



Technical Report

VMware vSphere Virtual Volumes with ONTAP

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Abstract

NetApp worked with VMware to develop vSphere Virtual Volume support to enable policy-based management of storage at the individual VM level. NetApp continues to extend these capabilities, and this document describes use cases, best practices, and other information for using Virtual Volumes (VVols) to streamline operations and reduce errors.

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1 Why VVols for vSphere?

NetApp® ONTAP® software has been a leading storage solution for VMware vSphere environments for more than a decade, and it 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 by NetApp engineers and customers based on lab testing and extensive field experience. They might not be the only practices that work or are supported, but they are generally the simplest solutions that meet the needs of the most customers.

This document focuses on the capabilities in current releases of ONTAP (9.1 or later) and ONTAP tools (Virtual Storage Console and VASA Provider 7.1 and 7.2), running on vSphere 6.0 or later.

1.1 Virtual Volume (VVol) Overview

NetApp began working with VMware to support vSphere APIs for Storage Awareness (VASA) for vSphere 5. This early VASA Provider allowed storage capabilities to be defined in a profile that could be used to filter datastores when provisioning. Over time VASA evolved to add new capabilities to enable more automation in provisioning, as well as adding Virtual Volumes, where individual storage objects (LUNs, files) are used for virtual machine files and virtual disks. NetApp worked closely with VMware as a reference partner for VVols released with vSphere 6, and continues to enhance them to take advantage of the latest capabilities in ONTAP.

There are several components to be aware of.

VASA Provider	The software component that handles communication between VMware vCenter and the storage system. For ONTAP, the VASA Provider runs in a virtual machine (VM) together with the Virtual Storage Console (VSC) as part of the Unified Virtual Appliance. Once configured and registered with vCenter, there is little need to directly interact with it.
Protocol endpoint	A proxy for I/O between the ESXi hosts and the VVol datastore. The ONTAP VASA Provider creates these proxies automatically, either one protocol endpoint LUN (4MB in size) per NetApp FlexVol® volume in the VVol 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, because they are created, mounted, and deleted automatically by the VASA Provider, along with any necessary interface groups or export policies.
Virtual Volume datastore	The Virtual Volume datastore or container is the logical construct that stores the VVols in vCenter. ONTAP supports multiple FlexVol volumes in a single Virtual Volume datastore, and the datastore can span multiple nodes in an ONTAP cluster, combining flash and hybrid systems with different capabilities. They are provisioned by selecting a host or cluster in vCenter and then selecting Provision VVol Datastore from the VASA Provider for ONTAP menu.
Virtual Volumes (VVols)	VVols are the actual virtual machine files and disks stored in the VVol datastore. ONTAP creates LUNs or files, depending on whether this datastore uses SAN or NAS protocols. There are several different types of VVols; most

common are Config (metadata files), Data (virtual disk or VMDK), and Swap (created when VM is powered on).

In addition to ONTAP 9 on AFF and FAS systems, NetApp supports VMware workloads on ONTAP Select. Access is supported from vSphere guests (on premises or VMware Cloud on AWS) to NetApp Cloud Volumes ONTAP (formerly ONTAP Cloud) and NetApp Private Storage data. Direct access to traditional and VVol datastores is generally not appropriate for this cloud storage usage.

1.2 Policy-Based Management

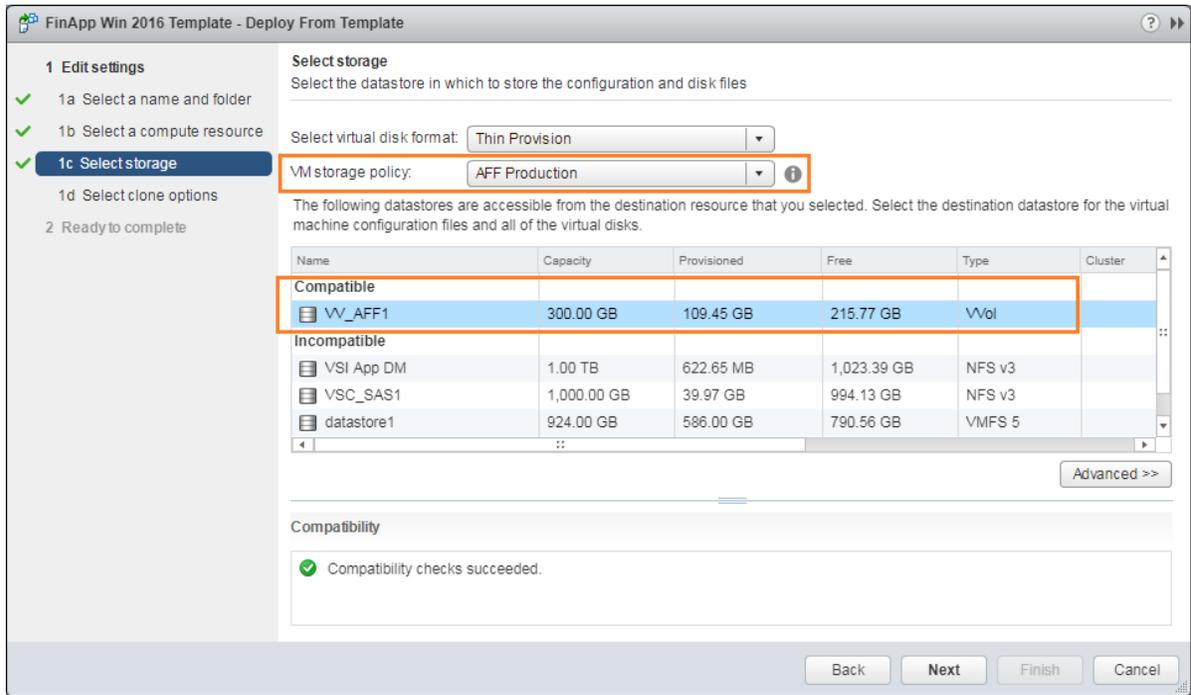
VMware vSphere APIs for Storage Awareness (VASA) make it easy for a storage administrator to configure datastores with well-defined capabilities and let the VM administrator use those whenever needed to provision VMs without the administrators having to interact with each other. Prior to VASA, VM administrators could define VM storage policies, but they had to work with the storage administrator to identify appropriate datastores, often by using documentation or naming conventions. With VASA, the storage administrator can define a range of storage capabilities, which the VM administrator can then use to provision VMs with a storage policy that identifies its requirements. The mapping between the VM storage policy and the datastore storage capability profile allows vCenter to display a list of compatible datastores for selection. This approach is known as *storage policy-based management*. Although storage capability profiles and policies can also be used with traditional datastores, the focus in this document is on VVol datastores.

There are two elements to storage policy-based management.

Storage Capability Profile (SCP)	Individual capabilities of a volume or set of volumes are grouped together as a Storage Capability Profile. These capabilities include performance, capacity, storage efficiency, and other storage features. They are created by using the VSC, under the VASA Provider for ONTAP menu. They can be created manually by selecting individual capabilities, or generated automatically from existing (traditional) datastores.
VM Storage Policy	VM Storage Policies are created in vCenter under Policies and Profiles. For VVols, create a rule-set using rules from the NetApp VVol storage type provider. The easiest approach is to directly reference an existing profile, rather than specifying individual rules.

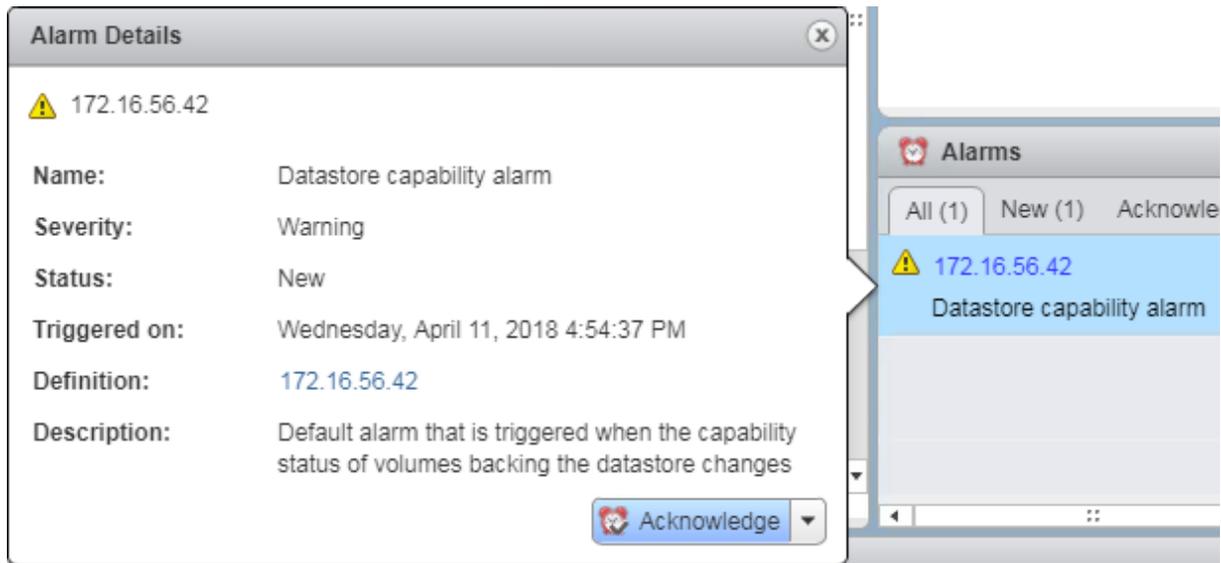
Using policies can help streamline the task of provisioning a volume. Simply select an appropriate policy, and the VASA Provider shows VVol datastores that support that policy and place the VVol into an individual FlexVol volume that is compliant (Figure 1).

Figure 1) Deploy a VM using VM Storage Policy.



Once a VM is provisioned, the VASA Provider continues to check compliance and alerts the VM administrator with an alarm in vCenter when the backing volume is no longer compliant with the profile (Figure 2). For example, perhaps a storage administrator moves a FlexVol volume backing the VVol datastore from AFF to FAS, making the datastore no longer compliant with the associated profile.

Figure 2) Datastore capability alarm.



1.3 Benefits of Using VVols in ONTAP

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

Policy-Based Management

As covered in section 1.2, policy-based management allows VMs to be provisioned and managed by using predefined policies. This can help IT operations in the following ways:

- **Storage provisioning separate from VM provisioning.** This separation allows independent teams, or independent activities by the same team.
- **Faster provisioning.** Different storage capabilities can be supported in a single datastore and 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.

VM Granular Management on SAN

SAN storage systems using Fibre Channel and iSCSI were the first to be supported by VMware for ESX, but they lack 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.

Greater Storage Offload Capabilities

Although vSphere Storage APIs - Array Integration (VAAI) offer a variety of operations that are offloaded to storage, there are some gaps that the VASA Provider addresses. SAN and NAS VAAI are not able to offload VMware-managed snapshots to the storage system. Because VVols use individual LUNs or files for virtual machine disks, ONTAP can quickly and efficiently clone the files or LUNs to create VM snapshots. NFS VAAI also does not support offloading clone operations for Storage vMotion (hot) migrations. The VM must be powered off to allow offload of the migration. The VASA Provider for ONTAP allows 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, NetApp offers an enhanced storage efficiency ratio of 4:1 for VVol workloads under its [Efficiency Guarantee](#) program.

Common Use Cases for VVols

Here are the common use cases for VVol storage:

- **On-demand provisioning of temporary VMs (labs, training).** In this case, customers use VVols with additional automation software to rapidly deploy new VMs for temporary usage in training or other labs, based on clones of existing VMs or VMDKs. Offloading clones to ONTAP is near instantaneous whether within a single volume or cross-volume.
- **On-demand provisioning of long-term VMs (private cloud with vRealize or OpenStack automation).** As with the previous use case, clones are quickly created within a single volume, or across multiple volumes in an aggregate. They are also storage efficient. Clones within a volume use ONTAP file clones, which are like NetApp FlexClone® volumes and only store changes from the source VVol file or LUN. Clone copies across volumes are not instantly storage efficient, but they benefit from background volume and aggregate deduplication on AFF systems. Therefore long-term VMs for production or other application purposes are created quickly, take minimal space, and can

benefit from VM-level protection (using VMware snapshots or VADP backup) and performance management (with ONTAP QoS).

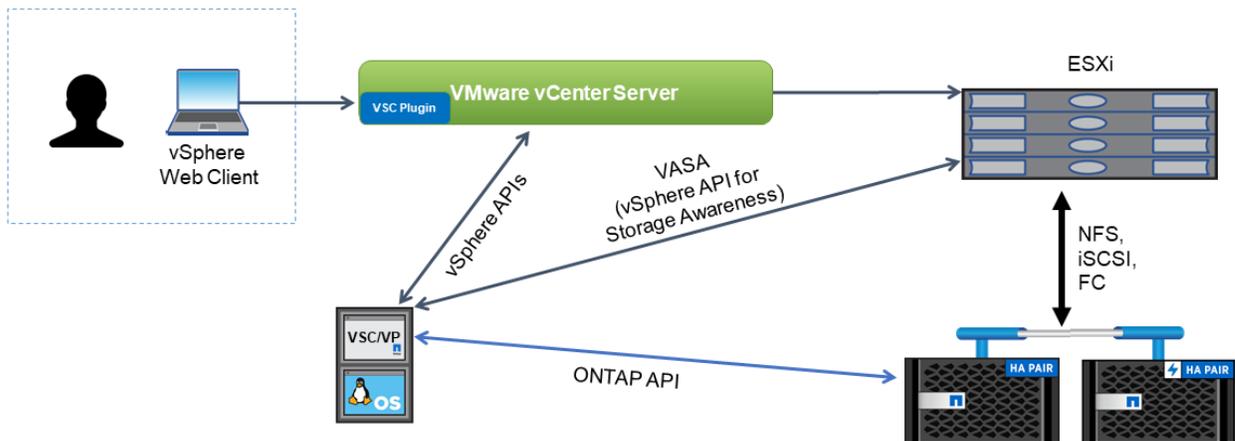
2 Using VVols with ONTAP

The key to using VVols with ONTAP is the NetApp VASA Provider. It is supplied as a virtual appliance combined with the Virtual Storage Console and Storage Replication Adapter (for VMware Site Recovery Manager).

2.1 Products and Documentation

The virtual appliance for Virtual Storage Console (VSC), VASA Provider, and Storage Replication Adapter (SRA) for VMware vSphere is the only software tool required to begin using VVols with ONTAP. In recent 7.X releases, NetApp supplies it as a single unified virtual appliance that runs on ESXi, providing the functionality of what formerly were three different appliances. For VVols, it is important to use the Virtual Storage Console as a general management tool and user interface for ONTAP functionality with vSphere, together with the VASA Provider, which provides specific VVol functionality. The SRA component is included for traditional datastores, but VMware Site Recovery Manager does not support VVols at this time.

Figure 3) ONTAP VASA Provider architecture.



Product Installation

For new installations, deploy the virtual appliance into your vSphere environment, configure VSC, and enable the VASA Provider. In addition to ESXi host and vCenter Server information, you will also need an IP address for the appliance. The VASA Provider requires the ONTAP FlexClone license. The 7.1 appliance has a built-in watchdog to ensure availability, and it can optionally be configured with the VMware High Availability or Fault Tolerance feature. See section 4.1 for details. Do not install or move the appliance to VVol storage; this can prevent the appliance from restarting.

For upgrades, note that 6.2 releases should be migrated to 7.0 first, then an in-place upgrade can be made to the 7.1 or 7.2 release. To migrate the VASA Provider configuration to the new appliance, follow the instructions in the *7.0 Deployment and Setup Guide* under “Migrating existing VASA Provider installation to the 7.0 version of the virtual appliance for VSC, VASA Provider, and SRA.” A [tool](#) is available to migrate storage system metadata to the unified virtual appliance 7.X releases.

Product Documentation

The following documentation is available (links are for release 7.2; other releases are available on the [Support site](#)).

- [Deployment and Setup Guide](#) (Deploying and configuring the appliance)
- [Administration Guide](#) (Administrative tasks)
- [Release Notes](#) (New features, limitations, and known issues)
- [Workflow Guide](#) (Using Storage Capability Profiles, provisioning datastores, etc.)

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

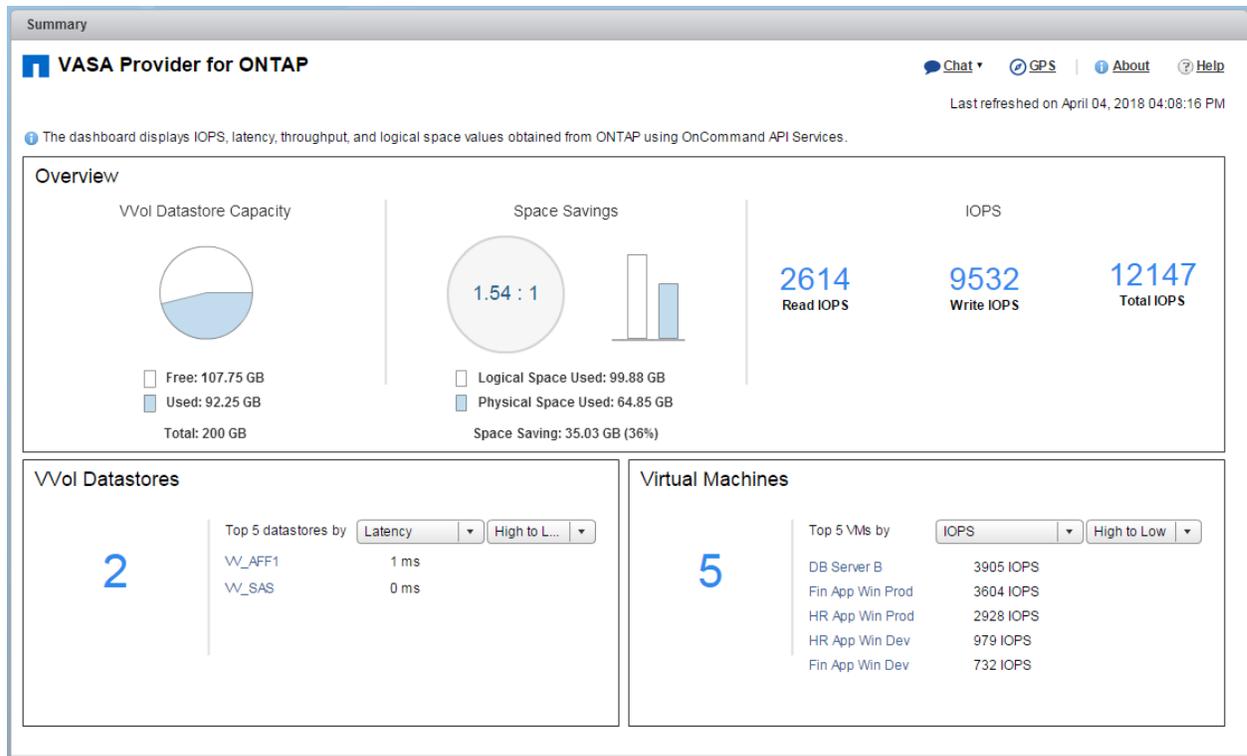
- [How to perform a VASA Provider Disaster Recovery](#)

VASA Provider Dashboard and OnCommand API Services

The VASA Provider 7.1 release introduced a dashboard with performance and capacity information for individual VVol VMs. This information comes directly from ONTAP for the VVol files and LUNs, including latency, IOPS, throughput, and uptime for the top five VMs, and latency and IOPS for the top five datastores. The dashboard is enabled by installing and registering NetApp OnCommand® API Services 2.1 with the VASA Provider. Note that VASA Provider requires a dedicated installation of OnCommand API Services, and it cannot be shared with multiple VASA Provider instances. Follow the installation instructions in the *API Services Installation and Setup Guide*. Configuration is done automatically by the VASA Provider. It can take up to 30 minutes for initial data to be retrieved and displayed in the dashboard.

- [OnCommand API Services Installation and Setup Guide](#)
- [OnCommand API Services Installation Workflow Overview \(video\)](#)

Figure 4) VASA Provider dashboard.



2.2 Best Practices

This section collects best practices for using VVols with ONTAP, along with other information.

Limits

In general, ONTAP supports VVol limits as defined by VMware (see published Configuration Maximums documents). The following table summarizes specific ONTAP limits in size and number of VVols for current releases of ONTAP (9.1 through 9.4). Refer to the *ONTAP SAN Configuration Guide* for information about LUN limits; the *ONTAP Logical Storage Management Guide* for storage limits such as file or LUN size and count; and the *ONTAP Performance Management Power Guide* for QoS limits.

Table 1) ONTAP VVol limits.

Capacity/Feature	SAN (iSCSI or FC)	NFS
Maximum VVol size	16TiB	16TiB
Maximum number of VVols per FlexVol volume	512	2 billion
Maximum number of VVols per ONTAP node	Up to 12,288*	50 billion
Maximum number of VVols per ONTAP pair	Up to 24,576*	50 billion
Maximum number of VVols per ONTAP cluster	Up to 98,304*	No specific cluster limit
Maximum QoS objects (shared policy group and individual VVol service level)	12,000 through ONTAP 9.3; 40,000 with ONTAP 9.4 and later	

* Number of SAN VVols (LUNs) varies based on platform.

Best Practices

Using ONTAP VVols with vSphere is easy and follows published vSphere methods (see “Working with Virtual Volumes” under “vSphere Storage” in the VMware documentation for the ESXi Server). Here are a few additional best practices to consider in conjunction with ONTAP.

General VVol Best Practices

Use the VASA Provider for ONTAP to provision VVol datastores and protocol endpoints.

Although it's possible to create VVols with the general vSphere interface, using the VASA Provider interface automatically creates protocol endpoints as needed, and creates FlexVol volumes using ONTAP best practices. Simply right-click the host, cluster, or datacenter, then select VASA Provider for ONTAP and Provision VVol Datastore.

Do not provision or migrate the VASA Provider virtual appliance to a VVol datastore. If you do, it may not be possible to boot the appliance or power on the VVol VMs.

Avoid VVol operations across different ONTAP releases. Supported storage capabilities such as QoS, personality, and more have changed in VASA Provider 7.2, and some depend on the 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.

Evaluate the optimal number of FlexVol volumes for your environment. A single FlexVol volume for the VVol datastore gives maximum storage efficiency. The VASA Provider offloads many VVol 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, but storage efficiency is not recovered until background jobs run.

However, using multiple FlexVol volumes can help achieve maximum performance from the hardware resources of a single controller. Multiple volumes are also valuable for SAN environments due to the LUN count limits of a single volume. And using FlexVol volumes with different attributes allows flexibility in provisioning and automatically migrating a VM within a single VVol datastore based on policy (see section 3.4).

Keep Storage Capability Profiles simple. To avoid specifying capabilities that aren't required, set them to Any. This setting minimizes 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 disables compression, even on an AFF system.

Specify the Storage Capability Profile by name when creating a VM Storage Policy. Earlier versions of the VASA Provider for ONTAP allowed specification of individual capabilities, like Protocol, Max_IOPS, and so on. But this made matching a policy with a profile complex and problematic. Instead, simply select the ProfileName when creating a policy. This is the only policy rule supported with version 7.2 of the VASA Provider. See section 3.3, "Managing VMs with Policies."

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 VVol for an unknown workload to avoid impact on other, more critical workloads. ONTAP Service Level can also be used in VASA Provider 7.2 to specify minimum and maximum IOPS per TB for a VVol. See section 3.4 for more about performance management.

3 Deploying VVol Storage

3.1 Overview

There are several steps to creating VVol storage for your VMs. The first two steps may not be needed for an existing vSphere environment that uses ONTAP for traditional datastores.

Follow these steps to create VVol storage for your VMs.

1. Create the SVM (protocol configuration, either NFSv3, iSCSI, or FCP) by using either OnCommand System Manager wizards or the command line.
 - One LIF per node for each switch/fabric connection.
 - Volumes can be created at this time, but it's simpler to let the Provision VVol Datastore wizard create them.
2. Add the ONTAP cluster to the Virtual Storage Console under Storage Systems.

- Although VSC and SRA support both cluster-level and SVM-level credentials, the VASA Provider supports only cluster-level credentials for storage systems.
3. If needed, create Storage Capability Profiles (SCPs).
 - The VASA Provider comes with several predefined policies that can be used; or see section 3.3 for information about creating SCPs.
 4. Use the VASA Provider for ONTAP menu in vCenter to start the Provision VVol Datastore wizard.
 - Select one or more SCPs to be supported by the VVol datastore.
 - Use the wizard to create new FlexVol volumes for each of the specified SCPs, or use existing volumes.
 5. Create VM policies for each SCP to be used in the datastore.
 - When creating a VM storage policy, specify a Storage Capability Profile by name.
 6. Create the VMs, selecting the VM Storage Policy and compatible datastore under Select Storage.

3.2 Migrating VMs from Traditional Datastores to VVols

Migrating VMs from traditional datastores to a VVol datastore is as easy as moving VMs within traditional datastores. Simply select one or more VMs, then select Migrate from the list of actions and select the Change Storage Only migration type. Migration copy operations are offloaded with vSphere 6.0 and later for SAN VMFS to VVol migrations, but not from NAS VMDKs to VVols.

3.3 Managing VMs with Policies

To automate storage provisioning with policy-based management, it is necessary 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 with VASA Provider 7.2, and 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 recommended. Table 2 compares capabilities across releases.

Table 2) Storage Capability Profile capabilities by VASA Provider release.

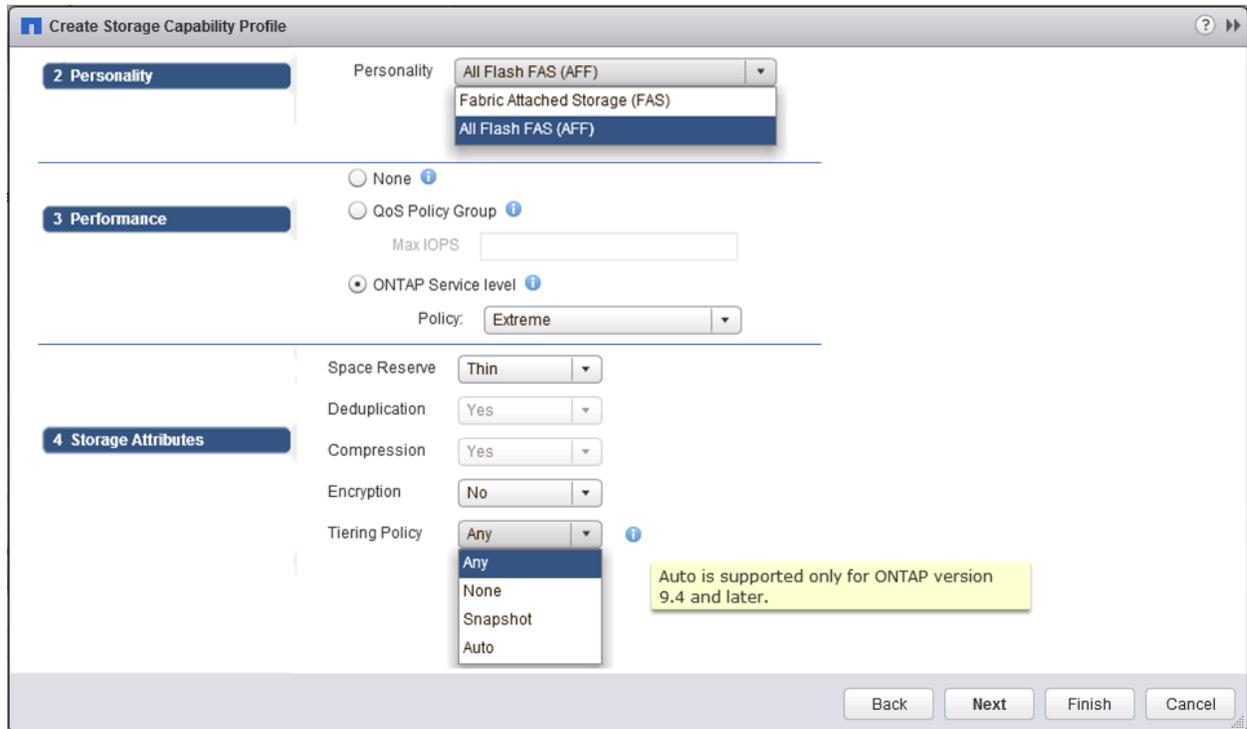
SCP Capability	Capability Values	Release Supported	Notes
Autogrow	Yes, No, Any	7.1 and earlier	Autogrow is enabled by default with 7.2 for VVol FlexVol volumes.
Availability	HA Pair, No HA, Any	7.1 and earlier	Was not useful for provisioning FlexVol volumes or VVols.
Compression	Yes, No, Any	All	Can't edit for AFF in 7.2 and later.
Deduplication	Yes, No, Any	All	Can't edit for AFF in 7.2 and later.
Disk Types	SATA, FCAL, SAS, SSD, Any	7.1 and earlier	7.2 is focused on performance and personality rather than disk type.
Encryption	Yes, No, Any	7.2 and later	Selects or creates encrypted FlexVol volume. Volume Encryption license required.

SCP Capability	Capability Values	Release Supported	Notes
Flash Accelerated	Yes, No, Any	7.1 and earlier	7.2 focuses on performance and personality rather than specific flash features.
Max IOPS	<number>	7.1 and 7.2, but differences	Listed under QoS Policy Group for 7.2 and later. See section 3.4 for more information.
ONTAP Service Level	Extreme, Performance, Value	7.2 and later	Only Value can be selected for FAS personality. See section 3.4 for more information.
Personality	AFF, FAS	7.2 and later	
Protocol	NFS, iSCSI, FCP, Any	7.1 and earlier	7.2 and later is effectively Any.
Replication Type	Asynchronous, Synchronous, None, Any	7.1 and earlier	Did not provision secondary FlexVol volume and replication relationship, so this was not useful.
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 with ONTAP 9.4.

Creating Storage Capability Profiles

The NetApp VASA Provider comes with several predefined SCPs (Bronze, Silver, Gold, Platinum). New SCPs can be created manually, by specifying capabilities in a new profile, by cloning an existing profile, or by autogenerating profiles from existing traditional datastores. This is done by using the menus under Virtual Storage Console > VASA Provider for ONTAP. Use Storage Capability Profiles to create or clone a profile, and use Storage Mapping to autogenerate a profile. Figure 5 shows the capabilities that can be specified with VASA Provider 7.2 (the image combines elements from several panels of the Create Storage Capability Profile wizard).

Figure 5) Storage capabilities for VASA Provider 7.2.



Creating VVol Datastores

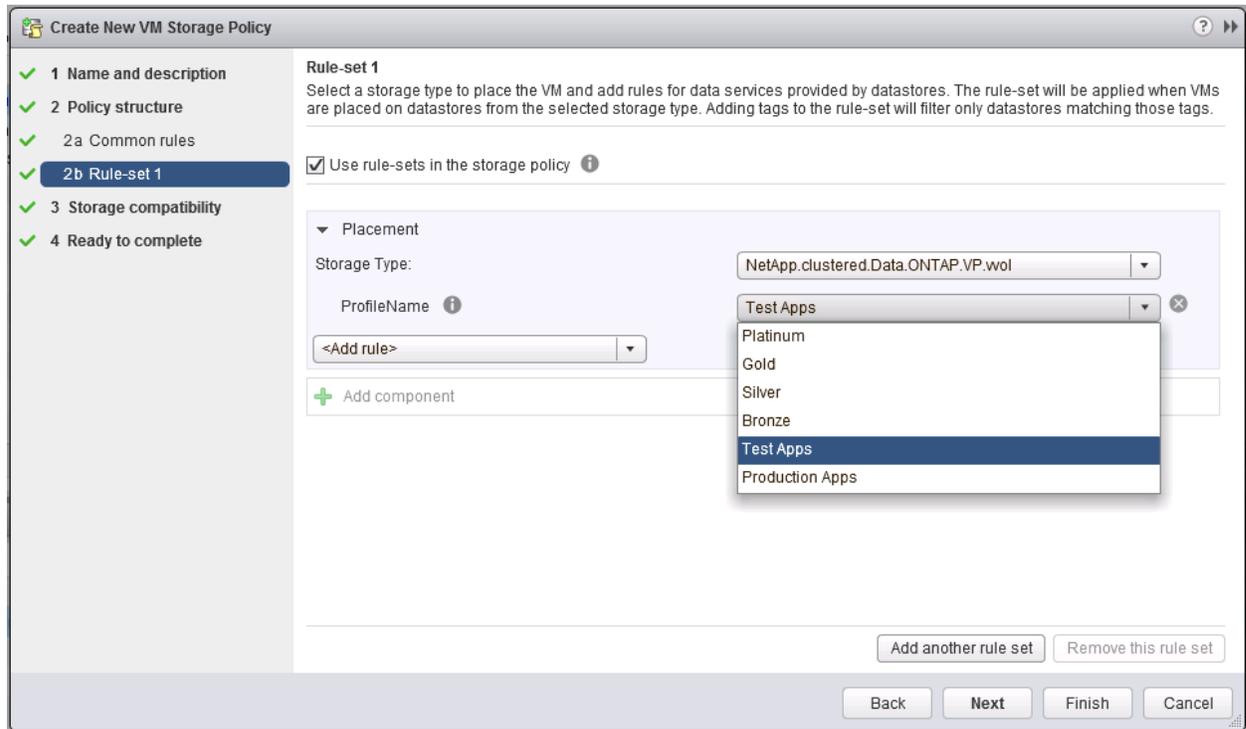
Once the necessary SCPs have been created, they can be used to create the VVol datastore (and optionally, FlexVol volumes within the datastore). Right-click the host, cluster, or datacenter on which to create the VVol datastore, then select VASA Provider for ONTAP > Provision VVol Datastore. Select one 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 and 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 with VASA Provider 7.2. Earlier releases are similar, and they also offer the ability to select individual capabilities. However, as mentioned previously, this is no longer recommended.

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 section 3.4.

Figure 6) VM Storage Policy creation for VASA Provider 7.2.



3.4 Performance Management with VASA Provider 7.2

VASA Provider 7.2 uses the Application Data Management and Balanced Placement capabilities of ONTAP 9.4 to place a new VVol in the best FlexVol volume within a VVol datastore. Placement is based on specified Max IOPS or ONTAP Service Level, together with the available performance capacity of the FlexVol volume, to make sure that the datastore and backing storage can meet the specified performance requirements.

Changing performance capabilities such as Max IOPS and ONTAP Service Level requires some attention to the specific configuration.

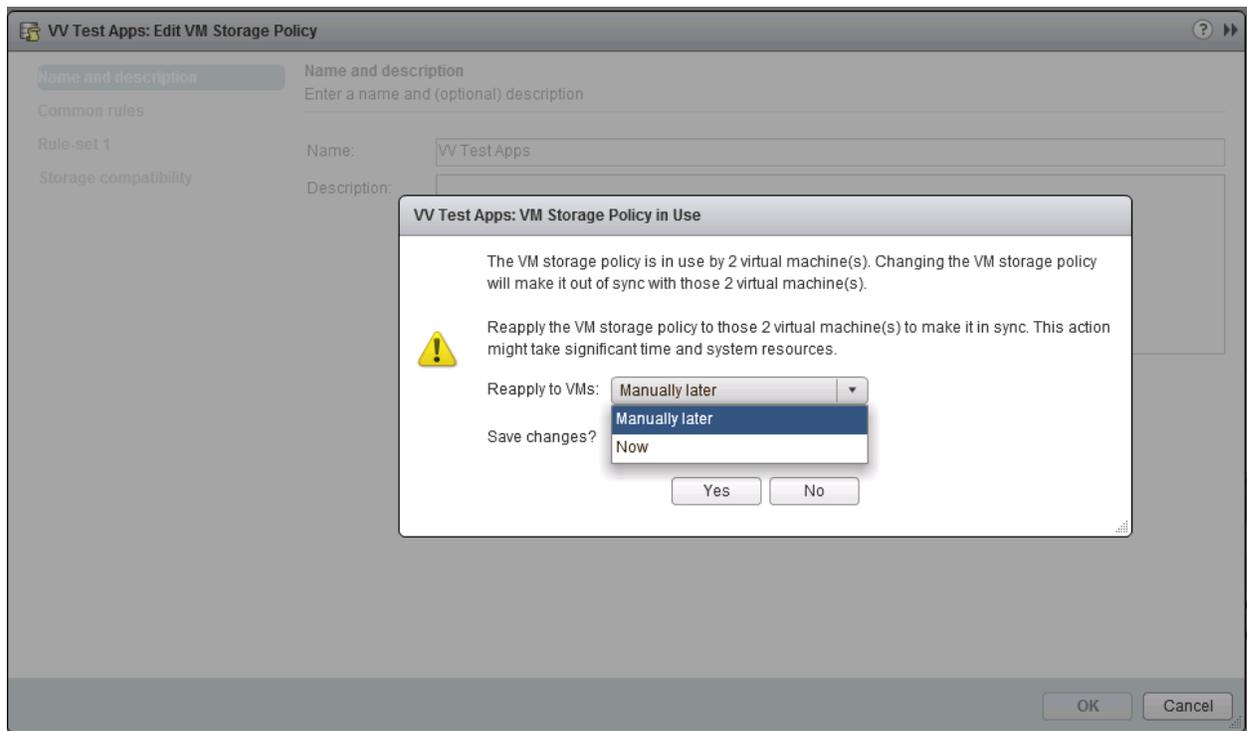
- **Max IOPS** can be specified in an SCP and used in a VM Policy.
 - With VASA Provider 7.2, changing the Max IOPS in the SCP does not change QoS on the VVol until the VM policy is edited and then reapplied to the VMs that use it (see Figure 7). Or create a new SCP with the desired Max IOPS and change the policy to use it (and reapply to VMs).
 - VASA Provider 7.1 also supports Max IOPS for VVols with ONTAP 9.3. However, because 7.1 supports specific policy rules beyond ProfileName, an actual change must be made to the policy so that vCenter tells VASA Provider about the change (for example, add another setting and remove it later, or change to a different SCP and then change back). A simpler approach is to create a new SCP with the desired Max IOPS and change the policy to use it (and reapply to VMs).
- **ONTAP Service Level** can be specified in an SCP starting with VASA Provider 7.2 and ONTAP 9.4. They are reapplied to a VM as described earlier for Max IOPS with 7.2. If the service level for a VVol is changed, the VASA Provider and ONTAP attempt to update it based on the capabilities of the platform specified by Personality. AFF personality supports Value, Performance, and Extreme; FAS personality supports only Value. If both personalities are included in a VVol datastore, changing the SCP to a different personality or a service level not supported by the personality may fail.

In some cases, the 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 described earlier).
- If the policy change cannot be supported by the current FlexVol volume that stores the VVol (for example, the platform does not support the service level, encryption, or tiering policy requested), the VM must be manually migrated in vCenter.
- VASA Provider 7.1 can also automatically migrate a VVol if the datastore contains multiple FlexVol volumes, and a different volume supports the changed policy. For example, if a VVol datastore contains encrypted and unencrypted FlexVol volumes and policy is changed for encryption, ONTAP moves the VVol as appropriate. This automatic migration is not currently supported with VASA Provider 7.2.

ONTAP 9.4 supports QoS policy groups that are not shared for Max IOPS, whereas with ONTAP 9.3 and earlier all objects assigned to the policy group share the Max IOPs limit. So in ONTAP 9.4 with VASA Provider 7.2 you may see a policy group with multiple objects assigned to it. However, note that each object receives an individual Max IOPS limit. VASA Provider 7.1 creates individual policy groups for each VVol, so they are not shared.

Figure 7) Reapplying VM Storage Policy



4 Protecting VVols

4.1 VASA Provider High Availability

The NetApp VASA Provider runs as part of the unified virtual appliance together with the Virtual Storage Console and Storage Replication Adapter. If the VASA Provider is not available, VMs using VVols will continue to run. However, new VVol datastores and VVols cannot be created. This means that VMs using VVols cannot be powered on, because vCenter is not able to request creation of the swap VVol.

VASA Provider 7.1 and later support new capabilities to make sure that 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 can be configured by using the same availability features that are used to protect vSphere VMs from faults in software, host hardware, and network. No additional configuration is required on the unified virtual appliance to use these features; simply configure them by 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. For more information about these features, refer to the *Virtual Storage Console, VASA Provider, and Storage Replication Adapter for VMware vSphere Deployment and Setup Guide*, as well as VMware vSphere documentation (look for vSphere Availability under ESXi and vCenter Server).

4.2 VVol Replication

Many ONTAP customers replicate their traditional datastores to secondary storage systems by using NetApp SnapMirror® and SnapVault® technology, 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 process, such as a backup software product like NetApp SnapCenter® software or VMware Site Recovery Manager (together with NetApp Storage Replication Adapter).

Use of a software tool is just as important to manage VVol replication. Although some aspects can be handled 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, DR testing, and recovery. Metadata about the VVols is protected in ONTAP as well as in the VASA Provider, but additional processing may be needed to use the VVols at a secondary site.

Earlier releases of the VASA Provider supported a replication capability in the SCP, but because this capability did not create a secondary FlexVol volume or datastore, or create a replication relationship and manage it, it was not useful in protecting the primary datastore. It was removed as a capability in the 7.2 release. NetApp does not support VVol replication with the current VASA Provider or with SnapCenter. An alternate approach for replication is to use NetApp MetroCluster™ software together with the VASA Provider, which is supported in the 7.2 release. NetApp is working with VMware to gain full VVol replication capabilities with a future release of Site Recovery Manager.

4.3 VVol Backup

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 can be protected by using the same mechanisms.

As of the 4.0 release, SnapCenter does not support backup and recovery of VVol VMs. As mentioned earlier, VMware-managed snapshots are offloaded to space-efficient and fast ONTAP file or LUN clones. These clones can be used for quick manual backups, but they are limited to a maximum of 32 snapshots. Use vCenter to take snapshots and revert as needed.

Many NetApp partners support VM backups, including VVols. See Appendix A for information about VVol backup protection with Commvault IntelliSnap for NetApp, and Veeam.

5 Troubleshooting

This section describes available troubleshooting resources, with links to additional information.

5.1 NetApp Support Site

In addition to a variety of Knowledgebase articles for NetApp virtualization products, the NetApp Support site offers a Guided Problem Solving portal for VMware Solutions - Virtual Storage Console. This portal contains links to articles, videos, technical reports, and VMware Solutions Discussions on NetApp Community. It is available at

<http://mysupport.netapp.com/NOW/products/vsc/>.

5.2 Product Troubleshooting

The *Virtual Storage Console*, *VASA Provider*, and *Storage Replication Adapter for VMware vSphere Deployment and Setup and Administration Guides* each have a section with specific troubleshooting procedures. Several address problems that are occasionally encountered with the VASA Provider.

VASA Provider UI Problems

Occasionally the vCenter vSphere Web Client (Adobe Flash-based) encounters problems with the Serenity components, causing the VASA Provider for ONTAP menu items to not be displayed. See “Resolving VASA Provider registration issues” in the Deployment Guide, or this Knowledgebase [article](#).

VVol Datastore Provisioning Fails

Occasionally vCenter services may time out or report missing administrative privileges when creating the VVol datastore. To correct this problem, restart the vmware-sps service and remount the VVol datastore by using the vCenter menus (Storage > New Datastore). This topic is covered under “VVol datastore provisioning fails with vCenter Server 6.5” in the Administration Guide.

Upgrading Unified Virtual Appliance Fails to Mount ISO

Because of a bug in vCenter, the ISO used to upgrade the Unified Virtual Appliance from one release to the next may fail to mount. Follow the process in this Knowledgebase [article](#) to resolve the issue.

Appendix A: VVol Protection Using Commvault and Veeam Software

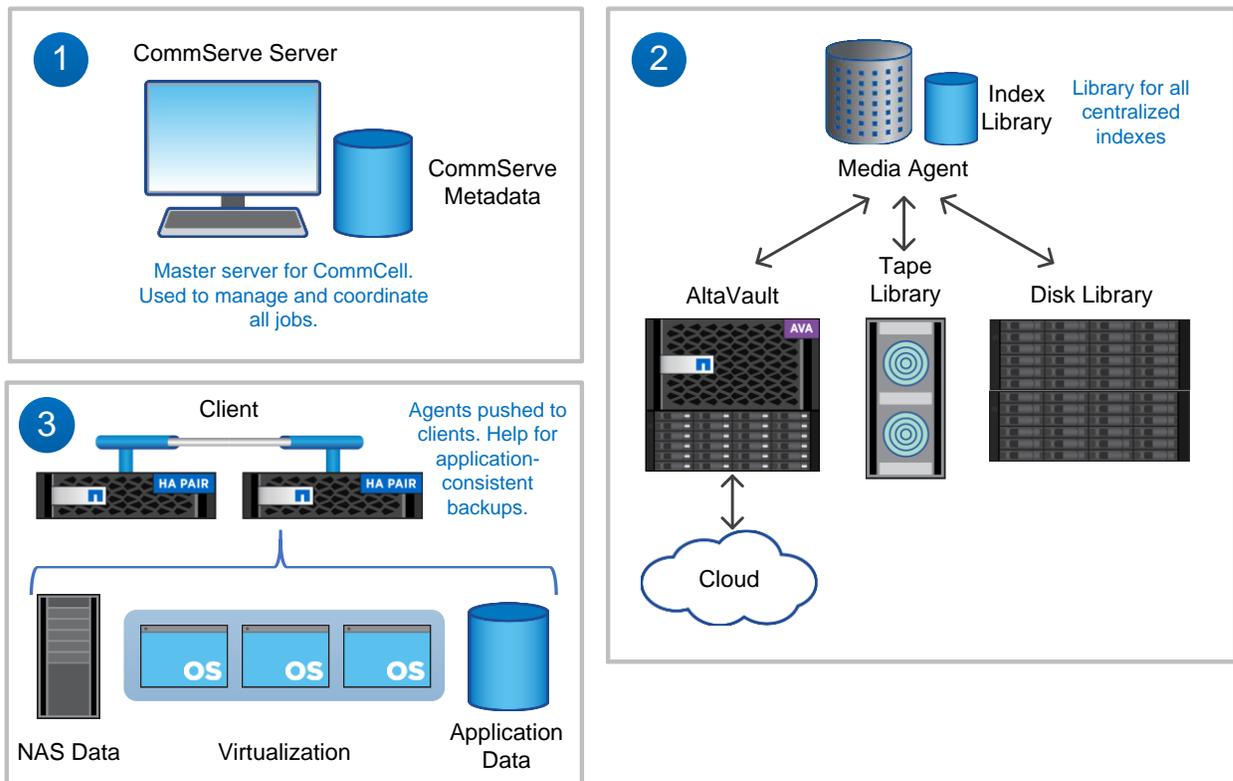
This appendix contains information about protecting VVols by using Commvault and Veeam backup software. Thanks to NetApp TME Ankita Dhawale for her efforts to test and document these processes!

Veeam and Commvault are NetApp's premier backup partners for enterprise applications. Both vendors have created software that is tightly integrated with NetApp Snapshot™ technology to perform quick backup and recovery of large workloads. Veeam and Commvault also offer their own proprietary formats for backup and restore solutions. These solutions tend to be more expensive in terms of space and time when compared to ONTAP Snapshot copies. However, when it comes to VVol backups, this support is currently available only by using Veeam's and Commvault's own proprietary formats. This appendix describes backup of VVols created using NetApp VSC 7.1.

Commvault

Commvault offers a broad software platform for data protection, with components such as CommServe, the master server that coordinates backup, restore, job cloning, and job scheduling, as well as Media Agents, which move data and manage the data storage libraries. For details, see the [Commvault documentation](#).

Figure 8) Commvault architecture.



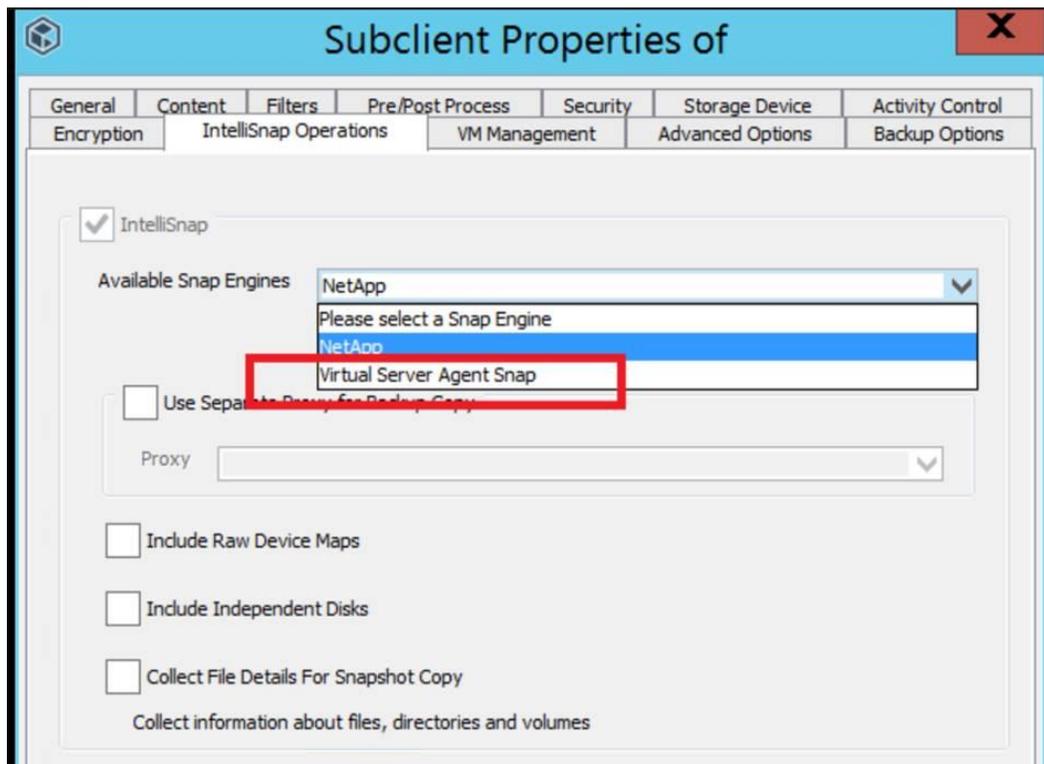
VVol backup using Commvault software uses VADP streaming backups. This capability is supported with the full Commvault backup software product as well as Commvault IntelliSnap for NetApp (requires V11SP11 or later). Both products take VMware-managed snapshots and then stream the backup data to storage libraries (locally attached or remote disks). Read more about Commvault VVol backup [here](#).

There are two options to back up VVols:

- **With IntelliSnap option enabled and using the Virtual Server Agent Snap engine (see Table 5).** This is a two-step process: Commvault creates the VMware-managed snapshot first, and it is retained inside vSphere until the backup copy is triggered, which in turn streams (VADP) data to the storage library. Once the data movement is complete, the Commvault-created snapshot is removed automatically.
- **Without enabling the IntelliSnap option.** In this case, it is one-step process: Commvault creates the VMware snapshot, data gets streamed (VADP) to the storage library, and the VMware-managed snapshot is immediately deleted.

To enable VVol support for a subclient, follow these steps.

1. From the CommCell Browser, navigate to Client Computers > virtualization_client > VMware > backup_set.
2. Right-click the subclient and select Properties.



3. In the Subclient Properties dialog box that opens, click the IntelliSnap Operations tab.
4. Select the IntelliSnap check box.
5. From the Available Snap Engines list, select Virtual Server Agent Snap.
6. Click OK.

Commvault Backup Process

As described in the previous steps, enable the IntelliSnap option, select Virtual Server Agent Snap, and [create a subclient](#) in Commvault. (A [subclient](#) is a logical container that defines the data to be protected.)

To back up a subclient, follow these steps.

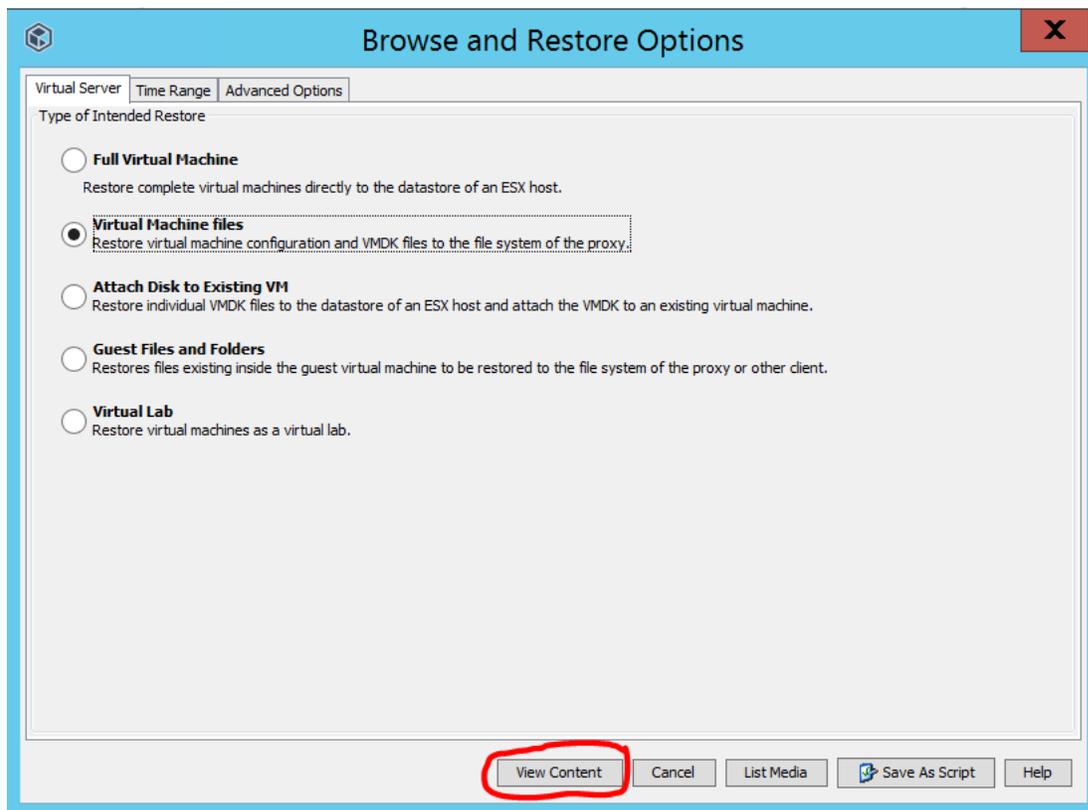
1. Right-click the subclient and select Backup.
2. Select Full Backup and click OK.

- In vCenter > Tasks, you see creation of the VMware-managed snapshot.
 - You can track backup completion under Job Controller in the Commvault GUI.
3. Right-click the subclient and select Run Backup Copy.
 - Running the backup copy streams the data.
 - You can track backup completion under Job Controller in the Commvault GUI. You can also see the data that has been copied in the disk location for the storage library.
 - When the backup copy is completed, Commvault deletes the VMware-managed snapshot, which can also be seen in VCenter Tasks.

Commvault Restore Process

To restore a subclient, follow these steps.

1. Right-click the subclient and select Browse and Restore.
2. Select the level at which to restore and click View Content.



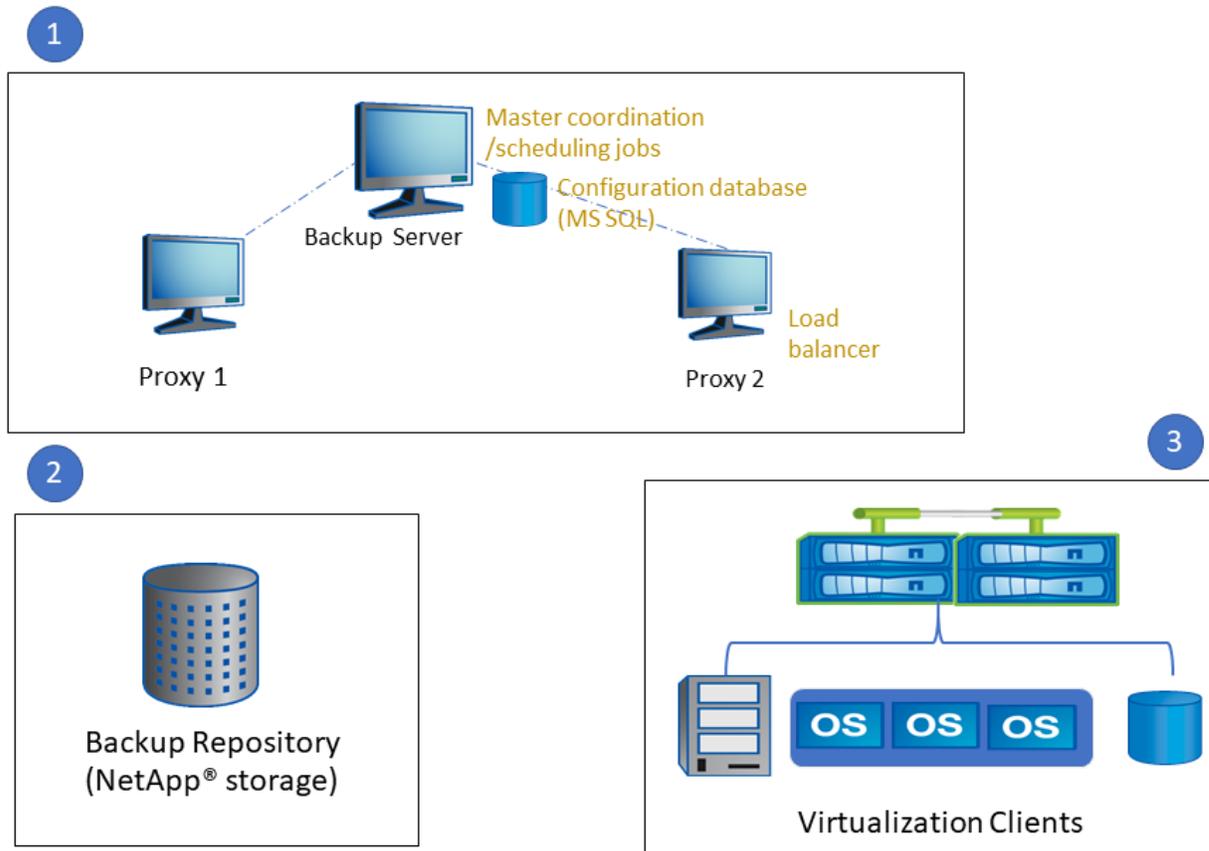
3. Select the items to restore and click Restore All Selected.
4. Select the proxy client to use (or use the default one), browse the path to restore the data, then click OK.
 - You can track restore job completion under Job Controller in the Commvault GUI.
 - You can also see the restored data in the path specified in this step.

Veeam

The Veeam backup and restore solution focuses on a virtual environment like VMware vSphere and Microsoft Hyper-V. Backup Server is the main server, which coordinates all the jobs. Proxies are the

actual servers through which data transfer happens during backup and restore jobs. For details, see the Veeam [documentation](#).

Figure 9) Veeam architecture.



VVol backup using Veeam software also uses VADP streaming-based backups. It does not currently use ONTAP Snapshot copies to protect VVols.

Veeam software creates a VMware-managed snapshot and then uses that snapshot to stream the data to the backup repository.

Veeam Backup Process

To back up a job in Veeam, follow these steps.

1. From main screen of the Veeam GUI, select Backup Job.
2. Name the backup job and click Next.
3. Add the VVol VMs to the backup job. Check the list and click Next.
4. Select the default backup repository where Veeam will stream the data. The NetApp Snapshot option should not be selected.
 - As mentioned previously, Veeam doesn't support storage snapshots for VVols; it only uses streaming backups for VVols.
5. Check the summary. If you want to run the backup immediately, select Run the job when I click Finish, and then click Finish.
 - vCenter > Tasks shows the creation of the VMware-managed snapshot.

- You can follow the backup job progress by clicking it in the Veeam GUI. You can also see the data that has been copied in the disk location for the backup repository.

Veeam Restore Process

To restore a job in Veeam, follow these steps.

1. Select Virtual Machines > [VM name] > Restore and then select the appropriate option, such as Restore VM files.
2. Select the restore destination and the appropriate options, and then click Finish.
 - You can follow the restore job progress by clicking it in the Veeam GUI. You can also see the data that has been restored in the restore destination specified in this step.

Version History

Version	Date	Document Version History
Version 2.0	July 2018	Karl Konnerth: Updated to reflect current ONTAP and VASA Provider releases. Changed focus from how to set up and use VVols, which is covered in other product documentation, to benefits of VVols, best practices, and related areas such as migration, protection, and troubleshooting.
Version 1.0	April 2015	Eric Wagar: Initial release

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