NetApp

VMware vSphere Virtual Volumes (vVols) with NetApp ONTAP

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TR-4400: VMware vSphere Virtual Volumes (vVols) with NetApp ONTAP

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Why vVols for vSphere?

NetApp ONTAP® software 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.

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 1 which are supported with the ONTAP tools 9.12 release.

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.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) is referring 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; most common are Config (metadata files), 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. Prior to 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 which vCenter users can then use to provision VMs. The mapping between VM storage policy and datastore storage capability profile allows vCenter to display a list of compatible datastores for selection, as well as enabling other technologies like Aria (formerly known as vRealize) Automation or Tanzu Kubernetes Grid to automatically select storage from an assigned policy. This approach is known as storage policy-based management. While storage capability profiles and policies may also be used with traditional datastores, our focus here is on vVols datastores.

There are two elements:

1. **Storage Capability Profile (SCP)** A storage capability profile (SCP) is a form of storage template that allows the vCenter admin to define what storage features they require without actually needing to understand how to manage those features in ONTAP. By taking a template style approach, it allows the admin to easily deliver storage services in a consistent and predictable way. Capabilities described in an SCP include performance, protocol, storage efficiency, and other features. Specific features vary by version. They are created using the ONTAP tools for VMware vSphere menu within the vCenter UI. You can also use REST APIs to create SCPs. They may be manually created by selecting individual capabilities, or automatically generated from existing (traditional) datastores.

2. **VM Storage Policy** 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 provides a simplified approach by allowing you to simply select an SCP rather than forcing you to specify individual rules.

As mentioned above, using policies can help streamline the task of provisioning a volume. 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 (Figure 1).

Deploy VM using Storage Policy

New Virtual Machine

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

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

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

NetApp ONTAP

In addition to ONTAP 9 on AFF, ASA, and FAS systems, NetApp supports VMware workloads on ONTAP Select, Amazon FSx for NetApp ONTAP with VMware Cloud on AWS, Azure NetApp Files with Azure VMware Solution, Cloud Volumes Service with Google Cloud VMware Engine, and NetApp Private Storage in Equinix, but specific functionality may vary based on service provider and available network connectivity. Access from vSphere guests to data stored in those configurations as well as Cloud Volumes ONTAP is also available.

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 systems such as those hosted by NetApp partners and services 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 induvial 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 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 offload 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, etc.
- **First Class Disks (FCDs)**
  - VMware Tanzu Kubernetes Grid [TKG] persistent volumes.
  - Provide Amazon EBS-like services though 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).
- 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 which can be independently managed separate from VMs that it might be attached to.

Using vVols with ONTAP

The key to using vVols with ONTAP is the VASA Provider software included as part of the ONTAP tools for VMware vSphere virtual appliance.

ONTAP tools also includes the vCenter UI extensions, REST API server, Storage Replication Adapter for VMware Site Recovery Manager, Monitoring and Host configuration tools, and an array of reports which help you better manage your VMware environment.

Products and Documentation

The ONTAP FlexClone license (included with ONTAP One) and the ONTAP tools appliance are the only additional products required to use vVols with NetApp ONTAP. Recent releases of ONTAP tools are supplied as a single unified appliance that runs on ESXi, providing the functionality of what formerly were three different appliances and servers. For vVols, it is important to use the ONTAP tools vCenter UI extensions or REST APIs as general management tools and user interfaces for ONTAP functions with vSphere, together with the VASA Provider which provides specific vVols functionality. The SRA component is included for traditional datastores,

but VMware Site Recovery Manager does not use SRA for vVols, instead implementing new services in SRM 8.3 and later which leverage the VASA provider for vVols replication.

ONTAP tools VASA Provider architecture when using iSCSI or FCP

Product Installation

For new installations, deploy the virtual appliance into your vSphere environment. Current releases of ONTAP tools will automatically register themselves with your vCenter and enable the VASA Provider by default. In addition to ESXi host and vCenter Server information, you will also need the IP address configuration details for the appliance. As previously stated, the VASA Provider requires the ONTAP FlexClone license be already installed onto any ONTAP clusters you plan to use for vVols. The appliance has a built-in watchdog to ensure availability, and as a best practice should be configured with VMware High Availability and optionally Fault Tolerance features. See section 4.1 for additional details. Do not install or move the ONTAP tools appliance or vCenter Server appliance (VCSA) to vVols storage as this can prevent the appliances from restarting.

In-place upgrades of ONTAP tools are supported by using the upgrade ISO file available for download on the NetApp Support Site (NSS). Follow the Deployment and Setup Guide instructions to upgrade the appliance.

For sizing your virtual appliance, and understanding the configuration limits, refer to this knowledge base article: Sizing Guide for ONTAP tools for VMware vSphere

Product Documentation

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

For the complete documentation repository, visit this link to docs.netapp.com

Get started

- Release notes
- Learn about ONTAP tools for Vmware vSphere
- ONTAP tools Quick start
- Deploy ONTAP tools
- Upgrade ONTAP tools

Use ONTAP tools

- Provision traditional datastores
- Provision vVols datastores
- Configure role-based access control
- Configure remote diagnostics
- Configure high availability

Protect and manage datastores

- Protect traditional datastores with SRM
- Protect vVols based virtual machines with SRM
- Monitor traditional datastores and virtual machines
- Monitor vVols datastores and virtual machines

In addition to product documentation, there are Support Knowledgebase articles that may be useful.

- How to perform a VASA Provider Disaster Recovery

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 uptime for the top 5 VMs, and latency and IOPS for the top 5 datastores. It is enabled by default when using ONTAP 9.7 or later. It can take up to 30 minutes for initial data to be retrieved and displayed in the dashboard.

ONTAP tools vVols dashboard

Best Practices

This section collects known best practices for using vVols with ONTAP along with other information.

Limits

In general, ONTAP supports vVols limits as defined by VMware (see published Configuration Maximums). The following table summarizes specific ONTAP limits in size and number of vVols. Always check the NetApp Hardware Universe for updated limits on numbers and sizes of LUNs and files.

ONTAP vVols Limits

Capacity/Feature	SAN (SCSI or NVMe-oF)	NFS
Maximum vVols size	62 TiB[1]	62 TiB[1]
Maximum number of vVols per FlexVol volume	1024	2 billion
Maximum number of vVols per ONTAP node	Up to 12,288[2]	50 billion
Maximum number of vVols per ONTAP pair	Up to 24,576[2]	50 billion
Maximum number of vVols per ONTAP cluster	Up to 98,304[2]	No specific cluster limit
Maximum QoS objects (shared policy group and individual vVols service level)	12,000 through ONTAP 9.3; 40,000 with ONTAP 9.4 and later	

NOTE:
[1] Size limit based on ASA systems or AFF and FAS systems running ONTAP 9.12.1P2 and later.

[2] Number of SAN vVols (NVMe namespaces or LUNs) varies based on platform. Always check the NetApp Hardware Universe for updated limits on numbers and sizes of LUNs and files.

Best Practices for using vVols with ONTAP

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.

1. **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 using ONTAP best practices and in compliance with your defined storage capability profiles. 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.

2. **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.

3. **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.

4. **Zone your Fibre Channel fabric before using NVMe/FC or 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:
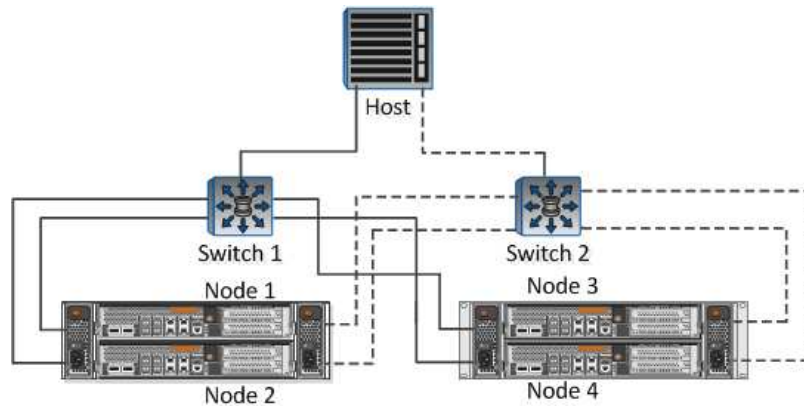
   Refer to the following documents for more best practices:

   TR-4080 Best practices for modern SAN ONTAP 9

   TR-4684 Implementing and configuring modern SANs with NVMe-oF

5. **Plan your backing FlexVols according to your needs.**
   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.

6. **Keep Storage Capability Profiles (SCPs) simple.**
   Avoid specifying capabilities that aren't required by setting them to Any. This will minimize problems when selecting or creating FlexVol volumes. For example, with VASA Provider 7.1 and earlier, if compression is left at the default SCP setting of No, it will attempt to disable compression, even on an AFF system.

7. **Use the default SCPs as example templates to create your own.**
   The included SCPs are suitable for most general-purpose uses, but your requirements may be different.

8. **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.

9. **Ensure you have sufficient data LIFs.**
   Create at least two LIFs per node per HA pair. More may be required based on your workload.

10. **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:
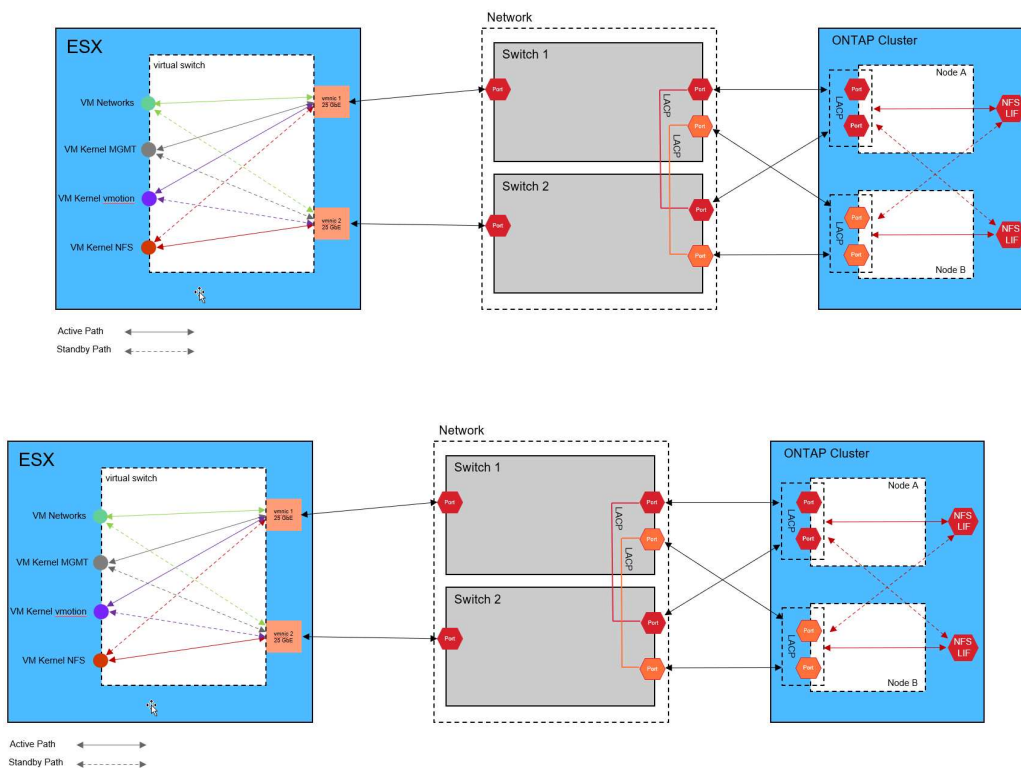
Deploying vVols Storage

There are several steps to creating vVols storage for your VMs.

The first two steps may not be needed for an existing vSphere environment that uses ONTAP for traditional datastores. You may already be using ONTAP tools for managing, automating, and reporting your VMFS or traditional NFSv3 based storage. These steps are covered in more detail in the following section.

1. Create the SVM (protocol configuration, either NVMe/FC, NFSv3, iSCSI, FCP, or a mix of those options) using either ONTAP System Manager wizards, or command line.

    ◦ At least one LIF per node for each switch/fabric connection. Preferably two or more per node for SAN protocols.

    ◦ Volumes may be created at this time, but it is simpler to let the *Provision Datastore* wizard create them. The only exception to this rule is if you plan to use vVols replication with VMware Site Recovery Manager. This is easier to set up with pre-existing FlexVol volumes with existing SnapMirror relationships. Be mindful to not 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.

3. Configure ONTAP tools for your environment.

    ◦ Add the ONTAP cluster to ONTAP tools under *Storage Systems*

        ▪ While ONTAP tools and SRA support both cluster-level and SVM-level credentials, the VASA

Provider supports only cluster-level credentials for storage systems. Therefore, if you plan to use vVols, you must add your ONTAP clusters using cluster scoped credentials.

- If your ONTAP data LIFs are on different subnets from your VMkernel adapters, then you must add the VMkernel adapter subnets to the selected subnets list in the settings menu of ONTAP tools. By default, ONTAP tools will secure your storage traffic by only allowing local subnet access.

- The ONTAP tools comes with several pre-defined policies that may be used or see Section 3.3 for guidance on creating SCPs.

4. Use the *ONTAP tools* menu in vCenter to start the *Provision datastore* wizard.

5. Provide a meaningful name and select the desired protocol. You may provide a description of the datastore as well.

6. Select one or more SCPs to be supported by the vVols datastore. This will filter out any ONTAP systems which are unable to match the profile. From the resulting list, select your desired cluster and SVM.

7. Use the wizard to create new FlexVol volumes for each of the specified SCPs or use existing volumes by selecting the appropriate radio button.

8. Create VM policies for each SCP that will be used in the datastore from the *Policies and Profiles* menu in the vCenter UI.

9. Choose the "NetApp.clustered.Data.ONTAP.VP.vvol" storage rule set. The "NetApp.clustered.Data.ONTAP.VP.VASA10" storage rule set is for SPBM support with non-vVols datastores

10. You will specify the Storage Capability Profile by name when creating a VM Storage Policy. While at this step, you may also configure SnapMirror policy matching by using the replication tab, and tag-based matching using the tags tab. Note that tags must already be created in order to be selectable.

11. Create your VMs, selecting the VM Storage Policy and compatible datastore under Select storage.

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*. Migration copy operations will 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, we need to:

- Define the capabilities of the storage (ONTAP node and FlexVol volume) with Storage Capability Profiles (SCPs).

- Create VM storage policies that map to the defined SCPs.

NetApp has simplified the capabilities and mapping beginning with VASA Provider 7.2 with continuing improvements throughout later versions. This section focuses on this new approach. Earlier releases supported a greater number of capabilities and allowed them to be mapped individually to storage policies, but this approach is no longer supported. Table 3 compares capabilities across releases.

Storage Capability Profile capabilities by ONTAP tools release

SCP Capability	Capability Values	Release Supported	Notes
Compression	Yes, No, Any	All	Mandatory for AFF in 7.2 and later.
Deduplication	Yes, No, Any	All	Mandatory for AFF in 7.2 and later.
Encryption	Yes, No, Any	7.2 and later	Selects/creates encrypted FlexVol volume.. ONTAP license required.
Max IOPS	<number>	7.1 and later, but differences	Listed under QoS Policy Group for 7.2 and later. See Table 4 for more information.
Personality	AFF, FAS	7.2 and later	FAS also includes other non-AFF systems, such as ONTAP Select. AFF includes ASA.
Protocol	NFS, NFS 4.1, iSCSI, FCP, NVMe/FC, Any	7.1 and earlier, 9.10 and later	7.2-9.8 is effectively "Any". Beginning again in 9.10 where NFS 4.1 and NVMe/FC were added to the original list.
Space Reserve (Thin Provisioning)	Thin, Thick, (Any)	All, but differences	Called Thin Provisioning in 7.1 and earlier, which also allowed value of Any. Called Space Reserve in 7.2. All releases default to Thin.
Tiering Policy	Any, None, Snapshot, Auto	7.2 and later	Used for FabricPool® – requires AFF or ASA with ONTAP 9.4 or later. Only Snapshot is recommended unless using an on-premise S3 solution like NetApp StorageGRID.

Creating Storage Capability Profiles

The NetApp VASA Provider comes with several pre-defined SCPs. New SCPs may be created manually, using the vCenter UI, or via automation using REST APIs. By specifying capabilities in a new profile, cloning an existing profile, or by auto-generating profile(s) from existing traditional datastores. This is done using the menus under ONTAP tools. Use *Storage Capability Profiles* to create or clone a profile, and *Storage Mapping* to auto-generate a profile.

Storage Capabilities for ONTAP tools 9.10 and later

Create Storage Capability Profile

General

Specify a name and description for the storage capability profile. ❓

Name: New_SCP

Description:

CANCEL NEXT

1 General
2 Platform
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5 Storage attributes
6 Summary

Create Storage Capability Profile

Performance

○ None ⓘ

● QoS policy group ⓘ

Min IOPS: 1000

Max IOPS:

☑ Unlimited

CANCEL BACK NEXT

1 General
2 Platform
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Create Storage Capability Profile

Protocol

Protocol: Any ⌄

| Any |
| FCP |
| NFS |
| NFS 4.1 |
| iSCSI |
| NVMe/FC |

CANCEL BACK NEXT

1 General
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6 Summary

Create Storage Capability Profile

Platform

Platform: All Flash FAS (AFF) ⌄

CANCEL BACK NEXT

1 General
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6 Summary

Create Storage Capability Profile

Summary

Name:	New_SCP
Description:	N/A
Platform:	All Flash FAS (AFF)
Protocol:	Any
Min IOPS:	1000 IOPS
Max IOPS:	Unlimited
Space reserve:	Thin
Deduplication:	Yes
Compression:	Yes
Encryption:	Yes
Tiering policy (FabricPool):	Snapshot

CANCEL BACK FINISH

1 General
2 Platform
3 Protocol
4 Performance
5 Storage attributes
6 Summary

Creating vVols Datastores

Once the necessary SCPs have been created, they may be used to create the vVols datastore (and optionally, FlexVol volumes for the datastore). Right-click on the host, cluster, or datacenter on which you want to create the vVols datastore, then select *ONTAP tools > Provision Datastore*. Select one or more SCPs to be supported by the datastore, then select from existing FlexVol volumes and/or provision new FlexVol volumes for the datastore. Finally, specify the default SCP for the datastore, which will be used for VMs that do not have an SCP specified by policy, as well as for swap vVols (these do not require high performance storage).

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 and "ProfileName" rule to apply a specific SCP to VMs through use of the Policy. See Figure 6 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.

Earlier releases are similar, but as mentioned in Table 3, your options will vary.

Once the storage policy has been created, it can be used when provisioning new VMs as shown in Figure 1. Guidelines for using performance management capabilities with VASA Provider 7.2 are covered in Table 4.

VM Storage Policy creation with ONTAP tools VASA Provider 9.10

Performance management with ONTAP tools 9.10 and later

- ONTAP tools 9.10 uses its own balanced placement algorithm to place a new vVol in the best FlexVol volume within a vVols datastore. Placement is based on the specified SCP and matching FlexVol volumes. 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 an SCP and used in a VM Policy.

    ▪ Changing the IOPS in the SCP will not change QoS on the vVols until the VM Policy is edited, and then reapplied to the VMs that use it (see Figure 7). Or create a new SCP with the desired IOPS and change the policy to use it (and reapply to VMs). Generally it is recommended to simply define separate SCPs and VM storage policies for different tiers of service and simply change the VM storage policy on the VM.

    ▪ AFF and FAS personalities have different IOPs settings. Both Min and Max are available on AFF. However non-AFF systems can only use Max IOPs settings.

- In some cases, a vVol may need to be migrated after a policy change (either manually, or automatically by VASA Provider and ONTAP):
  - Some changes require no migration (such as changing Max IOPS, which can be applied immediately to the VM as outlined above).
  - If the policy change cannot be supported by the current FlexVol volume that stores the vVol (for example, the platform does not support the encryption or tiering policy requested), you will need to manually migrate the VM in vCenter.
- 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
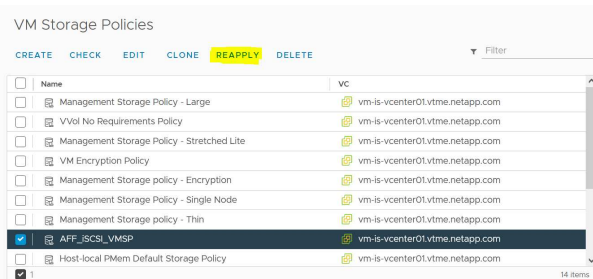
Protecting vVols

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:

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 FlexVols 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
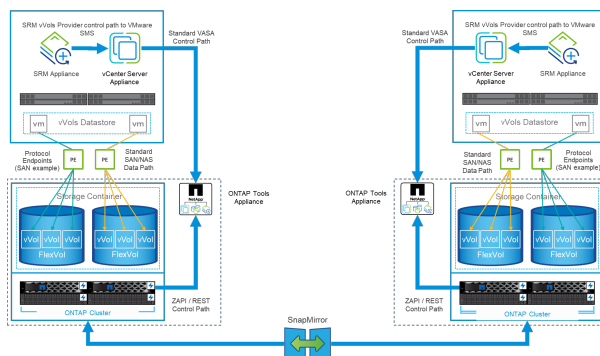
MetroCluster Support

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:

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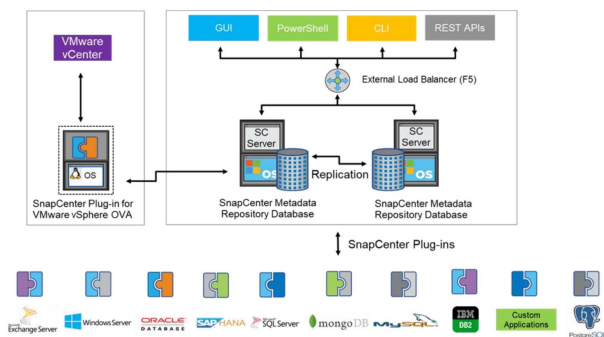
Since the other SnapCenter plugins don't yet support vVols at the time of this writing, we will focus on the standalone deployment model in this document.

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.

1. 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.

2. 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.

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

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

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

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

Resource group notification options

Edit Resource Group

✔ 1. General info & notification	vCenter Server:	vm-is-vcenter01.vtme.netapp.com ▾
✔ 2. Resource	Name:	vVols_VMs
✔ 3. Spanning disks	Description:	Description
✔ 4. Policies	Notification:	Never ▾
✔ 5. Schedules	Email send from:	Error or Warnings / Errors / Always / **Never**
✔ 6. Summary	Email send to:	
	Email subject:	
	Latest Snapshot name	☑ Enable _recent suffix for latest Snapshot Copy ⓘ
	Custom snapshot format:	☐ Use custom name format for Snapshot copy

Note that the Plug-in for VMware vSphere cannot do the following:

[BACK] [NEXT] [FINISH] CANCEL

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

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.