NetApp

Virtual Volumes (vVols) with ONTAP tools 10

Enterprise applications

NetApp
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Virtual Volumes (vVols) with ONTAP tools 10

Overview

ONTAP has been a leading storage solution for VMware vSphere environments for over two decades and continues to add innovative capabilities to simplify management while reducing costs.

This document covers ONTAP capabilities for VMware vSphere Virtual Volumes (vVols), including the latest product information and use cases along with best practices and other information to streamline deployment and reduce errors.

> ⓘ   This documentation replaces previously published technical reports *TR-4400: VMware vSphere Virtual Volumes (vVols) with ONTAP*

Best practices supplement other documents such as guides and compatibility lists. They are developed based on lab testing and extensive field experience by NetApp engineers and customers. They might not be the only practices that work or are supported but are generally the simplest solutions that meet the needs of most customers.

> ⓘ   This document has been updated to include new vVols features found in vSphere 8.0 update 3, the ONTAP tools 10.4 release, and new NetApp ASA systems.

Virtual Volumes (vVols) overview

NetApp began working with VMware to support vSphere APIs for Storage Awareness (VASA) for vSphere 5 in 2012. This early VASA Provider allowed for the definition of storage capabilities in a profile that could be used to filter datastores when provisioning and for checking compliance with the policy afterwards. Over time this evolved to add new capabilities to enable more automation in provisioning, as well as adding Virtual Volumes or vVols, where individual storage objects are used for virtual machine files and virtual disks. These objects could be LUNs, files, and now with vSphere 8 - NVMe namespaces (used with ONTAP tools 9.13P2). NetApp worked closely with VMware as a reference partner for vVols released with vSphere 6 in 2015, and again as a design partner for vVols using NVMe over fabrics in vSphere 8. NetApp continues to enhance vVols to take advantage of the latest capabilities in ONTAP.

There are several components to be aware of:

VASA Provider

This is the software component that handles communication between VMware vSphere and the storage system. For ONTAP, the VASA Provider runs in an appliance known as ONTAP tools for VMware vSphere (ONTAP tools for short). ONTAP tools also includes a vCenter plugin, a storage replication adapter (SRA) for VMware Site Recovery Manager, and REST API server for building your own automation. Once ONTAP tools is configured and registered with vCenter, there is little need to directly interact with the ONTAP system anymore, since nearly all of your storage needs can be managed from directly within the vCenter UI, or through REST API automation.

Protocol Endpoint (PE)

The protocol endpoint is a proxy for I/O between the ESXi hosts and the vVols datastore. The ONTAP VASA Provider creates these automatically, either one protocol endpoint LUN (4MB in size) per FlexVol volume of the

vVols datastore, or one NFS mount point per NFS interface (LIF) on the storage node hosting a FlexVol volume in the datastore. The ESXi host mounts these protocol endpoints directly rather than individual vVol LUNs and virtual disk files. There is no need to manage the protocol endpoints as they are created, mounted, unmounted, and deleted automatically by the VASA Provider, along with any necessary interface groups or export policies.

Virtual Protocol Endpoint (vPE)

New in vSphere 8, when using NVMe over Fabrics (NVMe-oF) with vVols, the concept of a protocol endpoint is no longer relevant in ONTAP. Instead, a virtual PE is instantiated automatically by the ESXi host for each ANA group as soon as the first VM is powered on. ONTAP automatically creates ANA groups for each FlexVol volume used by the datastore.

An additional advantage to using NVMe-oF for vVols is that there are no bind requests required of the VASA Provider. Instead, the ESXi host handles vVol binding functionality internally based on the vPE. This reduces the opportunity for a vVol bind storm to impact service.

For more information, see NVMe and Virtual Volumes on VMware.com

Virtual Volume datastore

| The Virtual Volume datastore is a logical datastore representation of a vVols container, which is created and maintained by a VASA Provider. The container represents a pool of storage capacity provisioned from storage systems managed by the VASA Provider. ONTAP tools supports allocating multiple FlexVol volumes (referred to as backing volumes) to a single vVols datastore, and these vVols datastores can span multiple nodes in an ONTAP cluster, combining flash and hybrid systems with different capabilities. The administrator may create new FlexVol volumes using the provisioning wizard or REST API, or select pre-created FlexVol volumes for backing storage if they are available.

Virtual Volumes (vVols)

vVols are the actual virtual machine files and disks stored in the vVols datastore. Using the term vVol (singular) refers to a single specific file, LUN, or namespace. ONTAP creates NVMe namespaces, LUNs, or files depending on what protocol the datastore uses. There are several distinct types of vVols; the most common are Config (the only one with VMFS on it, it contains metadata files like the VM's VMX file), Data (virtual disk or VMDK), and Swap (created when VM is powered on). vVols protected by VMware VM encryption will be of type Other. VMware VM encryption should not be confused with ONTAP volume or aggregate encryption.

Policy-based management

VMware vSphere APIs for Storage Awareness (VASA) make it easy for a VM administrator to use whatever storage capabilities are needed to provision VMs without having to interact with their storage team. Before VASA, VM administrators could define VM storage policies, but had to work with their storage administrators to identify appropriate datastores, often by using documentation or naming conventions. With VASA, vCenter administrators with the appropriate permissions can define a range of storage capabilities that vCenter users can then use to provision VMs. The mapping between VM storage policy and datastore capabilities allows vCenter to display a list of compatible datastores for selection, as well as enabling other technologies like VCF (formerly known as Aria and vRealize) Automation or VMware vSphere Kubernetes Service (VKS) to automatically select storage from an assigned policy. This approach is known as storage policy-based management. While VASA Provider rules and VM storage policies may also be used with traditional datastores, our focus here is on vVols datastores.

VM Storage Policies

VM Storage Policies are created in vCenter under Policies and Profiles. For vVols, create a ruleset using rules

from the NetApp vVols storage type provider. ONTAP tools 10.X now provides a simpler approach than ONTAP tools 9.X by allowing you to directly specify storage attributes in the VM storage policy itself.

As mentioned above, using policies can help streamline the task of provisioning a VM or VMDK. Simply select an appropriate policy, and the VASA Provider will show vVols datastores that support that policy and place the vVol into an individual FlexVol volume that is compliant.

Deploy VM using Storage Policy

New Virtual Machine   ×

✔ 1 Select a creation type	**Select storage**	
✔ 2 Select a name and folder	Select the storage for the configuration and disk files	
✔ 3 Select a compute resource		
4 Select storage	☐ Encrypt this virtual machine (Requires Key Management Server)	
5 Select compatibility	**VM Storage Policy** Platinum ⌄	
6 Select a guest OS	☐ Disable Storage DRS for this virtual machine	
7 Customize hardware		
8 Ready to complete		

Name ▼	Storage Compatibility ▼	Capacity ▼	Provisioned ▼	Free ▼	Type ▼	Clu
🔘 ▤ vVolsiSCSI	Compatible	100 GB	40.74 GB	64.88 GB	vVol	
○ ▤ vVolsNFS2202...	Compatible	2 TB	36.88 GB	1.96 TB	vVol	
○ ▤ local-esx01	Incompatible	3.63 TB	1.46 GB	3.63 TB	VMFS 6	
○ ▤ local-esx07	Incompatible	1.81 TB	3.85 GB	1.81 TB	VMFS 6	
○ ▤ local-esx08	Incompatible	1.69 TB	1.43 GB	1.69 TB	VMFS 6	
○ ▤ local-esx09	Incompatible	1.81 TB	3.85 GB	1.81 TB	VMFS 6	
○ ▤ local-esx15	Incompatible	3.63 TB	1.46 GB	3.63 TB	VMFS 6	
○ ▤ tier001_ds	Incompatible	22 TB	23.73 TB	18.09 TB	NFS v3	

CANCEL   BACK   NEXT

Once a VM is provisioned, the VASA Provider will continue to check compliance and alert the VM administrator with an alarm in vCenter when the backing volume is no longer compliant with the policy.

VM Storage Policy Compliance

Storage Policies

VM Storage Policies

AFF_VASA10

VM Storage Policy Compliance

⊗ Noncompliant

Last Checked Date

5/20/2022, 12:59:35 PM

VM Replication Groups

CHECK COMPLIANCE

NetApp vVols support

ONTAP has supported the VASA specification since its initial release in 2012. While other NetApp storage systems may support VASA, this document focuses on the currently supported releases of ONTAP 9.

ONTAP

In addition to ONTAP 9 on AFF, ASA, and FAS systems, NetApp supports VMware workloads on ONTAP Select, Amazon FSx for NetApp with VMware Cloud on AWS, Azure NetApp Files with Azure VMware Solution, Google Cloud NetApp Volumes with Google Cloud VMware Engine, and NetApp Private Storage in Equinix, but specific functionality may vary based on service provider and available network connectivity.

At the time of publication, hyperscaler environments are limited to traditional NFS v3 datastores only; therefore, vVols are only available with on-premises ONTAP systems, or cloud-connected systems that offer the full functionality of an on-premises system, such as those hosted by NetApp partners and service providers around the world.

For more information about ONTAP, see ONTAP product documentation

For more information about ONTAP and VMware vSphere best practices, see TR-4597

Benefits of using vVols with ONTAP

When VMware introduced vVols support with VASA 2.0 in 2015, they described it as "an integration and management framework delivering a new operational model for external storage (SAN/NAS)." This operational model offers several benefits together with ONTAP storage.

Policy-based management

As covered in section 1.2, policy-based management allows VMs to be provisioned and subsequently managed using pre-defined policies. This can help IT operations in several ways:

- **Increase velocity.** ONTAP tools eliminates the requirement for the vCenter administrator to open tickets with the storage team for storage provisioning activities. However, ONTAP tools RBAC roles in vCenter and on the ONTAP system still allow for independent teams (such as storage teams) or independent activities by the same team, by restricting access to specific functions if desired.

- **Smarter provisioning.** Storage system capabilities can be exposed through the VASA APIs, allowing provisioning workflows to take advantage of advanced capabilities without the VM administrator needing to understand how to manage the storage system.

- **Faster provisioning.** Different storage capabilities can be supported in a single datastore and automatically selected as appropriate for a VM based on the VM policy.

- **Avoid mistakes.** Storage and VM policies are developed in advance and applied as needed without having to customize storage each time a VM is provisioned. Compliance alarms are raised when storage capabilities drift from the defined policies. As previously mentioned, SCPs make the initial provisioning predictable and repeatable, while basing VM storage policies on the SCPs guarantees accurate placement.

- **Better capacity management.** VASA and ONTAP tools make it possible to view storage capacity down to the individual aggregate level if needed and provide multiple layers of alerting in the event capacity starts to run low.

VM granular management on the modern SAN

SAN storage systems using Fibre Channel and iSCSI were the first to be supported by VMware for ESX, but they have lacked the ability to manage individual VM files and disks from the storage system. Instead, LUNs are provisioned, and VMFS manages the individual files. This makes it difficult for the storage system to directly manage individual VM storage performance, cloning, and protection. vVols bring storage granularity that customers using NFS storage already enjoy, with the robust, high-performance SAN capabilities of ONTAP.

Now, with vSphere 8 and ONTAP tools for VMware vSphere 9.12 and later, those same granular controls used by vVols for legacy SCSI-based protocols are now available in the modern Fibre Channel SAN using NVMe over Fabrics for even greater performance at scale. With vSphere 8.0 update 1, it is now possible to deploy a complete end-to-end NVMe solution using vVols without any I/O translation in the hypervisor storage stack.

Greater storage offload capabilities

While VAAI offers a variety of operations that are offloaded to storage, there are some gaps that are addressed by the VASA Provider. SAN VAAI is not able to offload VMware-managed snapshots to the storage system. NFS VAAI can offload VM-managed snapshots, but there are limitations placed on a VM with storage native snapshots. Since vVols use individual LUNs, namespaces, or files for virtual machine disks, ONTAP can quickly and efficiently clone the files or LUNs to create VM-granular snapshots that no longer require delta files. NFS VAAI also does not support offloading clone operations for hot (powered-on) Storage vMotion migrations. The VM must be powered off to allow offloading of the migration when using VAAI with traditional NFS datastores. The VASA Provider in ONTAP tools allows for near instant, storage-efficient clones for hot and cold migrations, and it also supports near instant copies for cross-volume migrations of vVols. Because of these significant storage efficiency benefits, you may be able to take full advantage of vVols workloads under the Efficiency Guarantee program. Likewise, if cross-volume clones using VAAI don't meet your requirements, you will likely be able to solve your business challenge thanks to the improvements in the copy experience with vVols.

Common use cases for vVols

In addition to these benefits, we also see these common use cases for vVol storage:

- **On-Demand provisioning of VMs**
  - Private cloud or service provider IaaS.
  - Leverage automation and orchestration via the Aria (formerly vRealize) suite, OpenStack, and so on.
- **First Class Disks (FCDs)**
  - VMware vSphere Kubernetes Service (VKS) persistent volumes.
  - Provide Amazon EBS-like services through independent VMDK lifecycle management.
- **On-Demand Provisioning of Temporary VMs**
  - Test/dev labs
  - Training environments

Common benefits with vVols

When used to their full advantage, such as in the above use cases, vVols provide the following specific improvements:

- Clones are quickly created within a single volume, or across multiple volumes in an ONTAP cluster, which is an advantage when compared to traditional VAAI-enabled clones. They are also storage-efficient. Clones within a volume use ONTAP file clone, which are like FlexClone volumes and only store changes from the source vVol file/LUN/namespace. So long-term VMs for production or other application purposes are created quickly, take minimal space, and can benefit from VM-level protection (using NetApp SnapCenter plugin for VMware vSphere, VMware managed snapshots, or VADP backup) and performance management (with ONTAP QoS). Cross-volume clones are much faster with vVols than with VAAI because with VASA, we can create the clone and allow access to it at the destination before the copy is complete. Data blocks are copied as a background process to populate the destination vVol. This is similar to the way that ONTAP non-disruptive LUN move works for traditional LUNs.
- vVols are the ideal storage technology when using TKG with the vSphere CSI, providing discrete storage classes and capacities managed by the vCenter administrator.
- Amazon EBS-like services can be delivered through FCDs because an FCD VMDK, as the name suggests, is a first-class citizen in vSphere and has a lifecycle that can be independently managed ,separate from VMs that it might be attached to.

Checklist

Use this installation checklist to ensure a successful deployment (updated for 10.3 and later).

1 **Initial planning**

☐ Before beginning your installation, you should check the Interoperability Matrix Tool (IMT) to ensure your deployment has been certified.

☐ Determine what size and type of ONTAP tools configuration your environment requires. Refer to the Configuration limits to deploy ONTAP tools for VMware vSphere for more information.

☐ Determine if you will be using multitenant SVMs or allow full cluster access. If using multitenant SVMs, you

will need to have an SVM management LIF on each SVM to be used. This LIF must be reachable over port 443 by ONTAP tools.

☐ Determine if you will be using Fibre Channel (FC) for storage connectivity. If so, you must configure zoning on your FC switches to enable connectivity between the ESXi hosts and the SVM's FC LIFs.

☐ Determine if you will be using the ONTAP tools Storage Replication Adapter (SRA) for VMware Site Recovery Manager (SRM) or Live Site Recovery (VLSR). If so, you will need to access to the SRM/VLSR server management interface to install the SRA.

☐ If you will be using SnapMirror replication managed by ONTAP tools (including, but not limited to, SnapMirror active sync) then your ONTAP administrator must create a cluster peer relationship in ONTAP and create an intercluster SVM peer relationship in ONTAP before you can use ONTAP tools with SnapMirror.

☐ Download the ONTAP tools OVA, and if required, the SRA tar.gz file.

② Provision IP Addresses and DNS records

Request the following IP information from your network team. The first three IP addresses are required; node two and node three are used for scale-out high availability (HA) deployments. DNS host records are required and all node names and all addresses should be on the same VLAN and subnet.

☐ ONTAP tools application address _____ . _____ . _____ . _____

☐ Internal Services address _____ . _____ . _____ . _____

☐ Node one's DNS hostname _____

☐ Node one's IP address _____ . _____ . _____ . _____

☐ Subnet mask _____ . _____ . _____ . _____

☐ Default gateway _____ . _____ . _____ . _____

☐ DNS server 1 _____ . _____ . _____ . _____

☐ DNS server 2 _____ . _____ . _____ . _____

☐ DNS search domain _____

☐ Node two's DNS hostname(optional) _____

☐ Node two's IP address(optional) _____ . _____ . _____ . _____

☐ Node three's DNS hostname(optional) _____

☐ Node three's IP address(optional) _____ . _____ . _____ . _____

☐ Create DNS records for all IP addresses above.

③ Network firewall configuration

☐ Open the required ports for the above IP addresses in your network firewall. Refer to Port requirements for the latest update.

④ Storage

A datastore on a shared storage device is required. Optionally, you may use a content library on the same datastore as node one to facilitate quick cloning of the template with VAAI.

☐ Content library (only required for HA) _____

☐ Node one datastore _____

☐ Node two datastore (optional, but recommended for HA)
_____

☐ Node three datastore (optional, but recommended for HA)
_____

5 **Deploy the OVA**

Note that this step may take up to 45 minutes to complete

☐ Deploy the OVA using the vSphere client.

On step 3 of OVA deployment, select the option to "customize this virtual machine's hardware" and set the following on step 10:

☐ "Enable CPU Hot Add"

☐ "Memory Hot Plug"

6 **Add vCenters to ONTAP tools**

☐ Add vCenter Server instances in ONTAP tools manager.

7 **Add storage backends to ONTAP tools**

☐ Configure ONTAP user roles and privileges using the included JSON file if not using admin.

If you intend to assign specific SVMs to vCenters using storage multitenancy rather than using ONTAP cluster credentials in vCenter, please follow these steps:

☐ onboard clusters in ONTAP tools manager and associate them with vCenters.

☐ onboard SVMs in ONTAP tools vCenter UI.

If **not** using multitenant SVMs within vCenter:

☐ onboard clusters directly in ONTAP tools vCenter UI. Alternatively, in this scenario, it is possible to add SVMs directly when not utilizing vVols.

8 **Configure appliance services (optional)**

☐ To use vVols, you must first edit the appliance settings and enable the VASA service. At the same time, review the following two items.

☐ If you plan on using vVols in production, enable high availability with the two optional IP addresses above.

☐ If you plan on using the ONTAP tools Storage Replication Adapter (SRA) for VMware Site Recovery Manager or Live Site Recovery, enable the SRA services.

9 **Certificates (optional)**

Per VMware, CA signed certificates are required if using vVols with multiple vCenters.

☐ VASA services _____

☐ Administrative services _____

10   **Other post deployment tasks**

☐ Create anti-affinity rules for VMs in an HA deployment.

☐ If using HA, storage vMotion nodes two and three to separate datastores (optional, but recommended).

☐ use manage certificates in the ONTAP tools manager to install any required CA signed certificates.

☐ If you enabled SRA for SRM/VLSR to protect traditional datastores, configure SRA on VMware Live Site Recovery appliance.

☐ Configure native backups for Near zero-RPO.

☐ Configure regular backups to other storage media.

Using vVols with ONTAP

The key to using vVols with NetApp is ONTAP tools for VMware vSphere, which servers as the VASA (vSphere API for Storage Awareness) Provider interface for NetApp's ONTAP 9 systems.

ONTAP tools also includes vCenter UI extensions, REST API services, Storage Replication Adapters for VMware Site Recovery Manager / Live Site Recovery, monitoring and host configuration tools, and an array of reports which help you better manage your VMware environment.

Products and Documentation

The ONTAP One license includes all necessary licensing to use vVols with ONTAP systems. The only additional requirement is the free ONTAP tools OVA, which acts as the VASA Provider. In a vVols environment, the VASA Provider software translates array capabilities into policy-driven attributes that can be leveraged through the VASA APIs without the vSphere administrator needing to know how the capabilities are managed behind the scenes. This allows for dynamic consumption of allocated storage capacity based on policy, eliminating the need to manually create traditional datastores and manage their individual storage consumption rates. In short, vVols take all of the complexity of managing enterprise storage and abstracts it away from the vSphere admin so they can focus on the virtualization layer.

For customers using VMware Cloud Foundation with vSAN, vVols can be added to any management or workload domain as supplemental storage. vVols seamlessly integrates with vSAN through a common storage policy-based management framework.

The next generation ONTAP tools 10 release family modernizes previous capabilities with a scalable, containerized, microservice-based architecture that's deployable through a simple OVA format appliance on ESXi. ONTAP tools 10 combines all of the functionalities of three former appliances and products into a single deployment. For vVols management, you will use the intuitive vCenter UI extensions or REST APIs for the ONTAP tools VASA Provider. Note that the SRA component is for traditional datastores; VMware Site Recovery Manager does not use SRA for vVols.

ONTAP tools VASA Provider architecture when using iSCSI or FCP with unified systems
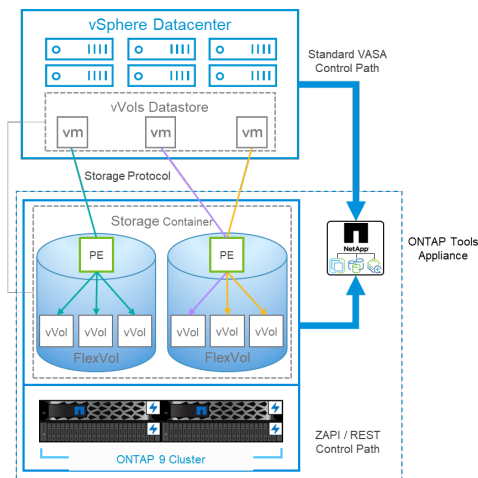
Product Installation

For new installations, deploy the virtual appliance into your vSphere environment. Once it is deployed, you can log into the manager UI or use the REST APIs to scale up or scale out your deployment, onboard vCenters (this registers the plugin with the vCenter), onboard storage systems, and associate storage systems with your vCenters. Onboarding storage systems in the ONTAP tools manager UI and associating clusters with vCenters is only required if you plan on use secure multitenancy with dedicated SVMs, otherwise you can simply onboard the desired storage cluster(s) in the ONTAP tools vCenter UI extensions, or by using the REST APIs.

Refer to Deploying vVols Storage in this document, or ONTAP tools for VMware vSphere documentation.

> 💡 The best practice is to store your ONTAP tools and vCenter appliances on traditional NFS or VMFS datastores to avoid any interdependency conflict. Because both vCenter and ONTAP tools are must communicate with each other during vVols operations, do not install or move the ONTAP tools appliances or vCenter Server appliances (VCSA) to vVols storage that they are managing. If this happens, rebooting the vCenter or ONTAP tools appliances can result in an interruption of control plane access and an inability of the appliance to boot.

In-place upgrades of ONTAP tools are supported by using the upgrade ISO file available for download at ONTAP tools for VMware vSphere 10 - Downloads on the NetApp Support Site (login required). Follow the Upgrade from ONTAP tools for VMware vSphere 10.x to 10.3 guide instructions to upgrade the appliance. It is also possible to do a side-by-side upgrade from ONTAP tools 9.13 to 10.3. Refer to Migrate from ONTAP tools for VMware vSphere 9.x to 10.3 for a deeper dive on that subject.

For sizing your virtual appliance, and understanding the configuration limits, refer to Configuration limits to deploy ONTAP tools for VMware vSphere

Product Documentation

The following documentation is available to help you deploy ONTAP tools.

ONTAP tools for VMware vSphere documentation

Get started

- Release notes
- ONTAP tools for VMware vSphere overview
- Deploy ONTAP tools

- Upgrade ONTAP tools

Use ONTAP tools

- Provision datastores
- Configure role-based access control
- Configure high availability
- Modify ESXi host settings

Protect and manage datastores

- Configure vSphere Metro Storage Cluster (vMSC) using ONTAP tools and SnapMirror active sync
- Protect virtual machines with SRM
- Monitor clusters, datastores and virtual machines

VASA Provider Dashboard

The VASA Provider includes a dashboard with performance and capacity information for individual vVols VMs. This information comes directly from ONTAP for the vVol files and LUNs, including latency, IOPS, throughput, and more. It is enabled by default when using all currently supported versions of ONTAP 9. Note that after initial configuration it can take up to 30 minutes for data to populate the dashboard.

Other Best Practices

Using ONTAP vVols with vSphere is simple and follows published vSphere methods (see Working with Virtual Volumes under vSphere Storage in VMware documentation for your version of ESXi). Here are a few additional practices to consider in conjunction with ONTAP.

Limits

In general, ONTAP supports vVols limits as defined by VMware (see published Configuration Maximums). Always check the NetApp Hardware Universe for updated limits on numbers and sizes of LUNs, namespaces, and files.

Use ONTAP tools for VMware vSphere's UI extensions or REST APIs to provision vVols datastores and Protocol Endpoints.

While it's possible to create vVols datastores with the general vSphere interface, using ONTAP tools will automatically create protocol endpoints as needed, and creates FlexVol volumes (not required with ASA r2) using ONTAP best practices. Simply right-click on the host/cluster/datacenter, then select *ONTAP tools* and *Provision datastore*. From there simply choose the desired vVols options in the wizard.

Never store the ONTAP tools appliance or vCenter Server Appliance (VCSA) on a vVols datastore that they are managing.

This can result in a "chicken and egg situation" if you need to reboot the appliances because they won't be able to rebind their own vVols while they are rebooting. You may store them on a vVols datastore managed by a different ONTAP tools and vCenter deployment.

**Avoid vVols operations across different ONTAP releases.**

Supported storage capabilities such as QoS, personality and more have changed in various releases of the VASA Provider, and some are dependent on ONTAP release. Using different releases in an ONTAP cluster or

moving vVols between clusters with different releases can result in unexpected behavior or compliance alarms.

Zone your Fibre Channel fabric before using FCP for vVols.

The ONTAP tools VASA provider takes care of managing FCP and iSCSI igroups as well as NVMe subsystems in ONTAP based on discovered initiators of managed ESXi hosts. However, it does not integrate with Fibre Channel switches to manage zoning. Zoning must be done according to best practices before any provisioning can take place. The following is an example of single initiator zoning to four ONTAP systems:

Single initiator zoning:
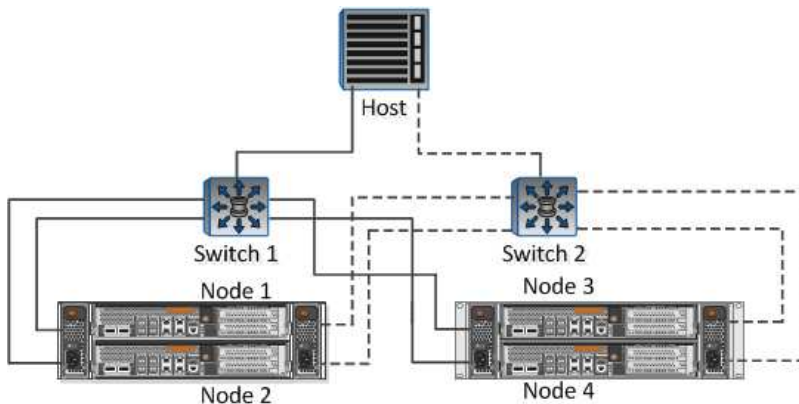
Refer to the following documents for more best practices:

[TR-4080 Best practices for modern SAN ONTAP 9](#)

[TR-4684 Implementing and configuring modern SANs with NVMe-oF](#)

Plan your backing FlexVol volumes according to your needs.

For non-ASA r2 systems, it can be desirable to add several backing volumes to your vVols datastore to distribute workload across the ONTAP cluster, to support different policy options, or to increase the number of allowed LUNs or files. However, if maximum storage efficiency is required, then place all your backing volumes on a single aggregate. Or if maximum cloning performance is required, then consider using a single FlexVol volume and keeping your templates or content library in the same volume. The VASA Provider offloads many vVols storage operations to ONTAP, including migration, cloning and snapshots. When this is done within a single FlexVol volume, space efficient file clones are used and are almost instantly available. When this is done across FlexVol volumes, the copies are quickly available and use inline deduplication and compression, but maximum storage efficiency may not be recovered until background jobs run on volumes using background deduplication and compression. Depending on the source and destination, some efficiency may be degraded.

With ASA r2 systems, this complexity is removed as the concept of a volume or aggregate is abstracted away from the user. Dynamic placement is handled automatically and protocol endpoints are created as needed. Additional protocol endpoints may be automatically created on the-fly if additional scale is needed.

Consider using Max IOPS to control unknown or test VMs.

First available in VASA Provider 7.1, Max IOPS can be used to limit IOPS to a specific vVol for an unknown workload to avoid impact on other, more critical workloads. See Table 4 for more on performance management.
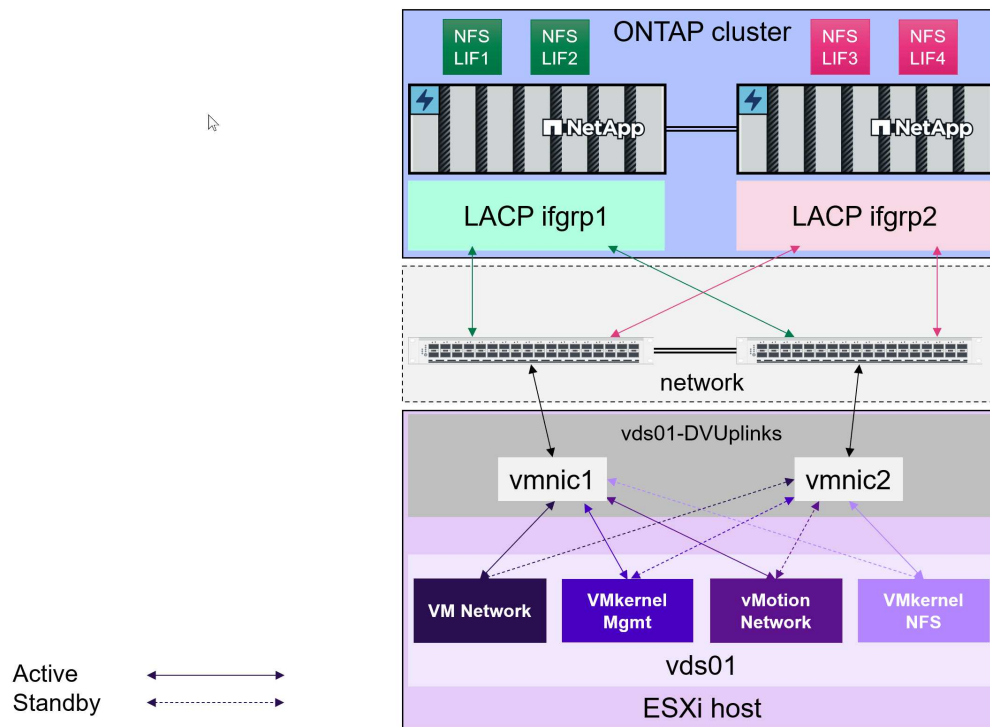
Ensure you have sufficient data LIFs.
Refer to [Deploying vVols Storage](#).

Follow all protocol best practices.

Refer to NetApp and VMware's other best practice guides specific to the protocol you've selected. In general, there are not any changes other than those already mentioned.

Example network configuration using vVols over NFS v3

Deploying vVols on AFF, ASA, ASA r2, and FAS Systems

Follow these best practices for creating vVols storage for your virtual machines.

Provisioning vVols datastores involves several steps. NetApp's ASA r2 systems are designed for VMware workloads and provide a user experience different from traditional ONTAP systems. When using ASA r2 systems, ONTAP tools versions 10.3 or later require fewer steps to set up and include UI extensions and REST API support optimized for the new storage architecture.

Preparing to create vVols Datastores with ONTAP tools

You can skip the first two steps of the deployment process if you are already using ONTAP tools to manage, automate, and report on your existing VMFS or traditional NFS-based storage. You may also refer to this complete checklist for deploying and configuring ONTAP tools.

1. Create the Storage Virtual Machine (SVM) and its protocol configuration. Note that this may not be required for ASA r2 systems since they will typically already have a single SVM for data services. You will select NVMe/FC (ONTAP tools 9.13 only), NFSv3, NFSv4.1, iSCSI, FCP, or a mix of those options. NVMe/TCP and NVMe/FC may also be used for traditional VMFS datastores with ONTAP tools 10.3 and later. You may use either ONTAP System Manager wizards or the cluster shell command line.

   ◦ Assign local tiers (aggregates) to SVMs for all non-ASA r2 systems.

   ◦ At least one LIF per node for each switch/fabric connection. As a best practice, create two or more per node for FCP, iSCSI, or NVMe-based protocols. One LIF per node is sufficient for NFS-based vVols,

but this LIF should be protected by an LACP ifgroup. Refer to Configure LIFs overview and Combine physical ports to create interface groups for details.

- At least one management LIF per SVM if you intend to use SVM-scoped credentials for your tenant vCenters.

- If you plan to use SnapMirror, make sure your source and target ONTAP clusters and SVMs are peered.

- For non-ASA r2 systems, volumes may be created at this time, but it is the best practice to let the *Provision Datastore* wizard in ONTAP tools create them. The only exception to this rule is if you plan to use vVols replication with VMware Site Recovery Manager and ONTAP tools 9.13. This is easier to set up with pre-existing FlexVol volumes with existing SnapMirror relationships. Be mindful not to enable QoS on any volumes to be used for vVols, as this is intended to be managed by SPBM and ONTAP tools.

2. Deploy ONTAP tools for VMware vSphere using the OVA downloaded from the NetApp Support Site.

- ONTAP tools 10.0 and later supports multiple vCenter servers per appliance; you are no longer required to deploy one ONTAP tools appliance per vCenter.

  - If you plan to connect multiple vCenters to a single ONTAP tools instance, you must create and install CA-signed certificates. Refer to Manage certificates for steps.

- Beginning in 10.3, ONTAP tools now deploys as a single-node small-type appliance suitable for most non-vVols workloads.

  - The recommended best practice is to scale-out ONTAP tools 10.3 and later to the 3-node high availability (HA) configuration for all production workloads. For labs or testing purposes, it is possible to use a single-node deployment.

  - The recommended best practice for production vVols use is to eliminate any single point of failure. Create anti-affinity rules to prevent the ONTAP tools VMs from running together on the same host. After initial deployment, it is also recommended to use storage vMotion to place the ONTAP tools VMs into different datastores. Read more about Using Affinity Rules without vSphere DRS or Create a VM-VM Affinity Rule. You should also schedule frequent backups, and/or use the built-in configuration backup utility.

3. Configure ONTAP tools 10.3 for your environment.

- Add vCenter Server instances in the ONTAP tools manager UI.

- ONTAP tools 10.3 supports secure multitenancy. If you do not need secure multitenancy, you may simply add your ONTAP clusters by going to the ONTAP tools menu in vCenter and clicking on *Storage backends* and clicking the *add* button.

- In a secure multitenant environment where you want to delegate specific Storage Virtual Machines (SVMs) to specific vCenters, you must do the following.

  - Log into the ONTAP tools manager UI

  - Onboard the storage cluster

  - Associate a storage backend with a vCenter Server instance

  - Provide the specific SVM credentials to the vCenter administrator, who will then add the SVM as a storage backend in the ONTAP tools storage backends menu in vCenter.

- It is a best practice to create RBAC roles for your storage accounts.
- ONTAP tools includes a JSON file containing the necessary role permissions needed by ONTAP tools storage accounts. You can upload the JSON file to ONTAP System Manager to simplify the creation of RBAC roles and users.
- You can read more about ONTAP RBAC roles at Configure ONTAP user roles and privileges.

The reason that the entire cluster must be onboarded in the ONTAP tools manager UI is that many of the APIs used for vVols are only available at the cluster level.

Creating vVols Datastores with ONTAP tools

Right-click on the host, cluster, or datacenter on which you want to create the vVols datastore, then select *ONTAP tools > Provision Datastore*.

- Choose vVols and provide a meaningful name and select the desired protocol. You may provide a description of the datastore as well.
  - ONTAP tools 10.3 with ASA r2.

- Select the ASA r2 system SVM and click *next*.

- Click *finish*

- It's that easy!
  - ONTAP tools 10.3 with ONTAP FAS, AFF, and ASA prior to ASA r2.
- Select the protocol

- Select the SVM and click *next*.

- Click *add new volumes* or *use existing volume* and specify the attributes. Note that in ONTAP tools 10.3, you can request multiple volumes to be created at the same time. You may also manually add multiple volumes to balance them across the ONTAP cluster. Click *next*

- Click *finish*

- You can see the assigned volumes in the ONTAP tools menu of the configure tab for the datastore.

- Now you can create VM storage policies from the *Policies and Profiles* menu in the vCenter UI.

Migrating VMs from traditional datastores to vVols

Migration of VMs from traditional datastores to a vVols datastore is as simple as moving VMs between traditional datastores. Simply select the VM(s), then select Migrate from the list of Actions, and select a migration type of *change storage only*. When prompted, select a VM storage policy that matches your vVols datastore. Migration copy operations can be offloaded with vSphere 6.0 and later for SAN VMFS to vVols migrations, but not from NAS VMDKs to vVols.

Managing VMs with policies

To automate storage provisioning with policy-based management, you need to create VM storage policies that map to the desired storage capabilities.

> ℹ️ ONTAP tools 10.0 and later no longer use Storage Capability Profiles like previous versions. Instead, the storage capabilities are defined directly in the VM storage policy itself.

Creating VM Storage Policies

VM Storage Policies are used in vSphere to manage optional features such as Storage I/O Control or vSphere Encryption. They are also used with vVols to apply specific storage capabilities to the VM. Use the "NetApp.clustered.Data.ONTAP.VP.vvol" storage type. See example network configuration using vVols over NFS v3 for an example of this with the ONTAP tools VASA Provider. Rules for "NetApp.clustered.Data.ONTAP.VP.VASA10" storage are to be used with non-vVols-based datastores.

Once the storage policy has been created, it can be used when provisioning new VMs.

Performance management with ONTAP tools

ONTAP tools uses its own balanced placement algorithm to place a new vVol in the best FlexVol volume with unified or classic ASA systems, or Storage Availability Zone (SAZ) with ASA r2 systems, within a vVols datastore. Placement is based on matching the backing storage with the VM storage policy. This makes sure that the datastore and backing storage can meet the specified performance requirements.

Changing Performance capabilities, such as Min and Max IOPS, requires some attention to the specific configuration.

- **Min and Max IOPS** may be specified in a VM Policy.
  - Changing the IOPS in the policy will not change QoS on the vVols until the VM Policy is reapplied to the VMs that use it. Or you may create a new policy with the desired IOPS and apply it to the target

VMs. Generally, it is recommended to simply define separate VM storage policies for different tiers of service and simply change the VM storage policy on the VM.

   ◦ ASA, ASA r2, AFF, and FAS personalities have different IOPs settings. Both Min and Max are available on all flash systems; however, non-AFF systems can only use Max IOPs settings.

• ONTAP tools creates individual non-shared QoS policies with currently supported versions of ONTAP. Therefore, each individual VMDK will receive its own allocation of IOPs.

Reapplying VM Storage Policy

Protecting vVols

The following sections outline the procedures and best practices for using VMware vVols with ONTAP storage.

VASA Provider High Availability

The NetApp VASA Provider runs as part of the virtual appliance together with the vCenter plugin and REST API server (formerly known as the Virtual Storage Console [VSC]) and Storage Replication Adapter. If the VASA Provider is not available, VMs using vVols will continue to run. However, new vVols datastores cannot be created, and vVols cannot be created or bound by vSphere. This means that VMs using vVols cannot be powered on as vCenter will not be able to request creation of the swap vVol. And running VMs cannot use vMotion for migration to another host because the vVols cannot be bound to the new host.

VASA Provider 7.1 and later support new capabilities to make sure the services are available when needed. It includes new watchdog processes that monitor VASA Provider and integrated database services. If it detects a failure, it updates the log files and then restarts the services automatically.

Further protection must be configured by the vSphere administrator using the same availability features used to protect other mission critical VMs from faults in software, host hardware and network. No additional configuration is required on the virtual appliance to use these features; simply configure them using standard vSphere approaches. They have been tested and are supported by NetApp.

vSphere High Availability is easily configured to restart a VM on another host in the host cluster in the event of failure. vSphere Fault Tolerance provides higher availability by creating a secondary VM that is continuously replicated and can take over at any point. Additional information on these features is available in the ONTAP tools for VMware vSphere documentation (Configure high availability for ONTAP tools), as well as VMware vSphere documentation (look for vSphere Availability under ESXi and vCenter Server).

The ONTAP tools VASA Provider automatically backs up the vVols configuration in real time to managed ONTAP systems where the vVols information is stored within FlexVol volume metadata. In the event that the ONTAP tools appliance becomes unavailable for any reason, you can easily and quickly deploy a new one and import the configuration. Refer to this KB article for more information on VASA Provider recovery steps:

How to perform a VASA Provider Disaster Recovery - Resolution Guide

vVols Replication

Many ONTAP customers replicate their traditional datastores to secondary storage systems using NetApp SnapMirror, and then use the secondary system to recover individual VMs or an entire site in the event of a disaster. In most cases, customers use a software tool to manage this, such as a backup software product like

the NetApp SnapCenter plugin for VMware vSphere or a disaster recovery solution such as VMware's Site Recovery Manager (together with the Storage Replication Adapter in ONTAP tools).

This requirement for a software tool is even more important to manage vVols replication. While some aspects can be managed by native capabilities (for example, VMware managed snapshots of vVols are offloaded to ONTAP which uses quick, efficient file or LUN clones), in general orchestration is needed to manage replication and recovery. Metadata about vVols is protected by ONTAP as well as the VASA Provider, but additional processing is needed to use them at a secondary site.

ONTAP tools 9.7.1 in conjunction with the VMware Site Recovery Manager (SRM) 8.3 release added support for disaster recovery and migration workflow orchestration taking advantage of NetApp SnapMirror technology.

In the initial release of SRM support with ONTAP tools 9.7.1 it was a requirement to pre-create FlexVol volumes and enable SnapMirror protection before using them as backing volumes for a vVols datastore. Beginning in ONTAP tools 9.10 that process is no longer required. You can now add SnapMirror protection to existing backing volumes and update your VM storage policies to take advantage of policy based management with disaster recovery and migration orchestration and automation integrated with SRM.

Currently, VMware SRM is the only disaster recovery and migration automation solution for vVols supported by NetApp, and ONTAP tools will check for the existence of an SRM 8.3 or later server registered with your vCenter before allowing you to enable vVols replication, although it is possible to leverage the ONTAP tools REST APIs to create your own services.

vVols replication with SRM
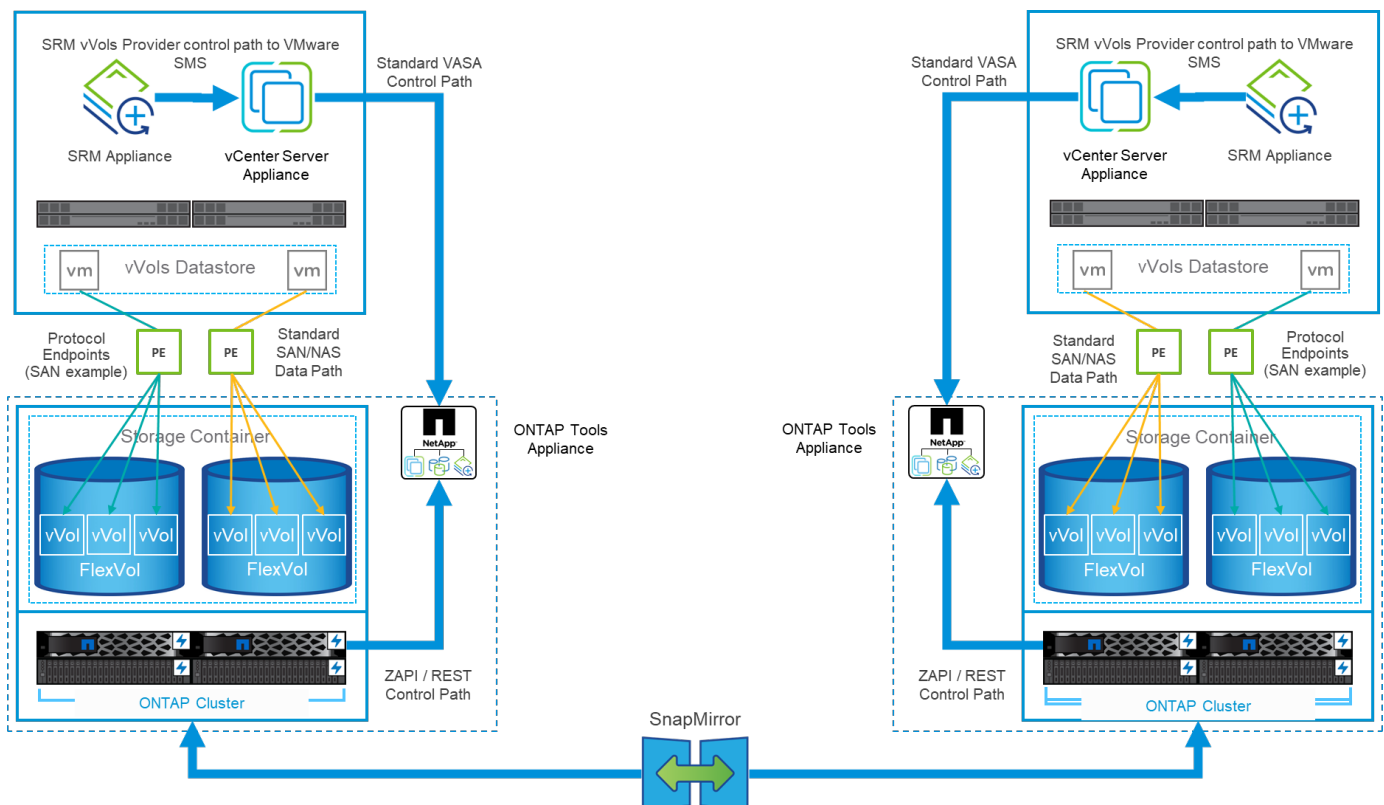
MetroCluster Support

Although ONTAP tools is not capable of triggering a MetroCluster switchover, it does support NetApp MetroCluster systems for vVols backing volumes in a uniform vSphere Metro Storage Cluster (vMSC) configuration. Switchover of a MetroCluster system is handled in the normal manner.

While NetApp SnapMirror Business Continuity (SM-BC) can also be used as the basis for a vMSC configuration, it is not currently supported with vVols.

Refer to these guides for more information on NetApp MetroCluster:

TR-4689 MetroCluster IP Solution architecture and design

TR-4705 NetApp MetroCluster Solution architecture and design

VMware KB 2031038 VMware vSphere Support with NetApp MetroCluster

vVols Backup Overview

There are several approaches to protecting VMs such as using in-guest backup agents, attaching VM data files to a backup proxy, or using defined APIs such as VMware VADP. vVols may be protected using the same mechanisms and many NetApp partners support VM backups, including vVols.

As mentioned earlier, VMware vCenter managed snapshots are offloaded to space efficient and fast ONTAP file/LUN clones. These may be used for quick, manual backups, but are limited by vCenter to a maximum of 32 snapshots. You may use vCenter to take snapshots and revert as needed.

Beginning with SnapCenter Plugin for VMware vSphere (SCV) 4.6 when used in conjunction with ONTAP tools 9.10 and later adds support for crash consistent backup and recovery of vVols based VMs leveraging ONTAP FlexVol volume snapshots with support for SnapMirror and SnapVault replication. Up to 1023 snapshots are supported per volume. SCV can also store more snapshots with longer retention on secondary volumes using SnapMirror with a mirror-vault policy.

vSphere 8.0 support was introduced with SCV 4.7, which used an isolated local plugin architecture. vSphere 8.0U1 support was added to SCV 4.8 which fully transitioned to the new remote plugin architecture.

vVols Backup with SnapCenter plugin for VMware vSphere

With NetApp SnapCenter you can now create resource groups for vVols based on tags and/or folders to automatically take advantage of ONTAP's FlexVol based snapshots for vVols based VMs. This allows you to define backup and recovery services which will protect VMs automatically as they get dynamically provisioned within your environment.

SnapCenter plugin for VMware vSphere is deployed as a standalone appliance registered as a vCenter extension, managed through the vCenter UI or via REST APIs for backup and recovery service automation.

SnapCenter architecture
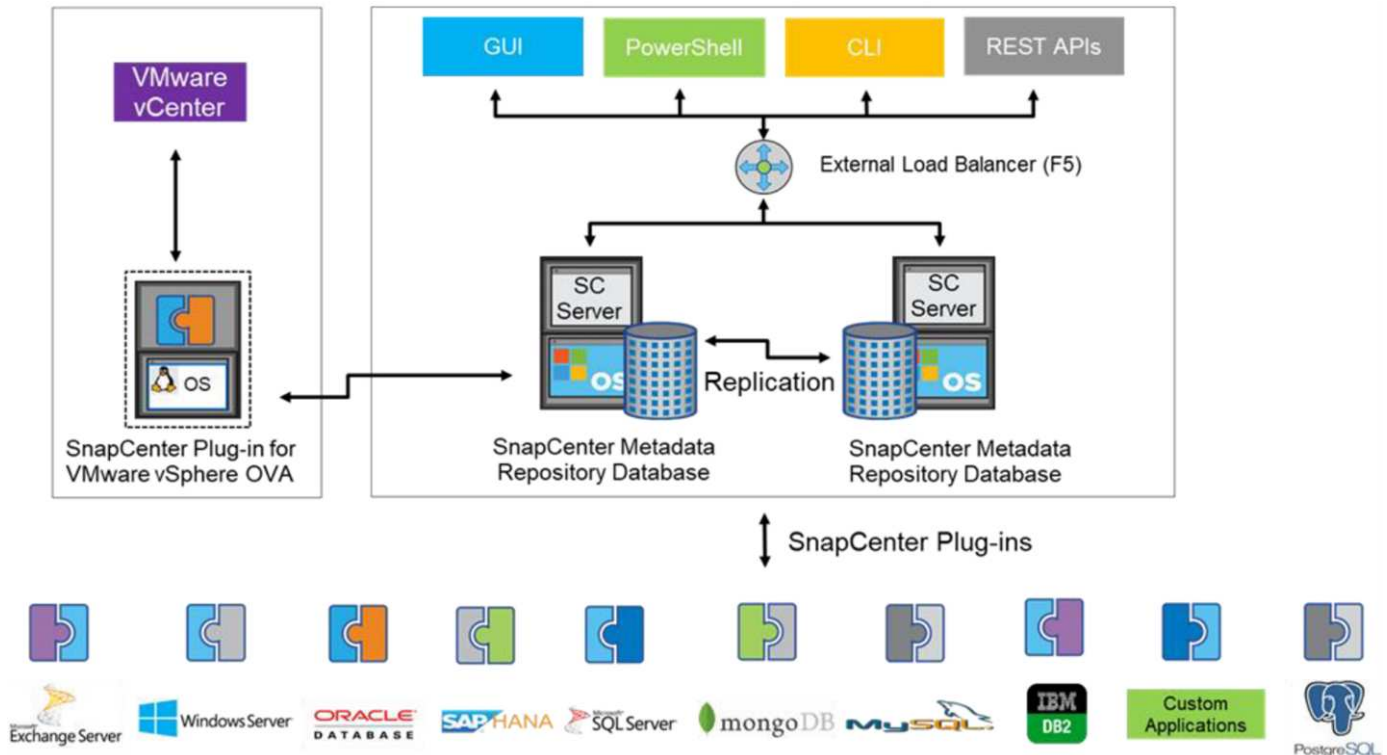
Since the other SnapCenter plugins don't yet support vVols at the time of this writing, we will focus on the standalone deployment model in this document.

Because SnapCenter uses ONTAP FlexVol snapshots there is no overhead placed on vSphere, nor is there any performance penalty as one might see with traditional VMs using vCenter managed snapshots. Furthermore, because SCV's functionality is exposed via REST APIs, it makes it easy to create automated workflows using tools like VMware Aria Automation, Ansible, Terraform, and virtually any other automation tool that is capable of using standard REST APIs.

For information on SnapCenter REST APIs, see Overview of REST APIs

For information on SnapCenter Plug-in for VMware vSphere REST APIs, see SnapCenter Plug-in for VMware vSphere REST APIs

Best Practices

The following best practices can help you get the most out of your SnapCenter deployment.

- SCV supports both vCenter Server RBAC and ONTAP RBAC and includes predefined vCenter roles which are automatically created for you when the plugin is registered. You can read more about the supported types of RBAC here.
  - Use the vCenter UI to assign least privileged account access using the predefined roles described here.
  - If you use SCV with SnapCenter Server, you must assign the *SnapCenterAdmin* role.
  - ONTAP RBAC refers to the user account used to add and manage the storage systems used by SCV. ONTAP RBAC doesn't apply to vVols based backups. Read more about ONTAP RBAC and SCV here.

- Replicate your backup datasets to a second system using SnapMirror for complete replicas of source volumes. As previously mentioned, you may also use mirror-vault policies for longer term retention of backup data independent of source volume snapshot retention settings. Both mechanisms are supported with vVols.

- Because SCV also requires ONTAP tools for VMware vSphere for vVols functionality, always check the NetApp Interoperability Matrix Tool (IMT) for specific version compatibility

- If you are using vVols replication with VMware SRM, be mindful of your policy RPO and backup schedule

- Design your backup policies with retention settings that meet your organizations defined recovery point objectives (RPOs)

- Configure notification settings on your resource groups to be notified of the status when backups run (see figure 10 below)

Resource group notification options

Get started with SCV using these documents

Learn about SnapCenter Plug-in for VMware vSphere

Deploy SnapCenter Plug-in for VMware vSphere

Troubleshooting

There are several troubleshooting resources available with additional information.

NetApp Support Site

In addition to a variety of Knowledgebase articles for NetApp virtualization products, the NetApp Support Site also offers a convenient landing page for the ONTAP tools for VMware vSphere product. This portal provides links to articles, downloads, technical reports, and VMware Solutions Discussions on NetApp Community. It is available at:

NetApp Support Site

Additional solution documentation is available here:

NetApp Solutions for Virtualization with VMware by Broadcom

Product Troubleshooting

The various components of ONTAP tools, such as the vCenter plugin, VASA Provider, and Storage Replication Adapter are all documented together in the NetApp documents repository. However, each has a separate subsection of the Knowledge Base and may have specific troubleshooting procedures. These address the most common issues that may be encountered with the VASA Provider.

VASA Provider UI Problems

Occasionally the vCenter vSphere Web Client encounters problems with the Serenity components, causing the VASA Provider for ONTAP menu items not to display. See Resolving VASA Provider registration issues in the Deployment Guide, or this Knowledgebase article.

vVols Datastore Provisioning Fails

Occasionally vCenter services may time out when creating the vVols datastore. To correct it, restart the vmware-sps service, and re-mount the vVols datastore using the vCenter menus (Storage > New Datastore). This is covered under vVols datastore provisioning fails with vCenter Server 6.5 in the Administration Guide.

Upgrading Unified Appliance Fails to Mount ISO

Due to a bug in vCenter, the ISO used to upgrade the Unified Appliance from one release to the next may fail to mount. If the ISO is able to be attached to the appliance in vCenter, follow the process in this Knowledgebase article to resolve.