVC must be in the same project.
2. Cloning is supported within the same storage class.
3. Cloning can be performed only when source and destination volumes use the same VolumeMode setting; for example, a block volume can only be cloned to another block volume.
VMs in an OpenShift cluster can be cloned in two ways:

1. By shutting down the source VM
2. By keeping the source VM live

**By Shutting down the source VM**

Cloning an existing VM by shutting down the VM is a native OpenShift feature that is implemented with support from Astra Trident. Complete the following steps to clone a VM.

1. Navigate to Workloads > Virtualization > Virtual Machines and click the ellipsis next to the virtual machine you wish to clone.
2. Click Clone Virtual Machine and provide the details for the new VM.
3. Click Clone Virtual Machine; this shuts down the source VM and initiates the creation of the clone VM.
4. After this step is completed, you can access and verify the content of the cloned VM.
By keeping the source VM live

An existing VM can also be cloned by cloning the existing PVC of the source VM and then creating a new VM using the cloned PVC. This method does not require you to shut down the source VM. Complete the following steps to clone a VM without shutting it down.

1. Navigate to Storage > PersistentVolumeClaims and click the ellipsis next to the PVC that is attached to the source VM.
2. Click Clone PVC and furnish the details for the new PVC.

3. Then click Clone. This creates a PVC for the new VM.
4. Navigate to Workloads > Virtualization > Virtual Machines and click Create > With YAML.
5. In the spec > template > spec > volumes section, attach the cloned PVC instead of the container disk. Provide all other details for the new VM according to your requirements.
6. Click Create to create the new VM.

7. After the VM is created successfully, access and verify that the new VM is a clone of the source VM.

**Workflows: Red Hat OpenShift Virtualization with NetApp ONTAP**

**Create VM from a Snapshot**

With Astra Trident and Red Hat OpenShift, users can take a snapshot of a persistent volume on Storage Classes provisioned by it. With this feature, users can take a point-in-time copy of a volume and use it to create a new volume or restore the same volume back to a previous state. This enables or supports a variety of use-cases, from rollback to clones to data restore.

For Snapshot operations in OpenShift, the resources VolumeSnapshotClass, VolumeSnapshot, and VolumeSnapshotContent must be defined.

- A VolumeSnapshotContent is the actual snapshot taken from a volume in the cluster. It is cluster-wide resource analogous to PersistentVolume for storage.
- A VolumeSnapshot is a request for creating the snapshot of a volume. It is analogous to a PersistentVolumeClaim.
- VolumeSnapshotClass lets the administrator specify different attributes for a VolumeSnapshot. It allows you to have different attributes for different snapshots taken from the same volume.
To create Snapshot of a VM, complete the following steps:

1. Create a VolumeSnapshotClass that can then be used to create a VolumeSnapshot. Navigate to Storage > VolumeSnapshotClasses and click Create VolumeSnapshotClass.

2. Enter the name of the Snapshot Class, enter csi.trident.netapp.io for the driver, and click Create.
3. Identify the PVC that is attached to the source VM and then create a Snapshot of that PVC. Navigate to Storage > VolumeSnapshots and click Create VolumeSnapshots.

4. Select the PVC that you want to create the Snapshot for, enter the name of the Snapshot or accept the default, and select the appropriate VolumeSnapshotClass. Then click Create.

Create VolumeSnapshot

PersistentVolumeClaim *

PVC **rhel8-short-frog-rootdisk-28dvb**

Name *

**rhel8-short-frog-rootdisk-28dvb-snapshot**

Snapshot Class *

VSC **trident-snapshot-class**

5. This creates the snapshot of the PVC at that point in time.
Create a new VM from the snapshot

1. First, restore the Snapshot into a new PVC. Navigate to Storage > VolumeSnapshots, click the ellipsis next to the Snapshot that you wish to restore, and click Restore as new PVC.

2. Enter the details of the new PVC and click Restore. This creates a new PVC.

3. Next, create a new VM from this PVC. Navigate to Workloads > Virtualization > Virtual Machines and click Create > With YAML.

4. In the spec > template > spec > volumes section, specify the new PVC created from Snapshot instead of

---

**Restore as new PVC**

When restore action for snapshot `rhel8-short-frog-rootdisk-28dub-snapshot` is finished a new crash-consistent PVC copy will be created.

Name *

```plaintext
rhel8-short-frog-rootdisk-28dub-snapshot-restore
```

Storage Class *

- SC basic

Access Mode *

- Single User (RWO)
- Shared Access (RWX)
- Read Only (ROX)

Size *

<table>
<thead>
<tr>
<th>Size</th>
<th>GiB</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

VolumeSnapshot details

- Created at: May 21, 12:46 am
- Namespace: default
- Status: Ready
- API version: snapshot.storage.k8s.io/v1
- Size: 20 GiB
from the container disk. Provide all other details for the new VM according to your requirements.

```yaml
- name: rootdisk
  persistentVolumeClaim:
    claimName: rhel8-short-frog-rootdisk-28dvc-snapshot-restore
```

5. Click Create to create the new VM.

6. After the VM is created successfully, access and verify that the new VM has the same state as that of the VM whose PVC was used to create the snapshot at the time when the snapshot was created.

**Workflows: Red Hat OpenShift Virtualization with NetApp ONTAP**

**Migration of VM from VMware to OpenShift Virtualization using Migration Toolkit for Virtualization**

In this section, we will see how to use the Migration Toolkit for Virtualization (MTV) to migrate virtual machines from VMware to OpenShift Virtualization running on OpenShift Container platform and integrated with NetApp ONTAP storage using Astra Trident.

The following video shows a demonstration of the migration of a RHEL VM from VMware to OpenShift Virtualization using ontap-san for persistent storage.

**Using Red Hat MTV to migrate VMs to OpenShift Virtualization with NetApp ONTAP Storage**

The following diagram shows a high level view of the migration of a VM from VMware to Red Hat OpenShift Virtualization.

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**Migration of VM from VMware to OpenShift Virtualization**

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**Prerequisites for the sample migration**
On VMware

- A RHEL 9 VM using rhel 9.3 with the following configurations were installed:
  - CPU: 2, Memory: 20 GB, Hard disk: 20 GB
  - user credentials: root user and an admin user credentials
- After the VM was ready, postgresql server was installed.
  - postgresql server was started and enabled to start on boot

```
systemctl start postgresql.service
systemctl enable postgresql.service
The above command ensures that the server can start in the VM in
OpenShift Virtualization after migration
```

- Added 2 databases, 1 table and 1 row in the table were added. Refer here for the instructions for
  installing postgresql server on RHEL and creating database and table entries.

**i** Ensure that you start the postgresql server and enable the service to start at boot.

On OpenShift Cluster

The following installations were completed before installing MTV:

- OpenShift Cluster 4.13.34
- Astra Trident 23.10
- Multipath on the cluster nodes enabled for iSCSI (for ontap-san storage class). See the provided yaml to
  create a daemon set that enables iSCSI on each node in the cluster.
- Trident backend and Storage class for ontap SAN using iSCSI. See the provided yaml files for trident
  backend and storage class.
- OpenShift Virtualization

To install iscsi and multipath on the OpenShift Cluster nodes use the yaml file given below

**Preparing the cluster nodes for iSCSI**

```yaml
apiVersion: apps/v1
kind: DaemonSet
metadata:
  namespace: trident
  name: trident-iscsi-init
labels:
  name: trident-iscsi-init
spec:
  selector:
    matchLabels:
      name: trident-iscsi-init
template:
```
Use the following yaml file to create trident backend configuration for using ontap san storage

Trident backend for iSCSI

```yaml
metadata:
  labels:
    name: trident-iscsi-init
spec:
  hostNetwork: true
  serviceAccount: trident-node-linux
  initContainers:
  - name: init-node
    command:
      - nsenter
      - --mount=/proc/1/ns/mnt
      - --
      - sh
      - -c
    args: ["${STARTUP_SCRIPT}" ]
  image: alpine:3.7
  env:
  - name: STARTUP_SCRIPT
    value: |
      #!/bin/bash
      sudo yum install -y lsscsi iscsi-initiator-utils sg3_utils
      device-mapper-multipath
      rpm -q iscsi-initiator-utils
      sudo sed -i 's/\(^\(node\.session\.scan\)\).*/\1 = manual/'
      /etc/iscsi/iscsid.conf
      cat /etc/iscsi/initiatorname.iscsi
      sudo mpathconf --enable --with_multipathd y --find_multipaths
      n
      sudo systemctl enable --now iscsid multipathd
      sudo systemctl enable --now iscsi
  securityContext:
    privileged: true
  hostPID: true
  containers:
  - name: wait
    image: k8s.gcr.io/pause:3.1
  hostPID: true
  hostNetwork: true
  tolerations:
  - effect: NoSchedule
    key: node-role.kubernetes.io/master
  updateStrategy:
    type: RollingUpdate
```
Use the following yaml file to create trident storage class configuration for using ontap san storage

**Trident storage class for iSCSI**

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

**Install MTV**

Now you can install the Migration Toolkit for virtualization (MTV). Refer to the instructions provided here for help with the installation.

The Migration Toolkit for Virtualization (MTV) user interface is integrated into the OpenShift web console. You can refer here to start using the user interface for various tasks.
Create Source Provider

In order to migrate the RHEL VM from VMware to OpenShift Virtualization, you need to first create the source provider for VMware. Refer to the instructions here to create the source provider.

You need the following to create your VMware source provider:

- VCenter url
- VCenter Credentials
- VCenter server thumbprint
- VDDK image in a repository

Sample source provider creation:
The Migration Toolkit for Virtualization (MTV) uses the VMware Virtual Disk Development Kit (VDDK) SDK to accelerate transferring virtual disks from VMware vSphere. Therefore, creating a VDDK image, although optional, is highly recommended. To make use of this feature, you download the VMware Virtual Disk Development Kit (VDDK), build a VDDK image, and push the VDDK image to your image registry.

Follow the instructions provided here to create and push the VDDK image to a registry accessible from the OpenShift Cluster.

Create Destination provider

The host cluster is automatically added as the OpenShift virtualization provider is the source provider.

Create Migration Plan

Follow the instructions provided here to create a migration plan.

While creating a plan, you need to create the following if not already created:

- A network mapping to map the source network to the target network.
- A storage mapping to map the source datastore to the target storage class. For this you can choose ontap-san storage class.

Once the migration plan is created, the status of the plan should show **Ready** and you should now be able to Start the plan.

Clicking on **Start** will run through a sequence of steps to complete the migration of the VM.
When all steps are completed, you can see the migrated VMs by clicking on the virtual machines under Virtualization in the left-side navigation menu.

Instructions to access the virtual machines are provided here.

You can log into the virtual machine and verify the contents of the postgresql databases. The databases, tables and the entries in the table should be the same as what was created on the source VM.