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VMware Cloud Foundation

VMware Cloud Foundation (VCF) is an integrated software defined data center (SDDC) platform that provides a complete stack of software-defined infrastructure for running enterprise applications in a hybrid cloud environment. It combines compute, storage, networking, and management capabilities into a unified platform, offering a consistent operational experience across private and public clouds.

Author: Josh Powell

VMware Cloud Foundation with NetApp All-Flash SAN Arrays

This document provides information on storage options available for VMware Cloud Foundation using the NetApp All-Flash SAN Array. Supported storage options are covered with specific instruction for deploying iSCSI datastores as supplemental storage for management domains and both vVol (iSCSI) and NVMe/TCP datastores as supplemental datastores for workload domains. Also covered is data protection of VMs and datastores using SnapCenter for VMware vSphere.

Use Cases

Use cases covered in this documentation:

• Storage options for customers seeking uniform environments across both private and public clouds.
• Automated solution for deploying virtual infrastructure for workload domains.
• Scalable storage solution tailored to meet evolving needs, even when not aligned directly with compute resource requirements.
• Deploy supplemental storage to management and VI workload domains using ONTAP Tools for VMware vSphere.
• Protect VMs and datastores using the SnapCenter Plug-in for VMware vSphere.

Audience

This solution is intended for the following people:

• Solution architects looking for more flexible storage options for VMware environments that are designed to maximize TCO.
• Solution architects looking for VCF storage options that provide data protection and disaster recovery options with the major cloud providers.
• Storage administrators wanting specific instruction on how to configure VCF with principal and supplemental storage.
• Storage administrators wanting specific instruction on how to protect VMs and datastores residing on ONTAP storage.

Technology Overview

The VCF with NetApp ASA solution is comprised of the following major components:
VMware Cloud Foundation extends VMware’s vSphere hypervisor offerings by combining key components such as SDDC Manager, vSphere, vSAN, NSX, and VMware Aria Suite to create a software-defined datacenter.

The VCF solution supports both native Kubernetes and virtual machine-based workloads. Key services such as VMware vSphere, VMware vSAN, VMware NSX-T Data Center, and VMware Aria Cloud Management are integral components of the VCF package. When combined, these services establish a software-defined infrastructure capable of efficiently managing compute, storage, networking, security, and cloud management.

VCF is comprised of a single management domain and up to 24 VI workload domains that each represent a unit of application-ready infrastructure. A workload domain is comprised of one or more vSphere clusters managed by a single vCenter instance.

For more information on VCF architecture and planning, refer to Architecture Models and Workload Domain Types in VMware Cloud Foundation.
VCF Storage Options

VMware divides storage options for VCF into principal and supplemental storage. The VCF management domain must use vSAN as its principal storage. However, there are many supplemental storage options for the management domain and both principal and supplemental storage options available for VI workload domains.

**Principal Storage for Workload Domains**

Principal storage refers to any type of storage that can be directly connected to a VI workload domain during the setup process within SDDC Manager. Principal storage is deployed with SDDC manager as part of cluster creation orchestration and is the first datastore configured for a workload domain. It includes vSAN, vVols (VMFS), NFS and VMFS on Fibre Channel.

**Supplemental Storage for Management and Workload Domains**

Supplemental storage is the storage type that can be added to the management or workload domains at any time after the cluster has been created. Supplemental storage represents the widest range of supported storage options, all of which are supported on NetApp ASA arrays. Supplemental storage can be deployed using ONTAP Tools for VMware vSphere for most storage protocol types.

Additional documentation resources for VMware Cloud Foundation:
* VMware Cloud Foundation Documentation
* Supported Storage Types for VMware Cloud Foundation
* Managing Storage in VMware Cloud Foundation
NetApp All-Flash SAN Arrays

The NetApp All-Flash SAN Array (ASA) is a high-performance storage solution designed to meet the demanding requirements of modern data centers. It combines the speed and reliability of flash storage with NetApp’s advanced data management features to deliver exceptional performance, scalability, and data protection.

The ASA lineup is comprised of both A-Series and C-Series models.

The NetApp A-Series all-NVMe flash arrays are designed for high-performance workloads, offering ultra-low latency and high resiliency, making them suitable for mission-critical applications.

C-Series QLC flash arrays are aimed at higher-capacity use cases, delivering the speed of flash with the economy of hybrid flash.

Storage Protocol Support

The ASA supports all standard SAN protocols including, iSCSI, Fibre Channel (FC), Fibre Channel over Ethernet (FCoE), and NVME over fabrics.

**iSCSI** - NetApp ASA provides robust support for iSCSI, allowing block-level access to storage devices over IP networks. It offers seamless integration with iSCSI initiators, enabling efficient provisioning and management of iSCSI LUNs. ONTAP’s advanced features, such as multi-pathing, CHAP authentication, and ALUA support.

For design guidance on iSCSI configurations refer to the [SAN Configuration reference documentation](#).

**Fibre Channel** - NetApp ASA offers comprehensive support for Fibre Channel (FC), a high-speed network technology commonly used in storage area networks (SANs). ONTAP seamlessly integrates with FC
infrastructure, providing reliable and efficient block-level access to storage devices. It offers features like zoning, multi-pathing, and fabric login (FLOGI) to optimize performance, enhance security, and ensure seamless connectivity in FC environments.

For design guidance on Fibre Channel configurations refer to the SAN Configuration reference documentation.

**NVMe over Fabrics** - NetApp ONTAP and ASA support NVMe over fabrics. NVMe/FC enables the use of NVMe storage devices over Fibre Channel infrastructure, and NVMe/TCP over storage IP networks.

For design guidance on NVMe refer to NVMe configuration, support and limitations

**Active-active technology**

NetApp All-Flash SAN Arrays allows for active-active paths through both controllers, eliminating the need for the host operating system to wait for an active path to fail before activating the alternative path. This means that the host can utilize all available paths on all controllers, ensuring active paths are always present regardless of whether the system is in a steady state or undergoing a controller failover operation.

Furthermore, the NetApp ASA offers a distinctive feature that greatly enhances the speed of SAN failover. Each controller continuously replicates essential LUN metadata to its partner. As a result, each controller is prepared to take over data serving responsibilities in the event of a sudden failure of its partner. This readiness is possible because the controller already possesses the necessary information to start utilizing the drives that were previously managed by the failed controller.

With active-active pathing, both planned and unplanned takeovers have IO resumption times of 2-3 seconds.

For more information see TR-4968, NetApp All-SAS Array – Data Availability and Integrity with the NetApp ASA.

**Storage guarantees**

NetApp offers a unique set of storage guarantees with NetApp All-flash SAN Arrays. The unique benefits include:

- **Storage efficiency guarantee:** Achieve high performance while minimizing storage cost with the Storage Efficiency Guarantee. 4:1 for SAN workloads.

- **6 Nines (99.9999%) data availability guarantee:** Guarantees remediation for unplanned downtime in excess of 31.56 seconds per year.

- **Ransomware recovery guarantee:** Guaranteed data recovery in the event of a ransomware attack.

See the NetApp ASA product portal for more information.

**NetApp ONTAP Tools for VMware vSphere**

ONTAP Tools for VMware vSphere allows administrators to manage NetApp storage directly from within the vSphere Client. ONTAP Tools allows you to deploy and manage datastores, as well as provision vVol datastores.

ONTAP Tools allows mapping of datastores to storage capability profiles which determine a set of storage system attributes. This allows the creation of datastores with specific attributes such as storage performance
and QoS.

ONTAP Tools also includes a VMware vSphere APIs for Storage Awareness (VASA) Provider for ONTAP storage systems, which enables the provisioning of VMware Virtual Volumes (vVols) datastores, creation and use of storage capability profiles, compliance verification, and performance monitoring.

For more information on NetApp ONTAP tools see the ONTAP tools for VMware vSphere Documentation page.

SnapCenter Plug-in for VMware vSphere

The SnapCenter Plug-in for VMware vSphere (SCV) is a software solution from NetApp that offers comprehensive data protection for VMware vSphere environments. It is designed to simplify and streamline the process of protecting and managing virtual machines (VMs) and datastores. SCV uses storage based snapshot and replication to secondary arrays to meet lower recovery time objectives.

The SnapCenter Plug-in for VMware vSphere provides the following capabilities in a unified interface, integrated with the vSphere client:

**Policy-Based Snapshots** - SnapCenter allows you to define policies for creating and managing application-consistent snapshots of virtual machines (VMs) in VMware vSphere.

**Automation** - Automated snapshot creation and management based on defined policies help ensure consistent and efficient data protection.

**VM-Level Protection** - Granular protection at the VM level allows for efficient management and recovery of individual virtual machines.

**Storage Efficiency Features** - Integration with NetApp storage technologies provides storage efficiency features like deduplication and compression for snapshots, minimizing storage requirements.

The SnapCenter Plug-in orchestrates the quiescing of virtual machines in conjunction with hardware-based snapshots on NetApp storage arrays. SnapMirror technology is utilized to replicate copies of backups to secondary storage systems including in the cloud.

For more information refer to the SnapCenter Plug-in for VMware vSphere documentation.

BlueXP integration enables 3-2-1 backup strategies that extend copies of data to object storage in the cloud.

For more information on 3-2-1 backup strategies with BlueXP visit 3-2-1 Data Protection for VMware with SnapCenter Plug-in and BlueXP backup and recovery for VMs.

**Solution Overview**

The scenarios presented in this documentation will demonstrate how to use ONTAP storage systems as supplemental storage for management and workload domains. In addition, the SnapCenter Plug-in for VMware vSphere is used to protect VMs and datastores.

Scenarios covered in this documentation:

- **Use Ontap Tools to deploy iSCSI datastores in a VCF management domain.** Click here for deployment steps.
- **Use Ontap Tools to deploy vVols (iSCSI) datastores in a VI workload domain.** Click here for deployment steps.
In this scenario we will demonstrate how to deploy and use ONTAP Tools for VMware vSphere (OTV) to configure an iSCSI datastore for a VCF management domain.

Author: Josh Powell

Use ONTAP Tools to configure supplemental storage for VCF Management Domains

Scenario Overview

This scenario covers the following high level steps:

- Create a storage virtual machine (SVM) with logical interfaces (LIFs) for iSCSI traffic.
- Create distributed port groups for iSCSI networks on the VCF management domain.
- Create vmkernel adapters for iSCSI on the ESXi hosts for the VCF management domain.
- Deploy ONTAP Tools on the VCF management domain.
- Create a new VMFS datastore on the VCF management domain.

Prerequisites

This scenario requires the following components and configurations:

- An ONTAP ASA storage system with physical data ports on ethernet switches dedicated to storage traffic.
- VCF management domain deployment is complete and the vSphere client is accessible.

NetApp recommends fully redundant network designs for iSCSI. The following diagram illustrates an example of a redundant configuration, providing fault tolerance for storage systems, switches, networks adapters and host systems. Refer to the NetApp SAN configuration reference for additional information.
For multipathing and failover across multiple paths, NetApp recommends having a minimum of two LIFs per storage node in separate ethernet networks for all SVMs in iSCSI configurations.

This documentation demonstrates the process of creating a new SVM and specifying the IP address information to create multiple LIFs for iSCSI traffic. To add new LIFs to an existing SVM refer to Create a LIF (network interface).

For additional information on using VMFS iSCSI datastores with VMware refer to vSphere VMFS Datastore - iSCSI Storage backend with ONTAP.

In situations where multiple VMkernel adapters are configured on the same IP network, it is recommended to use software iSCSI port binding on the ESXi hosts to ensure that load balancing across the adapters occurs. Refer to KB article Considerations for using software iSCSI port binding in ESX/ESXi (2038869).

Deployment Steps

To deploy ONTAP Tools and use it to create a VMFS datastore on the VCF management domain, complete the following steps:
Create SVM and LIFs on ONTAP storage system

The following step is performed in ONTAP System Manager.
Create the storage VM and LIFs

Complete the following steps to create an SVM together with multiple LIFs for iSCSI traffic.

1. From ONTAP System Manager navigate to Storage VMs in the left-hand menu and click on + Add to start.

2. In the Add Storage VM wizard provide a Name for the SVM, select the IP Space and then, under Access Protocol, click on the *iSCSI tab and check the box to Enable iSCSI.
3. In the **Network Interface** section fill in the **IP address**, **Subnet Mask**, and **Broadcast Domain and Port** for the first LIF. For subsequent LIFs the checkbox may be enabled to use common settings across all remaining LIFs or use separate settings.

For multipathing and failover across multiple paths, NetApp recommends having a minimum of two LIFs per storage node in separate Ethernet networks for all SVMs in iSCSI configurations.
4. Choose whether to enable the Storage VM Administration account (for multi-tenancy environments) and click on **Save** to create the SVM.

**Set up networking for iSCSI on ESXi hosts**

The following steps are performed on the VCF management domain cluster using the vSphere client.
Create Distributed Port Groups for iSCSI traffic

Complete the following to create a new distributed port group for each iSCSI network:

1. From the vSphere client for the management domain cluster, navigate to **Inventory > Networking**. Navigate to the existing Distributed Switch and choose the action to create **New Distributed Port Group**.…

2. In the **New Distributed Port Group** wizard fill in a name for the new port group and click on **Next** to continue.

3. On the **Configure settings** page fill out all settings. If VLANs are being used be sure to provide the correct VLAN ID. Click on **Next** to continue.
4. On the **Ready to complete** page, review the changes and click on **Finish** to create the new distributed port group.

5. Repeat this process to create a distributed port group for the second iSCSI network being used and ensure you have input the correct **VLAN ID**.

6. Once both port groups have been created, navigate to the first port group and select the action to **Edit settings**.
7. On **Distributed Port Group - Edit Settings** page, navigate to **Teaming and failover** in the left-hand menu and click on **uplink2** to move it down to **Unused uplinks**.

8. Repeat this step for the second iSCSI port group. However, this time move **uplink1** down to **Unused uplinks**.
Create VMkernel adapters on each ESXi host

Repeat this process on each ESXi host in the management domain.

1. From the vSphere client navigate to one of the ESXi hosts in the management domain inventory. From the Configure tab select VMkernel adapters and click on Add Networking… to start.

2. On the Select connection type window choose VMkernel Network Adapter and click on Next to continue.

3. On the Select target device page, choose one of the distributed port groups for iSCSI that was created previously.
4. On the **Port properties** page keep the defaults and click on **Next** to continue.

5. On the **IPv4 settings** page fill in the **IP address**, **Subnet mask**, and provide a new **Gateway IP address** (only if required). Click on **Next** to continue.
6. Review the your selections on the **Ready to complete** page and click on **Finish** to create the VMkernel adapter.

7. Repeat this process to create a VMkernel adapter for the second iSCSI network.
Deploy and use ONTAP Tools to configure storage

The following steps are performed on the VCF management domain cluster using the vSphere client and involve deploying OTV, creating a VMFS iSCSI datastore, and migrating management VM's to the new datastore.
Deploy ONTAP tools for VMware vSphere

ONTAP tools for VMware vSphere (OTV) is deployed as a VM appliance and provides an integrated vCenter UI for managing ONTAP storage.

Complete the following to Deploy ONTAP tools for VMware vSphere:

1. Obtain the ONTAP tools OVA image from the NetApp Support site and download to a local folder.
2. Log into the vCenter appliance for the VCF management domain.
3. From the vCenter appliance interface right-click on the management cluster and select Deploy OVF Template...

4. In the Deploy OVF Template wizard click the Local file radio button and select the ONTAP tools OVA file downloaded in the previous step.
5. For steps 2 through 5 of the wizard select a name and folder for the VM, select the compute resource, review the details, and accept the license agreement.

6. For the storage location of the configuration and disk files, select the vSAN datastore of the VCF management domain cluster.

7. On the Select network page select the network used for management traffic.
8. On the Customize template page fill out all required information:
   - Password to be used for administrative access to OTV.
   - NTP server IP address.
   - OTV maintenance account password.
   - OTV Derby DB password.
   - Do not check the box to **Enable VMware Cloud Foundation (VCF)**. VCF mode is not required for deploying supplemental storage.
   - FQDN or IP address of the vCenter appliance and provide credentials for vCenter.
   - Provide the required network properties fields.

Click on **Next** to continue.
9. Review all information on the Ready to complete page and the click Finish to begin deploying the OTV appliance.
Configure a VMFS iSCSI datastore on Management Domain using OTV

Complete the following to use OTV to configure a VMFS iSCSI datastore as supplemental storage on the management domain:

1. In the vSphere client navigate to the main menu and select NetApp ONTAP Tools.

2. Once in ONTAP Tools, from the Getting Started page (or from Storage Systems), click on Add to add a new storage system.
3. Provide the IP address and credentials of the ONTAP storage system and click on Add.
Add Storage System

<table>
<thead>
<tr>
<th>vCenter server</th>
<th>vcf-m01-vc01.sdedc.netapp.com</th>
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<td>••••••••</td>
</tr>
<tr>
<td>Port:</td>
<td>443</td>
</tr>
</tbody>
</table>

4. Click on **Yes** to authorize the cluster certificate and add the storage system.
Add Storage System

Any communication between ONTAP tools plug-in and the storage system should be mutually authenticated.

vCenter server: vcf-m01-vc01.sddc.netapp.com

Authorize Cluster Certificate

Host 172.16.9.25 has identified itself with a self-signed certificate.

Show certificate

Do you want to trust this certificate?

[Yes] [No]
Migrate management VM's to iSCSI Datastore

In cases where it is preferred to use ONTAP storage to protect the VCF management VM's vMotion can be use to migrate the VM's to the newly created iSCSI datastore.

Complete the following steps to migrate the VCF management VM's to the iSCSI datastore.

1. From the vSphere Client navigate to the management domain cluster and click on the VMs tab.
2. Select the VMs to be migrated to the iSCSI datastore, right click and select Migrate...
3. In the Virtual Machines - Migrate wizard, select Change storage only as the migration type and click on Next to continue.
4. On the Select storage page, select the iSCSi datastore and select Next to continue.
5. Review the selections and click on **Finish** to start the migration.
6. The relocation status can be viewed from the **Recent Tasks** pane.
iSCSI Datastores as Supplemental Storage for VCF Management Domains

In this scenario we will demonstrate how to deploy and use ONTAP Tools for VMware vSphere (OTV) to configure a vVols datastore for a VCF workload domain.

iSCSI is used as the storage protocol for the vVols datastore.

Author: Josh Powell

Use ONTAP Tools to configure supplemental storage (vVols) for VCF Workload Domains

Scenario Overview

This scenario covers the following high level steps:

- Create a storage virtual machine (SVM) with logical interfaces (LIFs) for iSCSI traffic.
- Create distributed port groups for iSCSI networks on the VI workload domain.
- Create vmkernel adapters for iSCSI on the ESXi hosts for the VI workload domain.
- Deploy ONTAP Tools on the VI workload domain.
- Create a new vVols datastore on the VI workload domain.

Prerequisites

This scenario requires the following components and configurations:

- An ONTAP ASA storage system with physical data ports on ethernet switches dedicated to storage traffic.
- VCF management domain deployment is complete and the vSphere client is accessible.
- A VI workload domain has been previously deployed.

NetApp recommends fully redundant network designs for iSCSI. The following diagram illustrates an example of a redundant configuration, providing fault tolerance for storage systems, switches, networks adapters and host systems. Refer to the NetApp SAN configuration reference for additional information.
For multipathing and failover across multiple paths, NetApp recommends having a minimum of two LIFs per storage node in separate ethernet networks for all SVMs in iSCSI configurations.

This documentation demonstrates the process of creating a new SVM and specifying the IP address information to create multiple LIFs for iSCSI traffic. To add new LIFs to an existing SVM refer to Create a LIF (network interface).

In situations where multiple VMkernel adapters are configured on the same IP network, it is recommended to use software iSCSI port binding on the ESXi hosts to ensure that load balancing across the adapters occurs. Refer to KB article Considerations for using software iSCSI port binding in ESX/ESXi (2038869).

For additional information on using VMFS iSCSI datastores with VMware refer to vSphere VMFS Datastore - iSCSI Storage backend with ONTAP.

Deployment Steps

To deploy ONTAP Tools and use it to create a vVol's datastore on the VCF management domain, complete the following steps:
Create SVM and LIFs on ONTAP storage system

The following step is performed in ONTAP System Manager.
Create the storage VM and LIFs

Complete the following steps to create an SVM together with multiple LIFs for iSCSI traffic.

1. From ONTAP System Manager navigate to **Storage VMs** in the left-hand menu and click on **+ Add** to start.

2. In the **Add Storage VM** wizard provide a **Name** for the SVM, select the **IP Space** and then, under **Access Protocol**, click on the **iSCSI** tab and check the box to **Enable iSCSI**.
3. In the **Network Interface** section fill in the **IP address**, **Subnet Mask**, and **Broadcast Domain and Port** for the first LIF. For subsequent LIFs the checkbox may be enabled to use common settings across all remaining LIFs or use separate settings.

For multipathing and failover across multiple paths, NetApp recommends having a minimum of two LIFs per storage node in separate Ethernet networks for all SVMs in iSCSI configurations.
4. Choose whether to enable the Storage VM Administration account (for multi-tenancy environments) and click on Save to create the SVM.

### Storage VM Administration

- Manage administrator account

**Set up networking for iSCSI on ESXi hosts**

The following steps are performed on the VI Workload Domain cluster using the vSphere client. In this case vCenter Single Sign-On is being used so the vSphere client is common across the management and workload domains.
Create Distributed Port Groups for iSCSI traffic

Complete the following to create a new distributed port group for each iSCSI network:

1. From the vSphere client, navigate to **Inventory > Networking** for the workload domain. Navigate to the existing Distributed Switch and choose the action to create **New Distributed Port Group**.

2. In the **New Distributed Port Group** wizard fill in a name for the new port group and click on **Next** to continue.

3. On the **Configure settings** page fill out all settings. If VLANs are being used be sure to provide the correct VLAN ID. Click on **Next** to continue.
4. On the **Ready to complete** page, review the changes and click on **Finish** to create the new distributed port group.

5. Repeat this process to create a distributed port group for the second iSCSI network being used and ensure you have input the correct **VLAN ID**.

6. Once both port groups have been created, navigate to the first port group and select the action to **Edit settings**....
7. On Distributed Port Group - Edit Settings page, navigate to Teaming and failover in the left-hand menu and click on uplink2 to move it down to Unused uplinks.

8. Repeat this step for the second iSCSI port group. However, this time move uplink1 down to Unused uplinks.
Create VMkernel adapters on each ESXi host

Repeat this process on each ESXi host in the workload domain.

1. From the vSphere client navigate to one of the ESXi hosts in the workload domain inventory. From the Configure tab select VMkernel adapters and click on Add Networking… to start.

2. On the Select connection type window choose VMkernel Network Adapter and click on Next to continue.

3. On the Select target device page, choose one of the distributed port groups for iSCSI that was created previously.
4. On the **Port properties** page keep the defaults and click on **Next** to continue.

5. On the **IPv4 settings** page fill in the **IP address**, **Subnet mask**, and provide a new **Gateway IP address** (only if required). Click on **Next** to continue.
6. Review the your selections on the Ready to complete page and click on Finish to create the VMkernel adapter.

7. Repeat this process to create a VMkernel adapter for the second iSCSI network.
Deploy and use ONTAP Tools to configure storage

The following steps are performed on the VCF management domain cluster using the vSphere client and involve deploying OTV, creating a vVol iSCSI datastore, and migrating management VM’s to the new datastore.

For VI workload domains, OTV is installed to the VCF Management Cluster but registered with the vCenter associated with the VI workload domain.

For additional information on deploying and using ONTAP Tools in a multiple vCenter environment refer to Requirements for registering ONTAP tools in multiple vCenter Servers environment.
Deploy ONTAP tools for VMware vSphere

ONTAP tools for VMware vSphere (OTV) is deployed as a VM appliance and provides an integrated vCenter UI for managing ONTAP storage.

Complete the following to Deploy ONTAP tools for VMware vSphere:

1. Obtain the ONTAP tools OVA image from the NetApp Support site and download to a local folder.
2. Log into the vCenter appliance for the VCF management domain.
3. From the vCenter appliance interface right-click on the management cluster and select **Deploy OVF Template...**
4. In the **Deploy OVF Template** wizard click the **Local file** radio button and select the ONTAP tools OVA file downloaded in the previous step.
5. For steps 2 through 5 of the wizard select a name and folder for the VM, select the compute resource, review the details, and accept the license agreement.

6. For the storage location of the configuration and disk files, select the vSAN datastore of the VCF management domain cluster.

7. On the Select network page select the network used for management traffic.
8. On the Customize template page fill out all required information:
   - Password to be used for administrative access to OTV.
   - NTP server IP address.
   - OTV maintenance account password.
   - OTV Derby DB password.
   - Do not check the box to **Enable VMware Cloud Foundation (VCF)**. VCF mode is not required for deploying supplemental storage.
   - FQDN or IP address of the vCenter appliance for the **VI Workload Domain**
   - Credentials for the vCenter appliance of the **VI Workload Domain**
   - Provide the required network properties fields.

   Click on **Next** to continue.
9. Review all information on the Ready to complete page and click Finish to begin deploying the OTV appliance.
Add a storage system to ONTAP Tools.

1. Access NetApp ONTAP Tools by selecting it from the main menu in the vSphere client.

   ![vSphere Client Menu]

   - Home
   - Shortcuts

   ![Inventory Menu]

   - Content Libraries
   - Workload Management
   - Global Inventory Lists

   - Policies and Profiles
   - Auto Deploy
   - Hybrid Cloud Services
   - Developer Center

   ![SnapCenter Plug-in for VMware vSphere]

   - NetApp ONTAP tools

   - Cloud Provider Services
   - NSX
   - VMware Aria Operations Configuration
   - Skyline Health Diagnostics

2. From the **INSTANCE** drop down menu in the ONTAP Tool interface, select the OTV instance associated with the workload domain to be managed.
3. In ONTAP Tools select **Storage Systems** from the left hand menu and then press **Add**.

4. Fill out the IP Address, credentials of the storage system and the port number. Click on **Add** to start the discovery process.

   vVol requires ONTAP cluster credentials rather than SVM credentials. For more information refer to **Add storage systems** in the ONTAP Tools documentation.
Add Storage System

Any communication between ONTAP tools plug-in and the storage system should be mutually authenticated.

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<thead>
<tr>
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<td>Port:</td>
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</tbody>
</table>

Advanced options

ONTAP Cluster Certificate:  ● Automatically fetch  ○ Manually upload

CANCEL  SAVE & ADD MORE  ADD
Create a storage capability profile in ONTAP Tools

Storage capability profiles describe the features provided by a storage array or storage system. They include quality of service definitions and are used to select storage systems that meet the parameters defined in the profile. One of the provided profiles can be used or new ones can be created.

To create a storage capability profile in ONTAP Tools complete the following steps:

1. In ONTAP Tools select **Storage capability profile** from the left-hand menu and then press **Create**.

2. In the **Create Storage Capability profile** wizard provide a name and description of the profile and click on **Next**.

3. Select the platform type and to specify the storage system is to be an All-Flash SAN Array set **Asymmetric** to false.
4. Next, select choice of protocol or **Any** to allow all possible protocols. Click **Next** to continue.

5. The **performance** page allows setting of quality of service in form of minimum and maximum IOPs allowed.
6. Complete the **storage attributes** page selecting storage efficiency, space reservation, encryption and any tiering policy as needed.

7. Finally, review the summary and click on Finish to create the profile.
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<td>Compression:</td>
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<tr>
<td>Encryption:</td>
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</tr>
<tr>
<td>Tiering Policy (FabricPool):</td>
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</tbody>
</table>
Create a vVols datastore in ONTAP Tools

To create a vVols datastore in ONTAP Tools complete the following steps:

1. In ONTAP Tools select Overview and from the Getting Started tab click on Provision to start the wizard.

2. On the General page of the New Datastore wizard select the vSphere datacenter or cluster destination. Select vVols as the datastore type, fill out a name for the datastore, and select iSCSI as the protocol. Click on Next to continue.

3. On the Storage system page select the select a storage capability profile, the storage system and SVM. Click on Next to continue.
4. On the **Storage attributes** page select to create a new volume for the datastore and fill out the storage attributes of the volume to be created. Click on **Add** to create the volume and then **Next** to continue.

5. Finally, review the summary and click on **Finish** to start the vVol datastore creation process.
Configure NVMe/TCP supplemental storage for VCF Workload Domains

Scenario Overview

This scenario covers the following high level steps:

- Create a storage virtual machine (SVM) with logical interfaces (LIFs) for NVMe/TCP traffic.
- Create distributed port groups for iSCSI networks on the VI workload domain.
- Create vmkernel adapters for iSCSI on the ESXi hosts for the VI workload domain.
- Add NVMe/TCP adapters on ESXi hosts.
- Deploy NVMe/TCP datastore.

Prerequisites

This scenario requires the following components and configurations:

- An ONTAP ASA storage system with physical data ports on ethernet switches dedicated to storage traffic.
- VCF management domain deployment is complete and the vSphere client is accessible.
- A VI workload domain has been previously deployed.

NetApp recommends fully redundant network designs for NVMe/TCP. The following diagram illustrates an
example of a redundant configuration, providing fault tolerance for storage systems, switches, networks adapters and host systems. Refer to the NetApp SAN configuration reference for additional information.

For multipathing and failover across multiple paths, NetApp recommends having a minimum of two LIFs per storage node in separate ethernet networks for all SVMs in NVMe/TCP configurations.

This documentation demonstrates the process of creating a new SVM and specifying the IP address information to create multiple LIFs for NVMe/TCP traffic. To add new LIFs to an existing SVM refer to Create a LIF (network interface).

For additional information on NVMe design considerations for ONTAP storage systems, refer to NVMe configuration, support and limitations.

Deployment Steps

To create a VMFS datastore on a VCF workload domain using NVMe/TCP, complete the following steps.

Create SVM, LIFs and NVMe Namespace on ONTAP storage system

The following step is performed in ONTAP System Manager.
Create the storage VM and LIFs

Complete the following steps to create an SVM together with multiple LIFs for NVMe/TCP traffic.

1. From ONTAP System Manager navigate to Storage VMs in the left-hand menu and click on + Add to start.

2. In the Add Storage VM wizard provide a Name for the SVM, select the IP Space and then, under Access Protocol, click on the NVMe tab and check the box to Enable NVMe/TCP.
3. In the **Network Interface** section fill in the **IP address**, **Subnet Mask**, and **Broadcast Domain and Port** for the first LIF. For subsequent LIFs the checkbox may be enabled to use common settings across all remaining LIFs, or use separate settings.

For multipathing and failover across multiple paths, NetApp recommends having a minimum of two LIFs per storage node in separate Ethernet networks for all SVMs in NVMe/TCP configurations.
4. Choose whether to enable the Storage VM Administration account (for multi-tenancy environments) and click on **Save** to create the SVM.
Storage VM Administration

- Manage administrator account

Save  Cancel
Create the NVMe Namespace

NVMe namespaces are analogous to LUNs for iSCSI or FC. The NVMe Namespace must be created before a VMFS datastore can be deployed from the vSphere Client. To create the NVMe namespace, the NVMe Qualified Name (NQN) must first be obtained from each ESXi host in the cluster. The NQN is used by ONTAP to provide access control for the namespace.

Complete the following steps to create an NVMe Namespace:

1. Open an SSH session with an ESXi host in the cluster to obtain its NQN. Use the following command from the CLI:

   ```bash
   esxcli nvme info get
   ```

   An output similar to the following should be displayed:

   ```text
   ```

2. Record the NQN for each ESXi host in the cluster.

3. From ONTAP System Manager navigate to **NVMe Namespaces** in the left-hand menu and click on **Add** to start.

4. On the **Add NVMe Namespace** page, fill in a name prefix, the number of namespaces to create, the size of the namespace, and the host operating system that will be accessing the namespace. In the
Host NQN section create a comma separated list of the NQN’s previously collected from the ESXi hosts that will be accessing the namespaces.

Click on More Options to configure additional items such as the snapshot protection policy. Finally, click on Save to create the NVMe Namespace.

Set up networking and NVMe software adapters on ESXi hosts

The following steps are performed on the VI workload domain cluster using the vSphere client. In this case vCenter Single Sign-On is being used so the vSphere client is common to both the management and workload domains.
Complete the following to create a new distributed port group for each NVMe/TCP network:

1. From the vSphere client, navigate to **Inventory > Networking** for the workload domain. Navigate to the existing Distributed Switch and choose the action to create **New Distributed Port Group**.

2. In the **New Distributed Port Group** wizard, fill in a name for the new port group and click on **Next** to continue.

3. On the **Configure settings** page, fill out all settings. If VLANs are being used, be sure to provide the correct VLAN ID. Click on **Next** to continue.
4. On the **Ready to complete** page, review the changes and click on **Finish** to create the new distributed port group.

5. Repeat this process to create a distributed port group for the second NVMe/TCP network being used and ensure you have input the correct **VLAN ID**.

6. Once both port groups have been created, navigate to the first port group and select the action to **Edit settings**....
7. On Distributed Port Group - Edit Settings page, navigate to Teaming and failover in the left-hand menu and click on uplink2 to move it down to Unused uplinks.

8. Repeat this step for the second NVMe/TCP port group. However, this time move uplink1 down to
### Unused uplinks.

**Distributed Port Group - Edit Settings**

<table>
<thead>
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</thead>
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<td></td>
<td><strong>Unused uplinks</strong></td>
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</tr>
<tr>
<td></td>
<td></td>
<td><strong>uplink1</strong></td>
</tr>
</tbody>
</table>
Create VMkernel adapters on each ESXi host

Repeat this process on each ESXi host in the workload domain.

1. From the vSphere client navigate to one of the ESXi hosts in the workload domain inventory. From the Configure tab select VMkernel adapters and click on Add Networking… to start.

2. On the Select connection type window choose VMkernel Network Adapter and click on Next to continue.

3. On the Select target device page, choose one of the distributed port groups for iSCSI that was created previously.
4. On the **Port properties** page click the box for **NVMe over TCP** and click on **Next** to continue.
5. On the **IPv4 settings** page fill in the **IP address**, **Subnet mask**, and provide a new Gateway IP address (only if required). Click on **Next** to continue.

6. Review the your selections on the **Ready to complete** page and click on **Finish** to create the VMkernel adapter.
7. Repeat this process to create a VMkernel adapter for the second iSCSI network.
Add NVMe over TCP adapter

Each ESXi host in the workload domain cluster must have an NVMe over TCP software adapter installed for every established NVMe/TCP network dedicated to storage traffic.

To install NVMe over TCP adapters and discover the NVMe controllers, complete the following steps:

1. In the vSphere client navigate to one of the ESXi hosts in the workload domain cluster. From the Configure tab click on Storage Adapters in the menu and then, from the Add Software Adapter drop-down menu, select Add NVMe over TCP adapter.

2. In the Add Software NVMe over TCP adapter window, access the Physical Network Adapter drop-down menu and select the correct physical network adapter on which to enable the NVMe adapter.

Add Software NVMe over TCP adapter

Enable software NVMe adapter on the selected physical network adapter.
3. Repeat this process for the second network assigned to NVMe over TCP traffic, assigning the correct physical adapter.

4. Select one of the newly installed NVMe over TCP adapters and, on the Controllers tab, select Add Controller.

5. In the Add controller window, select the Automatically tab and complete the following steps.
   - Fill in an IP addresses for one of the SVM logical interfaces on the same network as the physical adapter assigned to this NVMe over TCP adapter.
   - Click on the Discover Controllers button.
   - From the list of discovered controllers, click the check box for the two controllers with network addresses aligned with this NVMe over TCP adapter.
   - Click on the OK button to add the selected controllers.
6. After a few seconds you should see the NVMe namespace appear on the Devices tab.
7. Repeat this procedure to create an NVMe over TCP adapter for the second network established for NVMe/TCP traffic.
Deploy NVMe over TCP datastore

To create a VMFS datastore on the NVMe namespace, complete the following steps:

1. In the vSphere client navigate to one of the ESXi hosts in the workload domain cluster. From the Actions menu select Storage > New Datastore....

   ![](image)

2. In the New Datastore wizard, select VMFS as the type. Click on Next to continue.

3. On the Name and device selection page, provide a name for the datastore and select the NVMe namespace from the list of available devices.
4. On the VMFS version page select the version of VMFS for the datastore.

5. On the Partition configuration page, make any desired changes to the default partition scheme. Click on Next to continue.
6. On the **Ready to complete** page, review the summary and click on **Finish** to create the datastore.

7. Navigate to the new datastore in inventory and click on the **Hosts** tab. If configured correctly, all ESXi hosts in the cluster should be listed and have access to the new datastore.

Additional information

For information on configuring ONTAP storage systems refer to the [ONTAP 9 Documentation](#) center.

For information on configuring VCF refer to [VMware Cloud Foundation Documentation](#).
In this scenario we will demonstrate how to deploy and use the SnapCenter Plug-in for VMware vSphere (SCV) to backup and restore VM’s and datastores on a VCF workload domain. SCV uses ONTAP snapshot technology to take fast and efficient backup copies of the ONTAP storage volumes hosting vSphere datastores. SnapMirror and SnapVault technology are used to create secondary backups on a separate storage system and with retention policies that mimic the original volume or can be independent of the original volume for longer term retention.

iSCSI is used as the storage protocol for the VMFS datastore in this solution.

Author: Josh Powell

Use SnapCenter Plug-in for VMware vSphere to protect VMs on VCF Workload Domains

Scenario Overview

This scenario covers the following high level steps:

• Deploy the SnapCenter Plug-in for VMware vSphere (SCV) on the VI workload domain.
• Add storage systems to SCV.
• Create backup policies in SCV.
• Create Resource Groups in SCV.
• Use SCV to backup datastores or specific VMs.
• Use SCV to restores VMs to an alternate location in the cluster.
• Use SCV to restores files to a windows file system.

Prerequisites

This scenario requires the following components and configurations:

• An ONTAP ASA storage system with iSCSI VMFS datastores allocated to the workload domain cluster.
• A secondary ONTAP storage system configured to received secondary backups using SnapMirror.
• VCF management domain deployment is complete and the vSphere client is accessible.
• A VI workload domain has been previously deployed.
• Virtual machines are present on the cluster SCV is designated to protect.

For information on configuring iSCSI VMFS datastores as supplemental storage refer to iSCSI as supplemental storage for Management Domains in this documentation. The process for using OTV to deploy datastores is identical for management and workload domains.

In addition to replicating backups taken with SCV to secondary storage, offsite copies of data can be made to object storage on one of the three (3) leading cloud providers using NetApp BlueXP backup and recovery for VMs. For more information refer to the solution 3-2-1 Data Protection for VMware with SnapCenter Plug-in and BlueXP backup and recovery for VMs.
Deployment Steps

To deploy the SnapCenter Plug-in and use it to create backups, and restore VMs and datastores, complete the following steps:

**Deploy and use SCV to protect data in a VI workload domain**

Complete the following steps to deploy, configure, and use SCV to protect data in a VI workload domain:
Deploy the SnapCenter Plug-in for VMware vSphere

The SnapCenter Plug-in is hosted on the VCF management domain but registered to the vCenter for the VI workload domain. One SCV instance is required for each vCenter instance and, keep in mind that, a Workload domain can include multiple clusters managed by a single vCenter instance.

Complete the following steps from the vCenter client to deploy SCV to the VI workload domain:

1. Download the OVA file for the SCV deployment from the download area of the NetApp support site HERE.
2. From the management domain vCenter Client, select to Deploy OVF Template.

3. In the Deploy OVF Template wizard, click on the Local file radio button and then select to upload the previously downloaded OVF template. Click on Next to continue.
4. On the **Select name and folder** page, provide a name for the SCV data broker VM and a folder on the management domain. Click on **Next** to continue.

5. On the **Select a compute resource** page, select the management domain cluster or specific ESXi host within the cluster to install the VM to.

6. Review information pertaining to the OVF template on the **Review details** page and agree to the licensing terms on the **Licensing agreements** page.

7. On the **Select storage** page choose the datastore which the VM will be installed to and select the **virtual disk format** and **VM Storage Policy**. In this solution, the VM will be installed on an iSCSI VMFS datastore located on an ONTAP storage system, as previously deployed in a separate section of this documentation. Click on **Next** to continue.
8. On the **Select network** page, select the management network that is able to communicate with the workload domain vCenter appliance and both the primary and secondary ONTAP storage systems.

9. On the **Customize template** page fill out all information required for the deployment:
   - FQDN or IP, and credentials for the workload domain vCenter appliance.
   - Credentials for the SCV administrative account.
   - Credentials for the SCV maintenance account.
   - IPv4 Network Properties details (IPv6 can also be used).
   - Date and Time settings.

   Click on **Next** to continue.
10. Finally, on the **Ready to complete page**, review all settings and click on Finish to start the deployment.
Add Storage Systems to SCV

Once the SnapCenter Plug-in is installed complete the following steps to add storage systems to SCV:

1. SCV can be accessed from the main menu in the vSphere Client.

2. At the top of the SCV UI interface, select the correct SCV instance that matches the vSphere cluster to be protected.
3. Navigate to **Storage Systems** in the left-hand menu and click on **Add** to get started.

4. On the **Add Storage System** form, fill in the IP address and credentials of the ONTAP storage system to be added, and click on **Add** to complete the action.
5. Repeat this procedure for any additional storage systems to be managed, including any systems to be used as secondary backup targets.
Configure backup policies in SCV

For more information on creating SCV backup policies refer to Create backup policies for VMs and datastores.

Complete the following steps to create a new backup policy:

1. From the left-hand menu select Policies and click on Create to begin.

2. On the New Backup Policy form, provide a Name and Description for the policy, the Frequency at which the backups will take place, and the Retention period which specifies how long the backup is retained.

   Locking Period enables the ONTAP SnapLock feature to create tamper proof snapshots and allows configuration of the locking period.

   For Replication Select to update the underlying SnapMirror or SnapVault relationships for the ONTAP storage volume.

   SnapMirror and SnapVault replication are similar in that they both utilize ONTAP SnapMirror technology to asynchronously replicate storage volumes to a secondary storage system for increased protection and security. For SnapMirror relationships, the retention schedule specified in the SCV backup policy will govern retention for both the primary and secondary volume. With SnapVault relationships, a separate retention schedule can be established on the secondary storage system for longer term or differing retention schedules. In this case the snapshot label is specified in the SCV backup policy and in the policy associated with the secondary volume, to identify which volumes to apply the independent retention schedule to.

   Choose any additional advanced options and click on Add to create the policy.
Create resource groups in SCV

For more information on creating SCV Resource Groups refer to Create resource groups.

Complete the following steps to create a new resource group:

1. From the left-hand menu select **Resource Groups** and click on **Create** to begin.

2. On the **General info & notification** page, provide a name for the resource group, notification settings, and any additional options for the naming of the snapshots.

3. On the **Resource** page select the datastores and VM’s to be protected in the resource group. Click on **Next** to continue.

   Even when only specific VMs are selected, the entire datastore is always backed up. This is because ONTAP takes snapshots of the volume hosting the datastore. However, note that selecting only specific VMs for backup limits the ability to restore to only those VMs.
4. On the Spanning disks page select the option for how to handle VMs with VMDK’s that span multiple datastores. Click on Next to continue.
5. On the Policies page select a previously created policy or multiple policies that will be used with this resource group. Click on Next to continue.
6. On the **Schedules** page establish for when the backup will run by configuring the recurrence and time of day. Click on **Next** to continue.
7. Finally review the **Summary** and click on **Finish** to create the resource group.
8. With the resource group created click on the Run Now button to run the first backup.

9. Navigate to the Dashboard and, under Recent Job Activities click on the number next to Job ID to open the job monitor and view the progress of the running job.
Use SCV to restore VMs, VMDKs and files

The SnapCenter Plug-in allows restores of VMs, VMDKs, files, and folders from primary or secondary backups.

VMs can be restored to the original host, or to an alternate host in the same vCenter Server, or to an alternate ESXi host managed by the same vCenter or any vCenter in linked mode.

vVol VMs can be restored to the original host.

VMDKs in traditional VMs can be restored to either the original or to an alternate datastore.

VMDKs in vVol VMs can be restored to the original datastore.

Individual files and folders in a guest file restore session can be restored, which attaches a backup copy of a virtual disk and then restores the selected files or folders.

Complete the following steps to restore VMs, VMDKs or individual folders.
Complete the following steps to restore a VM with SCV:

1. Navigate to the VM to be restored in the vSphere client, right click and navigate to **SnapCenter Plug-in for VMware vSphere**. Select **Restore** from the sub-menu.
An alternative is to navigate to the datastore in inventory and then under the **Configure** tab go to **SnapCenter Plug-in for VMware vSphere > Backups**. From the chosen backup, select the VMs to be restored.

2. In the **Restore** wizard select the backup to be used. Click on **Next** to continue.

3. On the **Select scope** page fill out all required fields:
• **Restore scope** - Select to restore the entire virtual machine.

• **Restart VM** - Choose whether to start the VM after the restore.

• **Restore Location** - Choose to restore to the original location or to an alternate location. When choosing alternate location select the options from each of the fields:
  - **Destination vCenter Server** - local vCenter or alternate vCenter in linked mode
  - **Destination ESXi host**
  - **Network**
  - **VM name after restore**
  - **Select datastore**

4. On the **Select location** page, choose to restore the VM from the primary or secondary ONTAP storage system. Click on **Next** to continue.
5. Finally, review the **Summary** and click on **Finish** to start the restore job.

6. The restore job progress can be monitored from the **Recent Tasks** pane in the vSphere Client and from the job monitor in SCV.
ON Tap Tools allows full restore of VMDK’s to their original location or the ability to attach a VMDK as a new disk to a host system. In this scenario a VMDK will be attached to a Windows host in order to access the file system.

To attach a VMDK from a backup, complete the following steps:

1. In the vSphere Client navigate to a VM and, from the Actions menu, select SnapCenter Plug-in for VMware vSphere > Attach Virtual Disk(s).

2. In the Attach Virtual Disk(s) wizard, select the backup instance to be used and the particular VMDK to be attached.
Filter options can be used to locate backups and to display backups from both primary and secondary storage systems.
3. After selecting all options, click on the **Attach** button to begin the restore process and attached the VMDK to the host.

4. Once the attach procedure is complete the disk can be accessed from the OS of the host system. In this case SCV attached the disk with its NTFS file system to the E: drive of our Windows SQL Server and the SQL database files on the file system are accessible through File Explorer.
Guest File System Restore using SnapCenter Plug-in

ONTAP Tools features guest file system restores from a VMDK on Windows Server OSes. This is performed centrally from the SnapCenter Plug-in interface.

For detailed information refer to Restore guest files and folders at the SCV documentation site.

To perform a guest file system restore for a Windows system, complete the following steps:

1. The first step is to create Run As credentials to provide access to the Windows host system. In the vSphere Client navigate to the CSV plug-in interface and click on Guest File Restore in the main menu.

2. Under Run As Credentials click on the + icon to open the Run As Credentials window.

3. Fill in a name for the credentials record, an administrator username and password for the Windows system, and then click on the Select VM button to select an optional Proxy VM to be used for the restore.
4. On the Proxy VM page provide a name for the VM and locate it by searching by ESXi host or by name. Once selected, click on **Save**.
5. Click on Save again in the Run As Credentials window to complete saving the record.

6. Next, navigate to a VM in the inventory. From the Actions menu, or by right-clicking on the VM, select SnapCenter Plug-in for VMware vSphere > Guest File Restore.
7. On the Restore Scope page of the Guest File Restore wizard, select the backup to restore from, the particular VMDK, and the location (primary or secondary) to restore the VMDK from. Click on Next to continue.
8. On the **Guest Details** page, select to use **Guest VM** or **Use Gues File Restore proxy VM** for the restore. Also, fill out email notification settings here if desired. Click on **Next** to continue.
9. Finally, review the **Summary** page and click on **Finish** to begin the Guest File System Restore session.

10. Back in the SnapCenter Plug-in interface, navigate to **Guest File Restore** again and view the running session under **Guest Session Monitor**. Click on the icon under **Browse Files** to continue.

11. In the **Guest File Browse** wizard select the folder or files to restore and the file system location to restore them to. Finally, click on **Restore** to start the **Restore** process.
12. The restore job can be monitored from the vSphere Client task pane.

Additional information

For information on configuring VCF refer to VMware Cloud Foundation Documentation.

For information on configuring ONTAP storage systems refer to the ONTAP 9 Documentation center.

For information on using the SnapCenter Plug-in for VMware vSphere refer to the SnapCenter Plug-in for VMware vSphere documentation.

VMware Cloud Foundation (VCF) is an integrated software defined data center (SDDC) platform that provides a complete stack of software-defined infrastructure for running enterprise applications in a hybrid cloud environment. It combines compute, storage, networking, and management capabilities into a unified platform, offering a consistent operational experience across private and public clouds.

Author: Josh Powell, Ravi BCB

VMware Cloud Foundation with NetApp AFF Arrays

This document provides information on storage options available for VMware Cloud Foundation using the NetApp All-Flash AFF storage system. Supported storage options are covered with specific instruction for
creating workload domains with NFS and vVol datastores as principal storage as well as a range of supplemental storage options.

Use Cases

Use cases covered in this documentation:

- Storage options for customers seeking uniform environments across both private and public clouds.
- Automated solution for deploying virtual infrastructure for workload domains.
- Scalable storage solution tailored to meet evolving needs, even when not aligned directly with compute resource requirements.
- Deploy VCF VI Workload Domains using ONTAP as principal storage.
- Deploy supplemental storage to VI Workload Domains using ONTAP Tools for VMware vSphere.

Audience

This solution is intended for the following people:

- Solution architects looking for more flexible storage options for VMware environments that are designed to maximize TCO.
- Solution architects looking for VCF storage options that provide data protection and disaster recovery options with the major cloud providers.
- Storage administrators wanting to understand how to configure VCF with principal and supplemental storage.

Technology Overview

The VCF with NetApp AFF solution is comprised of the following major components:

VMware Cloud Foundation

VMware Cloud Foundation extends VMware’s vSphere hypervisor offerings by combining key components such as SDDC Manager, vSphere, vSAN, NSX, and VMware Aria Suite to create a virtualized datacenter.

The VCF solution supports both native Kubernetes and virtual machine-based workloads. Key services such as VMware vSphere, VMware vSAN, VMware NSX-T Data Center, and VMware vRealize Cloud Management are integral components of the VCF package. When combined, these services establish a software-defined infrastructure capable of efficiently managing compute, storage, networking, security, and cloud management.

VCF is comprised of a single management domain and up to 24 VI Workload Domains that each represent a unit of application-ready infrastructure. A workload domain is comprised of one or more vSphere clusters managed by a single vCenter instance.
For more information on VCF architecture and planning, refer to Architecture Models and Workload Domain Types in VMware Cloud Foundation.

VCF Storage Options

VMware divides storage options for VCF into principal and supplemental storage. The VCF Management Domain must use vSAN as its principal storage. However, there are many supplemental storage options available for the Management Domain and both principal and supplemental storage options available for VI Workload Domains.
Principal Storage for Workload Domains
Principal Storage refers to any type of storage that can be directly connected to a VI Workload Domain during the setup process within SDDC Manager. Principal storage is the first datastore configured for a Workload Domain and includes vSAN, vVols (VMFS), NFS and VMFS on Fibre Channel.

Supplemental Storage for Management and Workload Domains
Supplemental storage is the storage type that can be added to the management or workload domains at any time after the cluster has been created. Supplemental storage represents the widest range of supported storage options, all of which are supported on NetApp AFF arrays.

Additional documentation resources for VMware Cloud Foundation:
* VMware Cloud Foundation Documentation
* Supported Storage Types for VMware Cloud Foundation
* Managing Storage in VMware Cloud Foundation

NetApp All-Flash Storage Arrays
NetApp AFF (All Flash FAS) arrays are high-performance storage solutions designed to leverage the speed and efficiency of flash technology. AFF arrays incorporate integrated data management features such as snapshot-based backups, replication, thin provisioning, and data protection capabilities.

NetApp AFF arrays utilize the ONTAP storage operating system, offering comprehensive storage protocol support for all storage options compatible with VCF, all within a unified architecture.
NetApp AFF storage arrays are available in the highest performing A-Series and a QLC flash-based C-Series. Both series use NVMe flash drives.

For more information on NetApp AFF A-Series storage arrays see the NetApp AFF A-Series landing page.

For more information on NetApp C-Series storage arrays see the NetApp AFF C-Series landing page.

**NetApp ONTAP Tools for VMware vSphere**

ONTAP Tools for VMware vSphere (OTV) allows administrators to manage NetApp storage directly from within the vSphere Client. ONTAP Tools allows you to deploy and manage datastores, as well as provision vVol datastores.

ONTAP Tools allows mapping of datastores to storage capability profiles which determine a set of storage system attributes. This allows the creation of datastores with specific attributes such as storage performance and QoS.

ONTAP Tools also includes a **VMware vSphere APIs for Storage Awareness (VASA) Provider** for ONTAP storage systems which enables the provisioning of VMware Virtual Volumes (vVols) datastores, creation and use of storage capability profiles, compliance verification, and performance monitoring.

For more information on NetApp ONTAP tools see the ONTAP tools for VMware vSphere Documentation page.

**Solution Overview**

In the scenarios presented in this documentation we will demonstrate how to use ONTAP storage systems as principal storage for VCF VI Workload Domain deployments. In addition, we will install and use ONTAP Tools for VMware vSphere to configure supplemental datastores for VI Workload Domains.

Scenarios covered in this documentation:

- **Configure and use an NFS datastore as principal storage during VI Workload Domain deployment.** Click here for deployment steps.
- **Install and demonstrate the use of ONTAP Tools to configure and mount NFS datastores as supplemental storage in VI Workload Domains.** Click here for deployment steps.

In this scenario we will demonstrate how to configure an NFS datastore as principal storage for the deployment of a VI Workload Domain in VCF. Where appropriate we will refer to external documentation for the steps that must be performed in VCF’s SDDC Manager, and cover those steps that are specific to the storage configuration portion.

Author: Josh Powell, Ravi BCB

**NFS as principal storage for VI Workload Domains**

**Scenario Overview**

This scenario covers the following high level steps:

- Verify networking for the ONTAP storage virtual machine (SVM) and that a logical interface (LIF) is present...
to carry NFS traffic.

• Create an export policy to allow the ESXi hosts access to the NFS volume.
• Create an NFS volume on the ONTAP storage system.
• Create a Network Pool for NFS and vMotion traffic in SDDC Manager.
• Commission hosts in VCF for use in a VI Workload Domain.
• Deploy a VI Workload Domain in VCF using an NFS datastore as principal storage.
• Install NetApp NFS Plug-in for VMware VAAI

Prerequisites

This scenario requires the following components and configurations:

• NetApp AFF storage system with a storage virtual machine (SVM) configured to allow NFS traffic.
• Logical interface (LIF) has been created on the IP network that is to carry NFS traffic and is associated with the SVM.
• VCF management domain deployment is complete and the SDDC Manager interface is accessible.
• 4 x ESXi hosts configured for communication on the VCF management network.
• IP addresses reserved for vMotion and NFS storage traffic on the VLAN or network segment established for this purpose.

When deploying a VI Workload Domain, VCF validates connectivity to the NFS Server. This is done using the management adapter on the ESXi hosts before any additional vmkernel adapter is added with the NFS IP address. Therefore, it is necessary to ensure that either 1) the management network is routable to the NFS Server, or 2) a LIF for the management network has been added to the SVM hosting the NFS datastore volume, to ensure that the validation can proceed.

For information on configuring ONTAP storage systems refer to the ONTAP 9 Documentation center.

For information on configuring VCF refer to VMware Cloud Foundation Documentation.

Deployment Steps

To deploy a VI Workload Domain with an NFS datastore as principal storage, complete the following steps:
Verify networking for ONTAP SVM

Verify that the required logical interfaces have been established for the network that will carry NFS traffic between the ONTAP storage cluster and VI Workload Domain.

1. From ONTAP System Manager navigate to **Storage VMs** in the left-hand menu and click on the SVM to be used for NFS traffic. On the **Overview** tab, under **NETWORK IP INTERFACES**, click on the numeric to the right of **NFS**. In the list verify that the required LIF IP addresses are listed.

![ONTAP System Manager Interface](image)

Alternately, verify the LIFs associated with an SVM from the ONTAP CLI with the following command:

```bash
network interface show -vserver <SVM_NAME>
```

1. Verify that the ESXi hosts can communicate to the ONTAP NFS Server. Log into the ESXi host via SSH and ping the SVM LIF:

```bash
vmkping <IP Address>
```
When deploying a VI Workload Domain, VCF validates connectivity to the NFS Server. This is done using the management adapter on the ESXi hosts before any additional vmkernel adapter is added with the NFS IP address. Therefore, it is necessary to ensure that either 1) the management network is routable to the NFS Server, or 2) a LIF for the management network has been added to the SVM hosting the NFS datastore volume, to ensure that the validation can proceed.
Create Export Policy for sharing NFS volume

Create an export policy in ONTAP System Manager to define access control for NFS volumes.

1. In ONTAP System Manager click on Storage VMs in the left-hand menu and select an SVM from the list.

2. On the Settings tab locate Export Policies and click on the arrow to access.

3. In the New export policy window add a name for the policy, click on the Add new rules button and then on the +Add button to begin adding a new rule.
4. Fill in the IP Addresses, IP address range, or network that you wish to include in the rule. Uncheck the SMB/Cifs and FlexCache boxes and make selections for the access details below. Selecting the UNIX boxes is sufficient for ESXi host access.
When deploying a VI Workload Domain, VCF validates connectivity to the NFS Server. This is done using the management adapter on the ESXi hosts before any additional vmkernel adapter is added with the NFS IP address. Therefore, it is necessary to ensure that the export policy includes the VCF management network in order to allow the validation to proceed.

5. Once all rules have been entered click on the **Save** button to save the new Export Policy.

6. Alternately, you can create export policies and rules in the ONTAP CLI. Refer to the steps for creating an export policy and adding rules in the ONTAP documentation.
   - Use the ONTAP CLI to **Create an export policy**.
   - Use the ONTAP CLI to **Add a rule to an export policy**.
Create NFS volume

Create an NFS volume on the ONTAP storage system to be used as a datastore in the Workload Domain deployment.

1. From ONTAP System Manager navigate to **Storage > Volumes** in the left-hand menu and click on **+Add** to create a new volume.

2. Add a name for the volume, fill out the desired capacity and select the storage VM that will host the volume. Click on **More Options** to continue.
3. Under Access Permissions, select the Export Policy which includes the VCF management network or IP address and NFS network IP addresses that will be used for both validation of the NFS Server and NFS traffic.
When deploying a VI Workload Domain, VCF validates connectivity to the NFS Server. This is done using the management adapter on the ESXi hosts before any additional vmkernel adapter is added with the NFS IP address. Therefore, it is necessary to ensure that either 1) the management network is routable to the NFS Server, or 2) a LIF for the management network has been added to the SVM hosting the NFS datastore volume, to ensure that the validation can proceed.

4. Alternately, ONTAP Volumes can be created in the ONTAP CLI. For more information refer to the lun create command in the ONTAP commands documentation.
Create Network Pool in SDDC Manager

A Network Pool must be created in SDDC Manager before commissioning the ESXi hosts, as preparation for deploying them in a VI Workload Domain. The Network Pool must include the network information and IP address range(s) for VMkernel adapters to be used for communication with the NFS server.

1. From the SDDC Manager web interface navigate to **Network Settings** in the left-hand menu and click on the **+ Create Network Pool** button.

2. Fill out a name for the Network Pool, select the check box for NFS and fill out all networking details. Repeat this for the vMotion network information.
3. Click the **Save** button to complete creating the Network Pool.
Before ESXi hosts can be deployed as a workload domain they must be added to the SDDC Manager inventory. This involves providing the required information, passing validation and starting the commissioning process.

For more information see Commission Hosts in the VCF Administration Guide.

1. From the SDDC Manager interface navigate to **Hosts** in the left-hand menu and click on the **Commission Hosts** button.

2. The first page is a prerequisite checklist. Double-check all prerequisites and select all checkboxes to proceed.
3. In the **Host Addition and Validation** window fill out the **Host FQDN**, **Storage Type**, **The Network Pool** name that includes the vMotion and NFS storage IP addresses to be used for the workload domain, and the credentials to access the ESXi host. Click on **Add** to add the host to the group of hosts to be validated.
4. Once all hosts to be validated have been added, click on the **Validate All** button to continue.
5. Assuming all hosts are validated, click on **Next** to continue.
6. Review the list of hosts to be commissioned and click on the **Commission** button to start the process. Monitor the commissioning process from the Task pane in SDDC manager.
## Commission Hosts

<table>
<thead>
<tr>
<th>Host Name</th>
<th>Network Pool Name</th>
<th>IP Address</th>
<th>Storage Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>vcf-wkld-ess04.sddc.netapp.com</td>
<td>NFS_NPO1</td>
<td>172.21.166.138</td>
<td>NFS</td>
</tr>
<tr>
<td>vcf-wkld-ess03.sddc.netapp.com</td>
<td>NFS_NPO1</td>
<td>172.21.166.137</td>
<td>NFS</td>
</tr>
<tr>
<td>vcf-wkld-ess02.sddc.netapp.com</td>
<td>NFS_NPO1</td>
<td>172.21.166.136</td>
<td>NFS</td>
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<tr>
<td>vcf-wkld-ess01.sddc.netapp.com</td>
<td>NFS_NPO1</td>
<td>172.21.166.135</td>
<td>NFS</td>
</tr>
</tbody>
</table>
Deploy VI Workload Domain

Deploying VI workload domains is accomplished using the VCF Cloud Manager interface. Only the steps related to the storage configuration will be presented here.

For step-by-step instructions on deploying a VI workload domain refer to Deploy a VI Workload Domain Using the SDDC Manager UI.

1. From the SDDC Manager Dashboard click on + Workload Domain in the upper right hand corner to create a new Workload Domain.

2. In the VI Configuration wizard fill out the sections for General Info, Cluster, Compute, Networking, and Host Selection as required.

For information on filling out the information required in the VI Configuration wizard refer to Deploy a VI Workload Domain Using the SDDC Manager UI.
1. In the NFS Storage section fill out the Datastore Name, the folder mount point of the NFS volume and the IP address of the ONTAP NFS storage VM LIF.

<table>
<thead>
<tr>
<th>VI Configuration</th>
<th>NFS Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 General Info</td>
<td>NFS Share Details</td>
</tr>
<tr>
<td>2 Cluster</td>
<td>Datastore Name: VCF_WKLD_D1</td>
</tr>
<tr>
<td>3 Compute</td>
<td>Folder: /VCF_WKLD_D1</td>
</tr>
<tr>
<td>4 Networking</td>
<td>NFS Server IP Address: 172.21.118.163</td>
</tr>
<tr>
<td>5 Host Selection</td>
<td></td>
</tr>
</tbody>
</table>

2. In the VI Configuration wizard complete the Switch Configuration and License steps, and then click on **Finish** to start the Workload Domain creation process.
3. Monitor the process and resolve any validation issues that arise during the process.

**Install NetApp NFS Plug-in for VMware VAAI**

The NetApp NFS Plug-in for VMware VAAI integrates the VMware Virtual Disk Libraries installed on the ESXi host and provides higher performance cloning operations that finish faster. This is a recommended procedure when using ONTAP storage systems with VMware vSphere.

For step-by-step instructions on deploying the NetApp NFS Plug-in for VMware VAAI following the instructions at [Install NetApp NFS Plug-in for VMware VAAI](#).

**Video demo for this solution**

*NFS Datastores as Principal Storage for VCF Workload Domains*
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