

# vSphere with Tanzu Configuration and Management

Update 3

VMware vSphere 7.0

vCenter Server 7.0

VMware ESXi 7.0

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# Contents

vSphere with Tanzu Configuration and Management	11
<b>1 Updated Information</b>	<b>12</b>
<b>2 vSphere with Tanzu Concepts</b>	<b>13</b>
What Is vSphere with Tanzu?	13
What Is a vSphere Pod?	16
What Is a Tanzu Kubernetes Cluster?	18
When to Use vSphere Pods and Tanzu Kubernetes Clusters	20
Using Virtual Machines in vSphere with Tanzu	20
vSphere with Tanzu User Roles and Workflows	22
How Does vSphere with Tanzu Change the vSphere Environment?	33
Licensing for vSphere with Tanzu	34
<b>3 vSphere with Tanzu Architecture and Components</b>	<b>37</b>
vSphere with Tanzu Architecture	37
Tanzu Kubernetes Grid Service Architecture	41
Tanzu Kubernetes Cluster Tenancy Model	43
vSphere with Tanzu Authentication	44
vSphere with Tanzu Networking	46
vSphere with Tanzu Security	46
vSphere with Tanzu Storage	47
<b>4 Networking for vSphere with Tanzu</b>	<b>50</b>
Supervisor Cluster Networking	50
Tanzu Kubernetes Cluster Networking	55
Configuring NSX-T Data Center for vSphere with Tanzu	56
System Requirements for Setting Up vSphere with Tanzu with NSX-T Data Center	58
Topologies for a Supervisor Cluster with NSX-T Data Center	64
Best Practice Considerations for Configuring the Supervisor Cluster with NSX-T Data Center	66
Install and Configure NSX-T Data Center for vSphere with Tanzu	66
Configuring vSphere Networking and NSX Advanced Load Balancer for vSphere with Tanzu	84
NSX Advanced Load Balancer Components	86
System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and NSX Advanced Load Balancer	87
Topology for Supervisor Cluster with vSphere Networking and NSX Advanced Load Balancer	91

Install and Configure the NSX Advanced Load Balancer	92
Configuring vSphere Networking and HA Proxy Load Balancer for vSphere with Tanzu	104
System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and HA Proxy Load Balancer	105
Topologies for Deploying the HAProxy Load Balancer	108
Create a vSphere Distributed Switch for a Supervisor Cluster for Use with HAProxy Load Balancer	116
Install and Configure the HAProxy Load Balancer	117
<b>5 Configuring and Managing a Supervisor Cluster</b>	<b>122</b>
Prerequisites for Configuring vSphere with Tanzu on a Cluster	123
Enable Workload Management with vSphere Networking	125
Enable Workload Management with NSX-T Data Center Networking	133
Assign the Tanzu Edition License to a Supervisor Cluster	136
Replace the VIP Certificate to Securely Connect to the Supervisor Cluster API Endpoint	136
Integrate the Tanzu Kubernetes Grid Service on the Supervisor Cluster with Tanzu Mission Control	137
Set the Default CNI for Tanzu Kubernetes Clusters	139
Add Workload Networks to a Supervisor Cluster Configured with VDS Networking	141
Change the Control Plane Size of a Supervisor Cluster	142
Change the Management Network Settings on a Supervisor Cluster	142
Change the Workload Network Settings on a Supervisor Cluster Configured with VDS Networking	143
Change Workload Network Settings on a Supervisor Cluster Configured with NSX-T Data Center	144
Resolving Errors Health Statuses on Supervisor Cluster During Initial Configuration Or Upgrade	145
<b>6 Creating and Managing Content Libraries in vSphere with Tanzu</b>	<b>149</b>
Creating and Managing Content Libraries for Tanzu Kubernetes releases	149
About Tanzu Kubernetes release Distributions	149
Create, Secure, and Synchronize a Subscribed Content Library for Tanzu Kubernetes releases	150
Create, Secure, and Synchronize a Local Content Library for Tanzu Kubernetes releases	153
Migrate Tanzu Kubernetes Clusters to a New Content Library	157
Import the HAProxy OVA to a Local Content Library	157
Creating and Managing Content Libraries for Stand-Alone VMs in vSphere with Tanzu	158
Create a Content Library for Stand-Alone VMs in vSphere with Tanzu	159
Populate a Content Library with VM Images for Stand-Alone VMs in vSphere with Tanzu	162
Associate a VM Content Library with a Namespace in vSphere with Tanzu	163
Manage VM Content Libraries on a Namespace in vSphere with Tanzu	164

**7 Configuring and Managing vSphere Namespaces 166**

- Create and Configure a vSphere Namespace 166
- Set Default Memory and CPU Reservations and Limits for vSphere Pod Containers 170
- Configure Limitations on Kubernetes Objects in a vSphere Namespace 170
- Monitor and Manage Resources in a vSphere Namespace 171
- Configure a vSphere Namespace for Tanzu Kubernetes releases 172
- Provision a Self-Service Namespace Template 174
  - Create and Configure a Self-Service Namespace Template 176
  - Deactivate a Self-Service Namespace 177
  - Create a Self-Service Namespace 178
  - Create a Self-Service Namespace with Annotations and Labels 178
  - Update a Self-Service Namespace Using kubectl annotate and kubectl label 180
  - Update a Self-Service Namespace Using kubectl edit 181
  - Delete a Self-Service Namespace 183

**8 Managing Supervisor Services with vSphere with Tanzu 184**

- Add a Supervisor Service to vCenter Server 186
- Install a Supervisor Service on Supervisor Clusters 188
- Access the Management Interface of a Supervisor Service on the Supervisor Cluster 190
- Add a New Version to a Supervisor Service 190
- View Supervisor Services Installed on a Supervisor Cluster 191
- Deactivate a Supervisor Service or a Version 192
- Activate a Supervisor Service Version on vCenter Server 193
- Uninstall a Supervisor Service from a Supervisor Cluster 194
- Delete a Supervisor Service Version 194
- Delete a Supervisor Service 195

**9 Connecting to vSphere with Tanzu Clusters 197**

- Download and Install the Kubernetes CLI Tools for vSphere 197
- Configure Secure Login for vSphere with Tanzu Clusters 198
- Connect to the Supervisor Cluster as a vCenter Single Sign-On User 199
- Authenticating with Tanzu Kubernetes Clusters 201
- Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User 202
- Connect to the Tanzu Kubernetes Cluster Control Plane as the Administrator 204
- SSH to Tanzu Kubernetes Cluster Nodes as the System User Using a Private Key 205
- SSH to Tanzu Kubernetes Cluster Nodes as the System User Using a Password 208
  - Create a Linux Jump Host VM 209
- Grant Developer Access to Tanzu Kubernetes Clusters 211

**10 Using Persistent Storage in vSphere with Tanzu 213**

- How vSphere with Tanzu Integrates with vSphere Storage 217

Functionality Supported by vSphere CNS-CSI and Paravirtual CSI in vSphere with Tanzu	220
Storage Permissions in vSphere with Tanzu	221
Create Storage Policies for vSphere with Tanzu	222
Change Storage Settings on the Supervisor Cluster	224
Change Storage Settings on a Namespace	225
Display Storage Classes in a vSphere Namespace or Tanzu Kubernetes Cluster	225
Provision a Dynamic Persistent Volume for a Stateful Application	226
Provision a Static Persistent Volume in a Tanzu Kubernetes Cluster	228
Creating ReadWriteMany Persistent Volumes in vSphere with Tanzu	230
Volume Expansion in vSphere with Tanzu	232
Expand a Persistent Volume in Offline Mode	233
Expand a Persistent Volume in Online Mode	235
Monitor Persistent Volumes in the vSphere Client	236
Monitor Volume Health in a vSphere Namespace or Tanzu Kubernetes Cluster	238
Using vSAN Data Persistence Platform with Modern Stateful Services	240
Tag Storage Devices for vSAN Direct	245
Set Up vSAN Direct for vSphere with Tanzu	251
Enable Stateful Services in vSphere with Tanzu	253
Monitor Stateful Services in vSphere with Tanzu	256
Check Storage Policies Available for Stateful Services	257
Create vSAN SNA Storage Policy	257
Create vSAN Direct Storage Policy	258
<b>11 Deploying Workloads to vSphere Pods</b>	<b>260</b>
Get and Use the Supervisor Cluster Context	260
Deploy an Application to a vSphere Pod on a vSphere Namespace	261
Deploy an Application to a vSphere Pod Using the Embedded Harbor Registry	262
Scale a vSphere Pod Application	263
Deploy a Confidential vSphere Pod	264
<b>12 Deploying and Managing Virtual Machines in vSphere with Tanzu</b>	<b>268</b>
Create a VM Class in vSphere with Tanzu	272
Attributes of VM Classes in vSphere with Tanzu	274
Add PCI Devices to a VM Class in vSphere with Tanzu	275
Edit or Delete a VM Class in vSphere with Tanzu	277
Associate a VM Class with a Namespace in vSphere with Tanzu	278
Manage VM Classes on a Namespace in vSphere with Tanzu	280
View VM Resources Available on a Namespace in vSphere with Tanzu	280
Deploy a Virtual Machine in vSphere with Tanzu	283
Install the NVIDIA Guest Driver in a VM in vSphere with Tanzu	286
Monitor Virtual Machines Available in vSphere with Tanzu	288

**13 Provisioning and Operating TKGS Clusters 290**

- Workflow for Provisioning Tanzu Kubernetes Clusters 290
- Virtual Machine Classes for Tanzu Kubernetes Clusters 294
- Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API 296
  - Requirements for Using the Tanzu Kubernetes Grid Service v1alpha2 API 296
  - Configuration Parameters for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API 297
  - Example YAML for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API 303
  - Updating a Tanzu Kubernetes Release After the Cluster Spec Is Converted to the Tanzu Kubernetes Grid Service v1alpha2 API 305
  - Configuring a Tanzu Kubernetes Cluster with a Routable Pod Network Using the v1alpha2 API 310
    - Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha2 API 313
    - Examples for Configuring the Tanzu Kubernetes Grid Service Using the v1alpha2 API 317
  - Scale a Tanzu Kubernetes Cluster Using the Tanzu Kubernetes Grid Service v1alpha2 API 322
- Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API 329
  - Workflow for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API 329
  - Configuration Parameters for Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API 334
  - Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API 343
  - Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API 352
  - Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API 356
  - Scale a Tanzu Kubernetes Cluster Using the Tanzu Kubernetes Grid Service v1alpha1 API 361
- Delete a Tanzu Kubernetes Cluster 367
- Specify a Default Text Editor for Kubectl 369
- Monitor Tanzu Kubernetes Cluster Status Using kubectl 370
- Monitor Tanzu Kubernetes Cluster Status Using the vSphere Client 371
- Check Tanzu Kubernetes Cluster Readiness 372
- Check Tanzu Kubernetes Cluster Health 377
- Check Tanzu Kubernetes Machine Health 379
- Get Tanzu Kubernetes Cluster Secrets 381
- Use Tanzu Kubernetes Cluster Networking Commands 382
- Use Tanzu Kubernetes Cluster Operational Commands 382
- View Tanzu Kubernetes Cluster Lifecycle Status 384
- View the Full Resource Hierarchy for a Tanzu Kubernetes Cluster 386

**14 Deploying Workloads and Extensions on TKGS Clusters 387**

Deploy Workloads on Tanzu Kubernetes Clusters	387
Deploy a Test Workload to a Tanzu Kubernetes Cluster	387
Install and Run Octant	388
Tanzu Kubernetes Service Load Balancer Example	389
Tanzu Kubernetes Service Load Balancer with Static IP Address Example	391
Tanzu Kubernetes Service Load Balancer Examples for Local Traffic Policy and Source IP Ranges	393
Tanzu Kubernetes Ingress Example Using Nginx	395
Tanzu Kubernetes Storage Class Example	398
Tanzu Kubernetes Persistent Volume Claim Examples	399
Tanzu Kubernetes Guestbook Tutorial	401
Guestbook Example YAML Files	403
Using Pod Security Policies with Tanzu Kubernetes Clusters	408
Example Role Bindings for Pod Security Policy	410
Example Role for Pod Security Policy	412
Deploy TKG Extensions on Tanzu Kubernetes Clusters	413
Download the TKG Extensions v1.3.1 Bundle	413
Install the TKG Extensions Prerequisites	414
Deploy and Manage the TKG Extension for Fluent Bit Logging	418
Deploy and Manage the TKG Extension for Contour Ingress	425
Deploy and Manage the TKG Extension for Prometheus Monitoring	434
Deploy and Manage the TKG Extension for Grafana Monitoring	447
Deploy and Manage the TKG Extension for Harbor Registry	454
Deploy and Manage the TKG Extension for External DNS Service Discovery	465
Deploy AI/ML Workloads on Tanzu Kubernetes Clusters	470
About Deploying AI/ML Workloads on TKGS Clusters	470
vSphere Administrator Workflow for Deploying AI/ML Workloads on TKGS Clusters (vGPU)	471
Cluster Operator Workflow for Deploying AI/ML Workloads on TKGS Clusters	484
vSphere Administrator Addendum for Deploying AI/ML Workloads on TKGS Clusters (vGPU and Dynamic DirectPath IO)	492
Cluster Operator Addendum for Deploying AI/ML Workloads on TKGS Clusters (DLS)	493
<b>15 Using a Container Registry for vSphere with Tanzu Workloads</b>	<b>496</b>
Enable the Embedded Harbor Registry on the Supervisor Cluster	497
Log In to the Embedded Harbor Registry Console	497
Download and Install the Embedded Harbor Registry Certificate	498
Configure a Docker Client with the Embedded Harbor Registry Certificate	499
Install the vSphere Docker Credential Helper and Connect to the Registry	501
Push Images to the Embedded Harbor Registry	503
Purge Images from the Embedded Harbor Registry	505
Use the Embedded Harbor Registry with Tanzu Kubernetes Clusters	506



Use an External Container Registry with Tanzu Kubernetes Clusters 509

## 16 Working with vSphere Lifecycle Manager 515

Requirements 515

Enable vSphere with Tanzu on a Cluster Managed by vSphere Lifecycle Manager 516

Upgrade a Supervisor Cluster 516

Add Hosts to a Supervisor Cluster 517

Remove Hosts from a Supervisor Cluster 518

Disable a Supervisor Cluster 518

## 17 Updating the vSphere with Tanzu Environment 520

About vSphere with Tanzu Updates 520

Network Topology Upgrade 523

    Upgrade the NSX-T Network Topology 526

    Upgrade vSphere Distributed Switch 527

Update the Supervisor Cluster by Performing a vSphere Namespaces Update 528

Supervisor Cluster Auto Upgrade 529

Update the vSphere Plugin for kubectl 530

List of Tanzu Kubernetes releases 530

Update Tanzu Kubernetes Clusters 531

    Update a Tanzu Kubernetes Cluster by Upgrading the Kubernetes Version 532

    Update a Tanzu Kubernetes Cluster by Changing the VirtualMachineClass 534

    Update a Tanzu Kubernetes Cluster by Changing the Storage Class 537

    Update Tanzu Kubernetes Clusters Using the Patch Method 539

## 18 Backing Up and Restoring vSphere with Tanzu 542

Considerations for Backing Up and Restoring vSphere with Tanzu 542

Install and Configure the Velero Plugin for vSphere on the Supervisor Cluster 544

Backup and Restore vSphere Pods Using the Velero Plugin for vSphere 554

Install and Configure the Velero Plugin for vSphere on a Tanzu Kubernetes Cluster 557

Backup and Restore Tanzu Kubernetes Cluster Workloads Using the Velero Plugin for vSphere 560

Install and Configure Standalone Velero and Restic on a Tanzu Kubernetes Cluster 562

Backup and Restore Tanzu Kubernetes Cluster Workloads Using Standalone Velero and Restic 567

Backup and Restore vCenter Server 575

Backup and Restore NSX-T Data Center 575

## 19 Troubleshooting vSphere with Tanzu 576

Storage Best Practices and Troubleshooting 576

    Use Anti-Affinity Rules for Control Plane VMs on Non-vSAN Datastores 576

Storage Policy Removed from vSphere Continues to Appear as Kubernetes Storage Class	577
Use External Storage with vSAN Direct	578
Troubleshooting Networking	580
Register vCenter Server with NSX Manager	580
Unable to Change NSX Appliance Password	580
Troubleshooting Failed Workflows and Unstable NSX Edges	581
Collect Support Bundles for Troubleshooting NSX-T	581
Collect Log Files for NSX-T	582
Restart the WCP Service If the NSX-T Management Certificate, Thumbprint, or IP Address Changes	582
VDS Required for Host Transport Node Traffic	583
Troubleshooting the NSX Advanced Load Balancer	584
Collect Support Bundles for Troubleshooting	584
Troubleshooting Network Topology Upgrade	585
Upgrade Precheck Fails Due to Insufficient Edge Load Balancer Capacity	585
Supervisor Cluster Workload Namespaces Skipped During Upgrade	585
Load Balancer Service Skipped During Upgrade	586
Troubleshooting Tanzu Kubernetes Clusters	586
Collect a Support Bundle for Tanzu Kubernetes Clusters	586
Troubleshoot vCenter Single Sign-On Connection Errors	586
Troubleshoot Subscribed Content Library Errors	587
Troubleshoot Cluster Provisioning Errors	587
Troubleshoot Workload Deployment Errors	588
Troubleshoot Virtual Machine Class Errors	588
Restart a Failed Tanzu Kubernetes Cluster Update Job	589
Troubleshooting Workload Management	590
Collect the Support Bundle for Workload Management	590
Tail the Workload Management Log File	590
Troubleshoot Workload Management Enablement Cluster Compatibility Errors	591
Shut Down and Start Up the vSphere with Tanzu Workload Domain	592

# vSphere with Tanzu Configuration and Management

*vSphere with Tanzu Configuration and Management* provides information about configuring and managing vSphere with Tanzu by using the vSphere Client. It also provides information about using kubectl to connect to namespaces running on vSphere with Tanzu and run Kubernetes workloads on designated namespaces.

*vSphere with Tanzu Configuration and Management* provides an overview of the platform architecture as well as considerations and best practices for setting up storage, compute, and networking that meet the specific requirements of vSphere with Tanzu. It provides instructions for enabling vSphere with Tanzu on existing vSphere clusters, creating and managing namespaces, and monitoring Tanzu Kubernetes clusters that are created by using the VMware Tanzu™ Kubernetes Grid™ Service.

This information also provides guidelines about establishing a session with the vSphere with Tanzu Kubernetes control plane through kubectl, running a sample application, and creating Tanzu Kubernetes clusters by using the VMware Tanzu™ Kubernetes Grid™ Service.

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## Intended Audience

*vSphere with Tanzu Configuration and Management* is intended for vSphere administrators who want to enable vSphere with Tanzu in vSphere, configure and provide namespaces to DevOps teams, as well as manage and monitor Kubernetes workloads in vSphere. vSphere administrators who want to use vSphere with Tanzu should have basic knowledge of containers and Kubernetes.

This information is also intended for DevOps engineers who want to establish a session with the vSphere with Tanzu control plane, run Kubernetes workloads, and deploy Kubernetes clusters by using the VMware Tanzu™ Kubernetes Grid™ Service.

# Updated Information

# 1

*vSphere with Kubernetes Configuration and Management* is updated regularly with new information and fixes as needed.

This table provides the update history of the *vSphere with Kubernetes Configuration and Management*.

Revision	Description
5 NOV 2021	<ul style="list-style-type: none"><li>■ Added a link for installing TKG 1.4 Packages on Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service. See <a href="#">Deploy TKG Extensions on Tanzu Kubernetes Clusters</a>.</li></ul>
29 OCT 2021	<ul style="list-style-type: none"><li>■ Updated the documentation for deploying vGPU workloads on TKGS clusters. See <a href="#">Deploy AI/ML Workloads on Tanzu Kubernetes Clusters</a>.</li><li>■ Updated the Velero Plugin for vSphere installation documentation. See <a href="#">Install and Configure the Velero Plugin for vSphere on the Supervisor Cluster</a>.</li><li>■ Updated RBAC examples. See <a href="#">Example Role Bindings for Pod Security Policy</a>.</li><li>■ Updated the Supervisor Cluster networking. See <a href="#">Supervisor Cluster Networking</a>.</li><li>■ Added a caution to the networking and enabling workload management prerequisite topics that DRS should not be disabled on the Supervisor Cluster and that disabling DRS leads to breaking of your clusters.</li></ul>
21 OCT 2021	<ul style="list-style-type: none"><li>■ Added documentation for deploying AI/ML workloads on vGPU-enabled TKGS clusters. See <a href="#">Deploy AI/ML Workloads on Tanzu Kubernetes Clusters</a>.</li><li>■ Updated <a href="#">Add PCI Devices to a VM Class in vSphere with Tanzu</a> with information about support of PCI devices in passthrough mode.</li><li>■ Moved the listing of Tanzu Kubernetes releases to dedicated <a href="#">Release Notes</a>. Refer to these release notes for all Tanzu Kubernetes release information.</li><li>■ Fixed typos and minor doc bugs.</li></ul>
08 OCT 2021	<ul style="list-style-type: none"><li>■ Updated the Tanzu Kubernetes release version. See <a href="#">List of Tanzu Kubernetes releases and Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API</a>.</li><li>■ Added the procedure for installing the Velero Plugin for vSphere in an air-gapped environment. For more information, see <a href="#">Install and Configure the Velero Plugin for vSphere on the Supervisor Cluster</a>.</li><li>■ Updated information about Supervisor Cluster backup and restore. For more information, see <a href="#">Considerations for Backing Up and Restoring vSphere with Tanzu</a>.</li><li>■ Fixed typos.</li></ul>
05 OCT 2021	Initial release.

# vSphere with Tanzu Concepts

# 2

By using vSphere with Tanzu you can turn a vSphere cluster to a platform for running Kubernetes workloads in dedicated resource pools. Once enabled on a vSphere cluster, vSphere with Tanzu creates a Kubernetes control plane directly in the hypervisor layer. You can then run Kubernetes containers by deploying vSphere Pods, or you can create upstream Kubernetes clusters through the VMware Tanzu™ Kubernetes Grid™ Service and run your applications inside these clusters.

This chapter includes the following topics:

- [What Is vSphere with Tanzu?](#)
- [What Is a vSphere Pod?](#)
- [What Is a Tanzu Kubernetes Cluster?](#)
- [When to Use vSphere Pods and Tanzu Kubernetes Clusters](#)
- [Using Virtual Machines in vSphere with Tanzu](#)
- [vSphere with Tanzu User Roles and Workflows](#)
- [How Does vSphere with Tanzu Change the vSphere Environment?](#)
- [Licensing for vSphere with Tanzu](#)

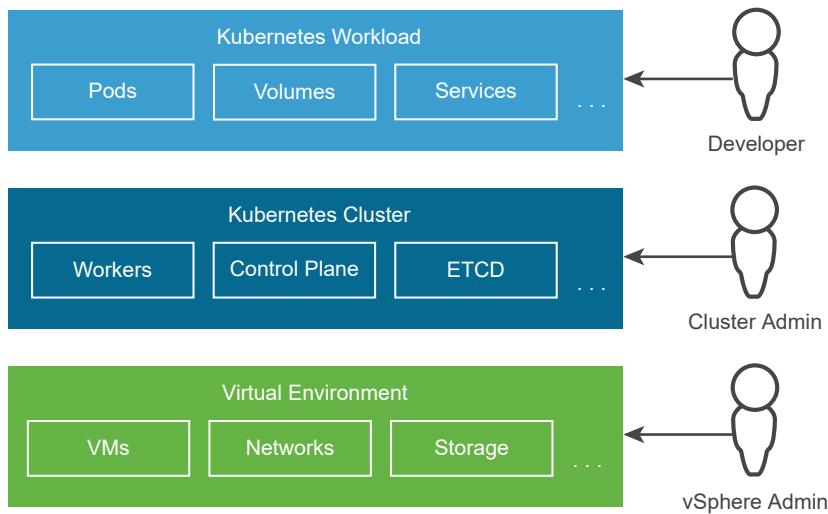
## What Is vSphere with Tanzu?

You can use vSphere with Tanzu to transform vSphere to a platform for running Kubernetes workloads natively on the hypervisor layer. When enabled on a vSphere cluster, vSphere with Tanzu provides the capability to run Kubernetes workloads directly on ESXi hosts and to create upstream Kubernetes clusters within dedicated resource pools.

## The Challenges of Today's Application Stack

Today's distributed systems are constructed of multiple microservices usually running a large number of Kubernetes pods and VMs. A typical stack that is not based on vSphere with Tanzu consists of an underlying virtual environment, with Kubernetes infrastructure that is deployed inside VMs, and respectively Kubernetes pods also running in these VMs. Three separate roles operate each part of the stack, which are application developers, Kubernetes cluster administrators, and vSphere administrators.

Figure 2-1. Today's Application Stack



The different roles do not have visibility or control over each other's environments:

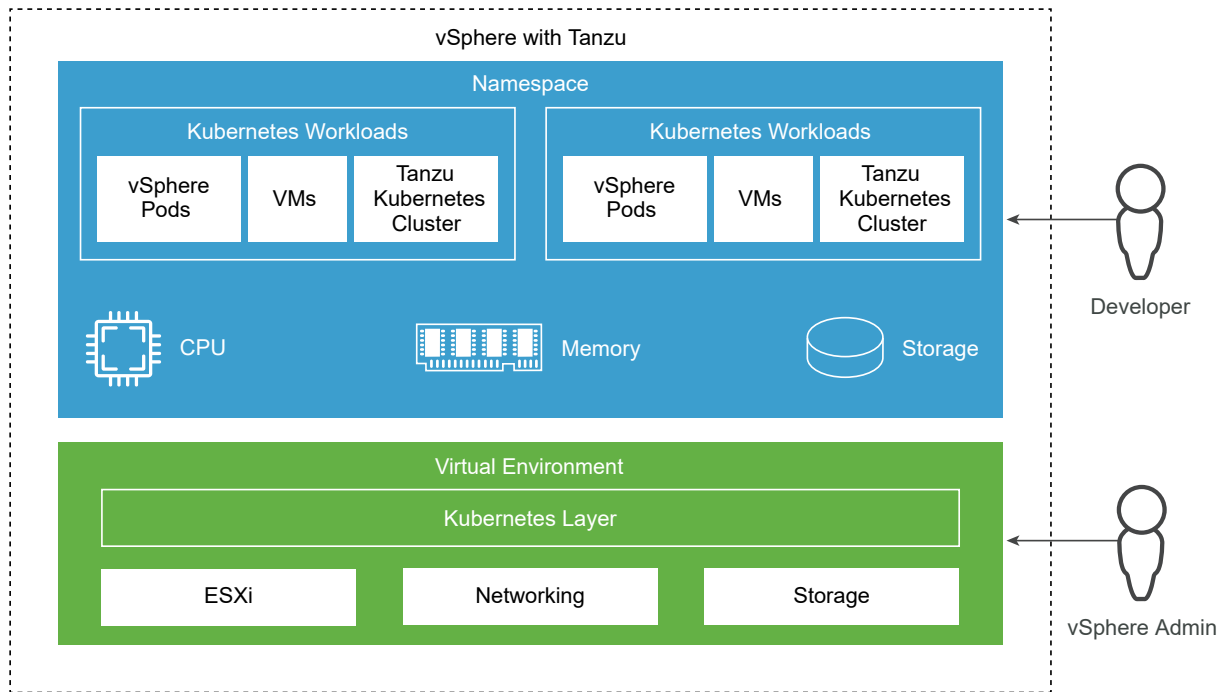
- As an application developer, you can run Kubernetes pods, and deploy and manage Kubernetes based applications. You do not have visibility over the entire stack that is running hundreds of applications.
- As a DevOps engineer, you only have control over the Kubernetes infrastructure, without the tools to manage or monitor the virtual environment and resolve any resource-related and other problems.
- As a vSphere administrator, you have full control over the underlying virtual environment, but you do not have visibility over the Kubernetes infrastructure, the placement of the different Kubernetes objects in the virtual environment, and how they consume resources.

Operations on the full stack can be challenging, because they require communication between all three roles. The lack of integration between the different layers of the stack can also introduce challenges. For example, the Kubernetes scheduler does not have visibility over the vCenter Server inventory and it cannot place pods intelligently.

## How Does vSphere with Tanzu Help?

vSphere with Tanzu creates a Kubernetes control plane directly on the hypervisor layer. As a vSphere administrator, you enable existing vSphere clusters for **Workload Management**, thus creating a Kubernetes layer within the ESXi hosts that are part of the cluster. A cluster enabled with **Workload Management** is called a Supervisor Cluster.

Figure 2-2. vSphere with Tanzu



Having a Kubernetes control plane on the hypervisor layer enables the following capabilities in vSphere:

- As a vSphere administrator, you can create namespaces on the Supervisor Cluster, called vSphere Namespaces, and configure them with specified amount of memory, CPU, and storage. You provide vSphere Namespaces to DevOps engineers.
- As a DevOps engineer, you can run workloads consisting of Kubernetes containers on the same platform with shared resource pools within a vSphere Namespace. In vSphere with Tanzu, containers run inside a special type of VM called vSphere Pod. You can also deploy regular VMs.
- As a DevOps engineer, you can create and manage multiple Kubernetes clusters inside a namespace and manage their lifecycle by using the Tanzu Kubernetes Grid Service. Kubernetes clusters created by using the Tanzu Kubernetes Grid Service are called Tanzu Kubernetes clusters.
- As a vSphere administrator, you can manage and monitor vSphere Pods, VMs, and Tanzu Kubernetes clusters by using the vSphere Client.
- As a vSphere administrator, you have full visibility over vSphere Pods, VMs, and Tanzu Kubernetes clusters running within different namespaces, their placement in the environment, and how they consume resources.

Having Kubernetes running on the hypervisor layer also eases the collaboration between vSphere administrators and DevOps teams, because both roles are working with the same objects.

## What Is a Workload?

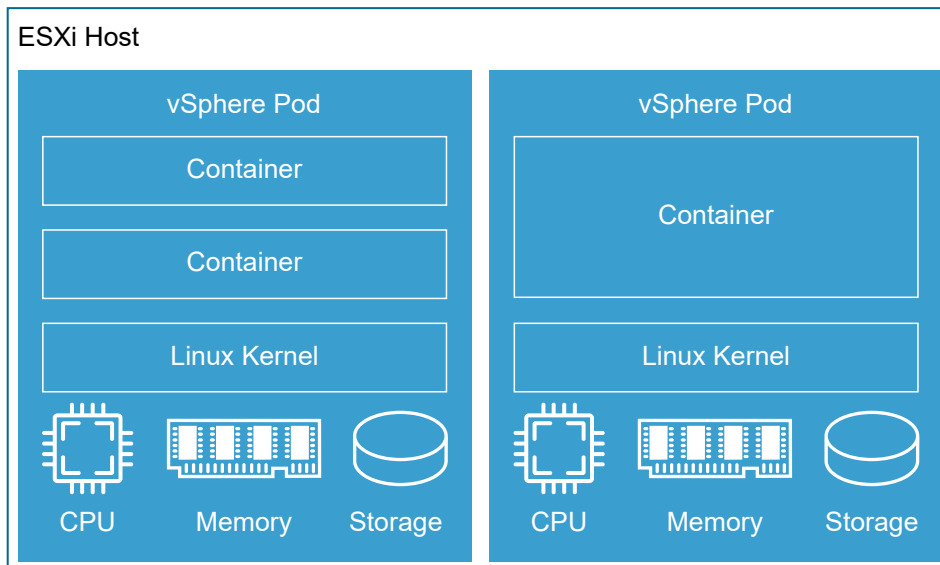
In vSphere with Tanzu, workloads are applications deployed in one of the following ways:

- Applications that consist of containers running inside vSphere Pods, regular VMs, or both.
- Tanzu Kubernetes clusters deployed by using the VMware Tanzu™ Kubernetes Grid™ Service.
- Applications that run inside the Tanzu Kubernetes clusters that are deployed by using the VMware Tanzu™ Kubernetes Grid™ Service.

## What Is a vSphere Pod?

vSphere with Tanzu introduces a new construct that is called vSphere Pod, which is the equivalent of a Kubernetes pod. A vSphere Pod is a VM with a small footprint that runs one or more Linux containers. Each vSphere Pod is sized precisely for the workload that it accommodates and has explicit resource reservations for that workload. It allocates the exact amount of storage, memory, and CPU resources required for the workload to run. vSphere Pods are only supported with Supervisor Clusters that are configured with NSX-T Data Center as the networking stack.

Figure 2-3. vSphere Pods



vSphere Pods are objects in vCenter Server, and therefore enable the following capabilities for workloads:

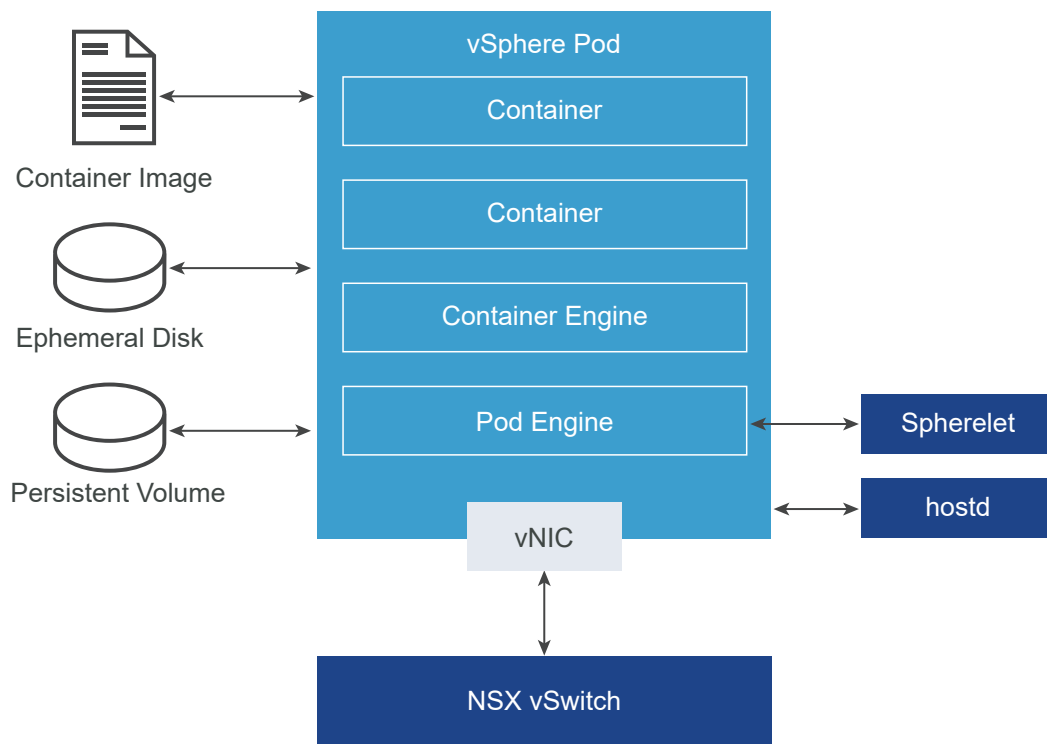
- Strong isolation. A vSphere Pod is isolated in the same manner as a virtual machine. Each vSphere Pod has its own unique Linux kernel that is based on the kernel used in Photon OS. Rather than many containers sharing a kernel, as in a bare metal configuration, in a vSphere Pod, each container has a unique Linux kernel



- **Resource Management.** vSphere DRS handles the placement of vSphere Pods on the Supervisor Cluster.
- **High performance.** vSphere Pods get the same level of resource isolation as VMs, eliminating noisy neighbor problems while maintaining the fast start-up time and low overhead of containers.
- **Diagnostics.** As a vSphere administrator you can use all the monitoring and introspection tools that are available with vSphere on workloads.

vSphere Pods are Open Container Initiative (OCI) compatible and can run containers from any operating system as long as these containers are also OCI compatible.

**Figure 2-4. vSphere Pod Networking and Storage**



vSphere Pods use three types of storage depending on the objects that are stored, that are ephemeral VMDKs, persistent volume VMDKs, and containers image VMDKs. As a vSphere administrator, you configure storage policies for placement of container image cache, ephemeral VMDKs, and control plane VMs on the Supervisor Cluster level. On a vSphere Namespace level, you configure storage policies for placement of persistent volumes and for placement of the VMs of Tanzu Kubernetes clusters. See [Chapter 10 Using Persistent Storage in vSphere with Tanzu](#) for details about the storage requirements and concepts with vSphere with Tanzu.

For networking, vSphere Pods and the VMs of the Tanzu Kubernetes clusters created through the Tanzu Kubernetes Grid Service use the topology provided by NSX-T Data Center. For details, see [Supervisor Cluster Networking](#).

vSphere Pods are only supported on Supervisor Clusters that use NSX-T Data Center as their networking stack. They are not supported on clusters that are configured with the vSphere networking stack.

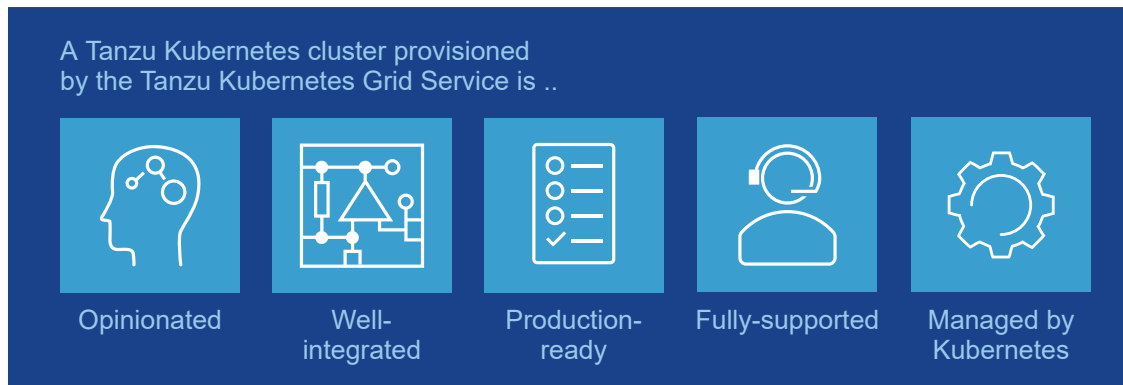
## What Is a Tanzu Kubernetes Cluster?

A Tanzu Kubernetes cluster is a full distribution of the open-source Kubernetes container orchestration platform that is built, signed, and supported by VMware. You can provision and operate Tanzu Kubernetes clusters on the Supervisor Cluster by using the Tanzu Kubernetes Grid Service. A Supervisor Cluster is a vSphere cluster that is enabled with vSphere with Tanzu.

### Key Characteristics of Tanzu Kubernetes Clusters Created by the Tanzu Kubernetes Grid Service

A Tanzu Kubernetes cluster that is provisioned by the Tanzu Kubernetes Grid Service has the following characteristics:

- Opinionated Installation of Kubernetes
- Integrated with the vSphere Infrastructure
- Production Ready
- Fully Supported by VMware
- Managed by Kubernetes



**Note** VMware markets a suite of Kubernetes-focused products under the Tanzu brand. The Tanzu Kubernetes clusters that you create by using the Tanzu Kubernetes Grid Service are components of the Tanzu edition license. For more information about the other Kubernetes-focused products that VMware markets under Tanzu, see the [VMware Tanzu](#) documentation. For information about licensing in vSphere with Tanzu, see [Licensing for vSphere with Tanzu](#).

### Opinionated Installation of Kubernetes

A Tanzu Kubernetes cluster is an opinionated installation of Kubernetes.

The Tanzu Kubernetes Grid Service provides well-thought-out defaults that are optimized for vSphere to provision Tanzu Kubernetes clusters. By using the Tanzu Kubernetes Grid Service, you can reduce the amount of time and effort that you typically spend for deploying and running an enterprise-grade Kubernetes cluster.

For more information, see [Tanzu Kubernetes Grid Service Architecture](#).

## Integrated with the vSphere Infrastructure

A Tanzu Kubernetes cluster is integrated with the underlying vSphere infrastructure, which is optimized for running Kubernetes.

A Tanzu Kubernetes cluster is integrated with the vSphere SDDC stack, including storage, networking, and authentication. In addition, a Tanzu Kubernetes cluster is built on a Supervisor Cluster that maps to a vCenter Server cluster. Because of the tight integration, running a Tanzu Kubernetes cluster is a unified product experience.

For more information, see [vSphere with Tanzu Architecture](#).

## Production Ready

A Tanzu Kubernetes cluster is tuned for running production workloads.

The Tanzu Kubernetes Grid Service provisions production-ready Tanzu Kubernetes clusters. You can run production workloads without the need to perform any additional configuration. In addition, you can ensure availability and allow for rolling Kubernetes software upgrades and run different versions of Kubernetes in separate clusters.

For more information, see [Chapter 13 Provisioning and Operating TKGS Clusters](#).

## Fully Supported by VMware

A Tanzu Kubernetes cluster is supported by VMware.

Tanzu Kubernetes clusters use the open source, Linux-based Photon OS from VMware, are deployed on vSphere infrastructure, and run on ESXi hosts. If you experience problems with any layer of the stack, from the hypervisor to the Kubernetes cluster, VMware is the only vendor you need to contact.

For more information, contact [VMware Support](#).

## Managed by Kubernetes

A Tanzu Kubernetes cluster is managed by Kubernetes.

Tanzu Kubernetes clusters are built on top of the Supervisor Cluster, which is itself a Kubernetes cluster. A Tanzu Kubernetes cluster is defined in the vSphere Namespace using a custom resource. You provision Tanzu Kubernetes clusters in a self-service way using familiar kubectl commands. There is consistency across the toolchain, whether you are provisioning a cluster or deploying workloads, you use the same commands, familiar YAML, and common workflows.

For more information, see [Tanzu Kubernetes Cluster Tenancy Model](#).

## When to Use vSphere Pods and Tanzu Kubernetes Clusters

Using vSphere Pods or Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service depends on your goals related to deploying and managing Kubernetes workloads on the Supervisor Cluster.

Use vSphere Pods if you are a vSphere administrator or DevOps engineer who wants to:

- Run containers without needing to customize a Kubernetes cluster.
- Create containerized applications with strong resource and security isolation.
- Deploy vSphere Pods directly on ESXi hosts.

Use Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service if you are a DevOps engineer or developer who wants to:

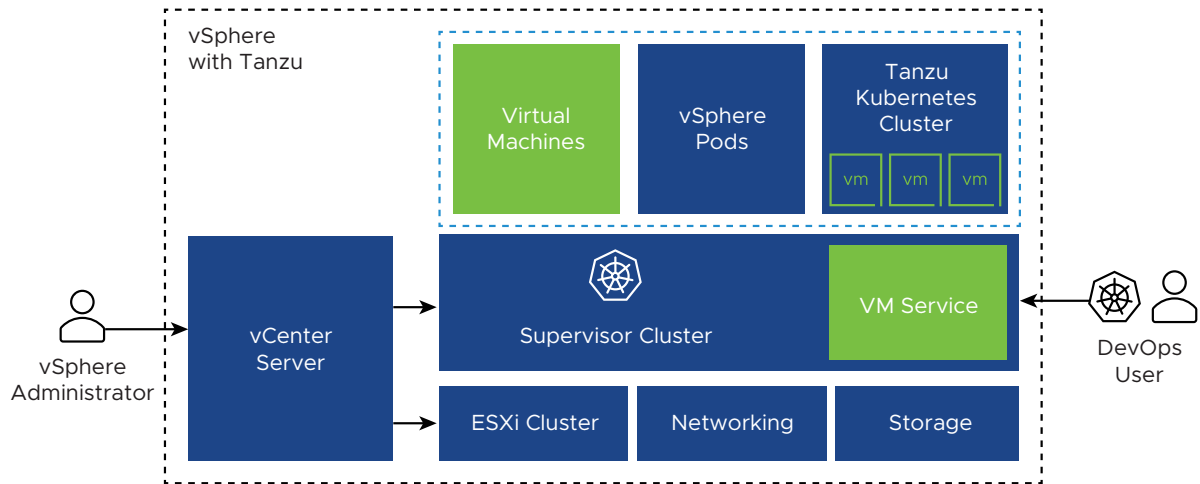
- Run containerized applications on open-source, community-aligned Kubernetes software.
- Have control over the Kubernetes cluster, including root level access to the control plane and worker nodes.
- Stay current with Kubernetes versions without requiring infrastructure upgrades.
- Use a CI/CD pipeline to provision short-lived Kubernetes clusters.
- Customize the Kubernetes cluster, for example, install custom resource definitions, Operators, and helm charts.
- Create Kubernetes namespaces using the `kubectl` CLI.
- Manage cluster-level access control and configure `PodSecurityPolicies`.
- Create services of type `NodePort`.
- Use `HostPath` volumes.
- Run privileged pods.

## Using Virtual Machines in vSphere with Tanzu

vSphere with Tanzu offers a VM Service functionality that enables DevOps engineers to deploy and run VMs, in addition to containers, in a common, shared Kubernetes environment. Both, containers and VMs, share the same vSphere Namespace resources and can be managed through a single vSphere with Tanzu interface.

The VM Service addresses the needs of DevOps teams that use Kubernetes, but have existing VM-based workloads that cannot be easily containerized. It also helps users reduce the overhead of managing a non-Kubernetes platform alongside a container platform. When running containers and VMs on a Kubernetes platform, DevOps teams can consolidate their workload footprint to just one platform.

**Note** In addition to stand-alone VMs, the VM Service manages the VMs that make up Tanzu Kubernetes clusters. For information about the clusters, see [Tanzu Kubernetes Grid Service Architecture](#) and [Chapter 13 Provisioning and Operating TKGS Clusters](#).



Each VM deployed through the VM Service functions as a complete machine running all the components, including its own operating system, on top of the vSphere with Tanzu infrastructure. The VM has access to networking and storage that a Supervisor Cluster provides, and is managed using the standard Kubernetes `kubectl` command. The VM runs as a fully isolated system that is immune to interference from other VMs or workloads in the Kubernetes environment.

## When to Use Virtual Machines on a Kubernetes Platform?

Generally, a decision to run workloads in a container or in a VM depends on your business needs and goals. Among the reasons to use VMs appear the following:

- Your applications cannot be containerized.
- You have specific hardware requirements for your project.
- Applications are designed for a custom kernel or custom operating system.
- Applications are better suited to running in a VM.
- You want to have a consistent Kubernetes experience and avoid overhead. Rather than running separate sets of infrastructure for your non-Kubernetes and container platforms, you can consolidate these stacks and manage them with a familiar `kubectl` command.

For information about deploying and managing virtual machines, see [Chapter 12 Deploying and Managing Virtual Machines in vSphere with Tanzu](#).

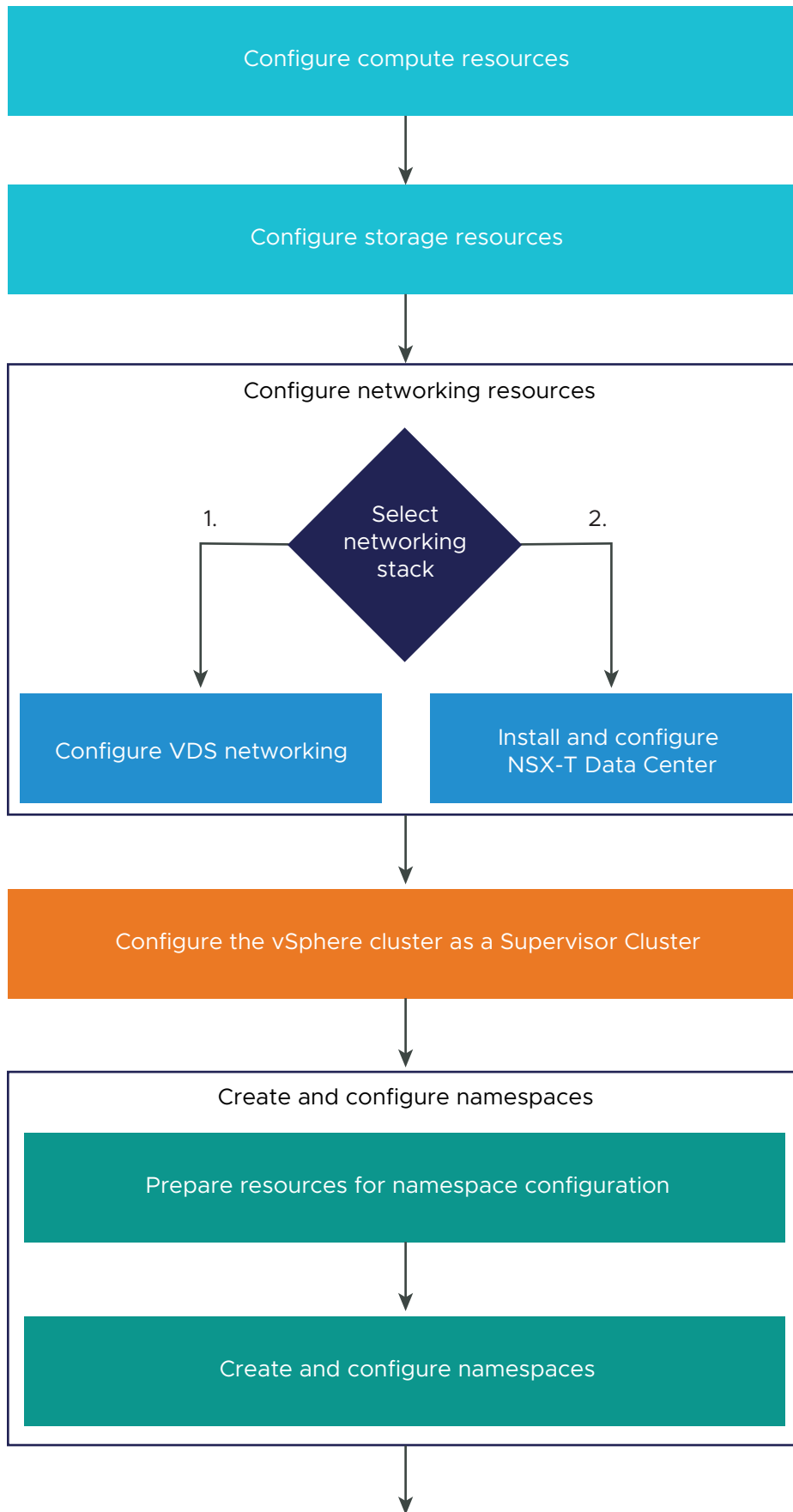
## vSphere with Tanzu User Roles and Workflows

The vSphere with Tanzu platform involves two roles, the vSphere administrator and the DevOps engineer. Both roles interact with the platform through different interfaces and can have users or user groups defined for them in vCenter Single Sign-On with associated permissions. The workflows for the vSphere administrator and DevOps engineer roles are distinct and determined by the specific area of expertise these roles require.

### User Roles and Workflows

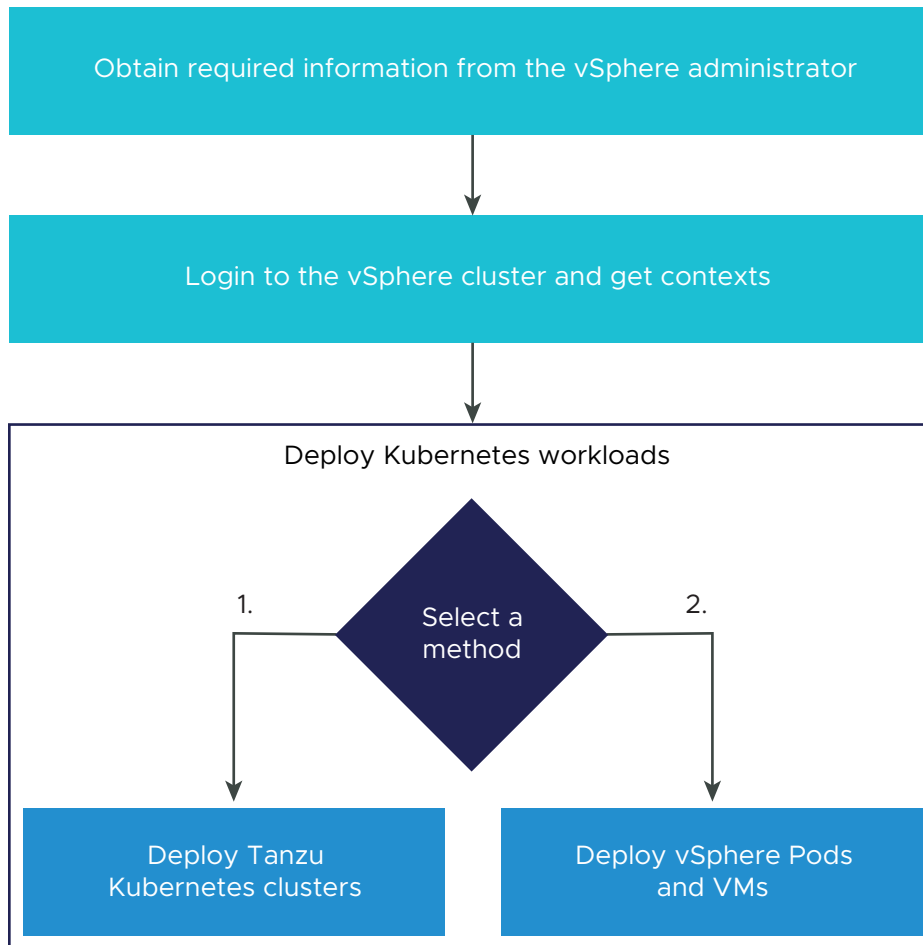
As a vSphere administrator, the primary interface through which you interact with the vSphere with Tanzu platform is the vSphere Client. At a high level, your responsibilities involve configuring a Supervisor Cluster and namespaces, where DevOps engineers can deploy Kubernetes workloads. You should have excellent knowledge about the vSphere and NSX-T technologies, and basic understanding about Kubernetes.

Figure 2-5. vSphere Administrator High Level Workflow



As a DevOps engineer, you might be a Kubernetes developer and an application owner, a Kubernetes administrator, or combine functions of both. As a DevOps engineer, you use `kubectl` commands to deploy vSphere Pods, VMs, and Tanzu Kubernetes clusters on existing namespaces on the Supervisor Cluster. Typically, as a DevOps engineer, you do not need to be an expert on vSphere and NSX-T, but have basic understanding about these technologies and the vSphere with Tanzu platform to interact with the vSphere administrators more efficiently.

**Figure 2-6. DevOps Engineer High Level Workflow**

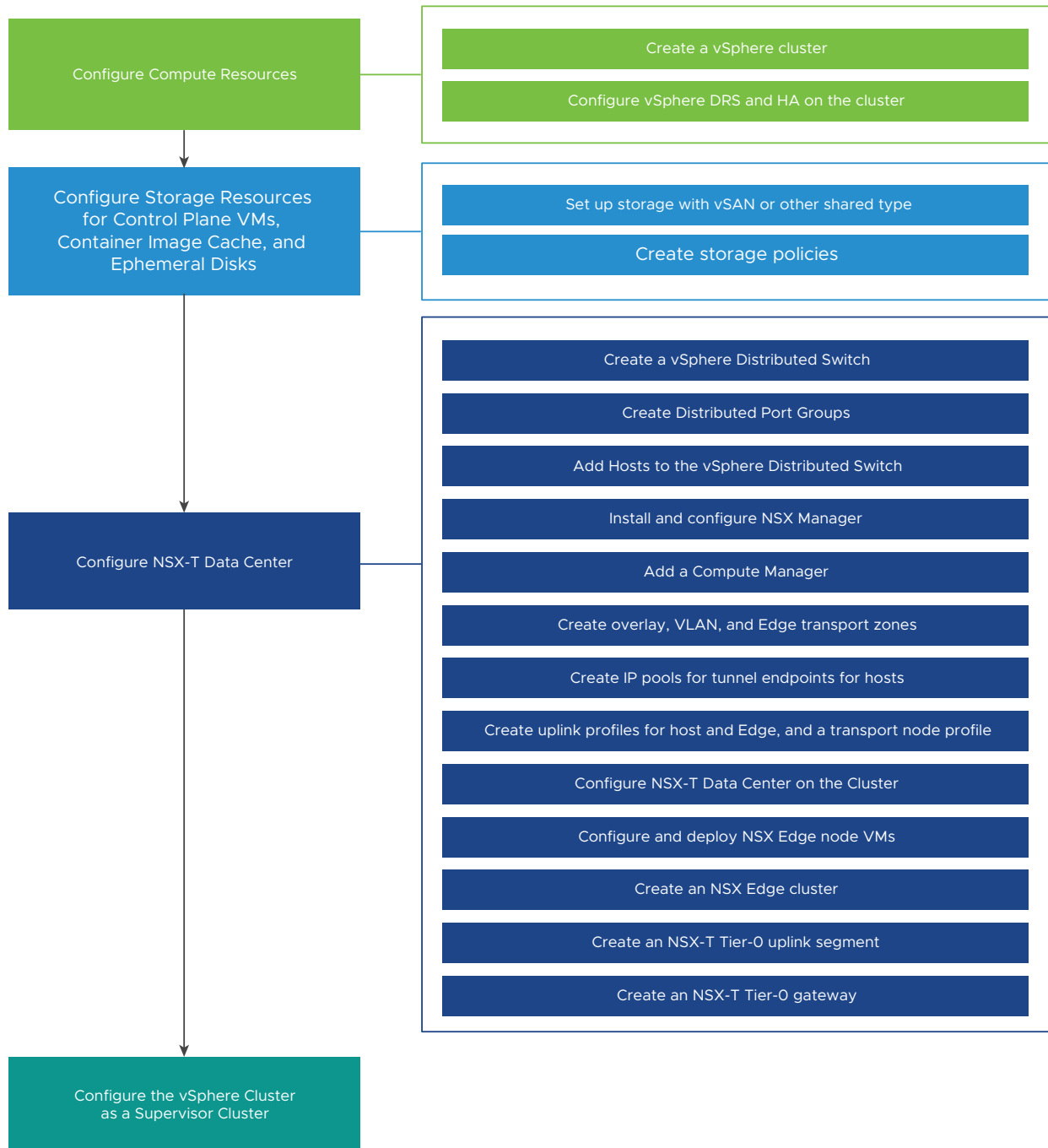


## Supervisor Cluster with NSX-T Data Center Workflow

As a vSphere administrator, you configure the vSphere with Tanzu platform with the necessary compute, storage, and networking components. You can use NSX-T Data Center as the networking stack for Supervisor Cluster. For more information about the system requirements, see [System Requirements for Setting Up vSphere with Tanzu with NSX-T Data Center](#).



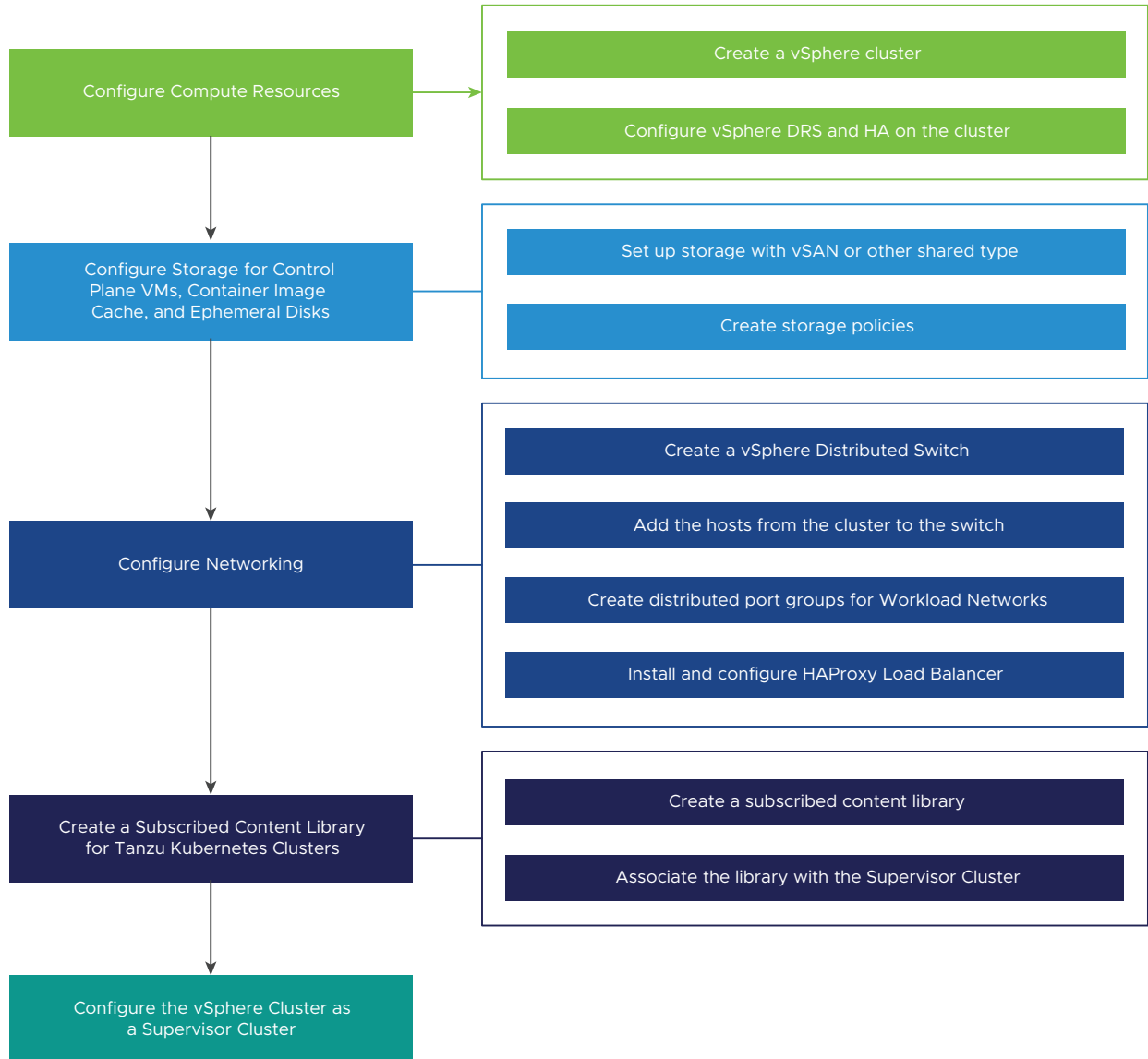
Figure 2-7. Supervisor Cluster with NSX-Data Center Networking Workflow



## Supervisor Cluster with vSphere Networking Stack Workflow

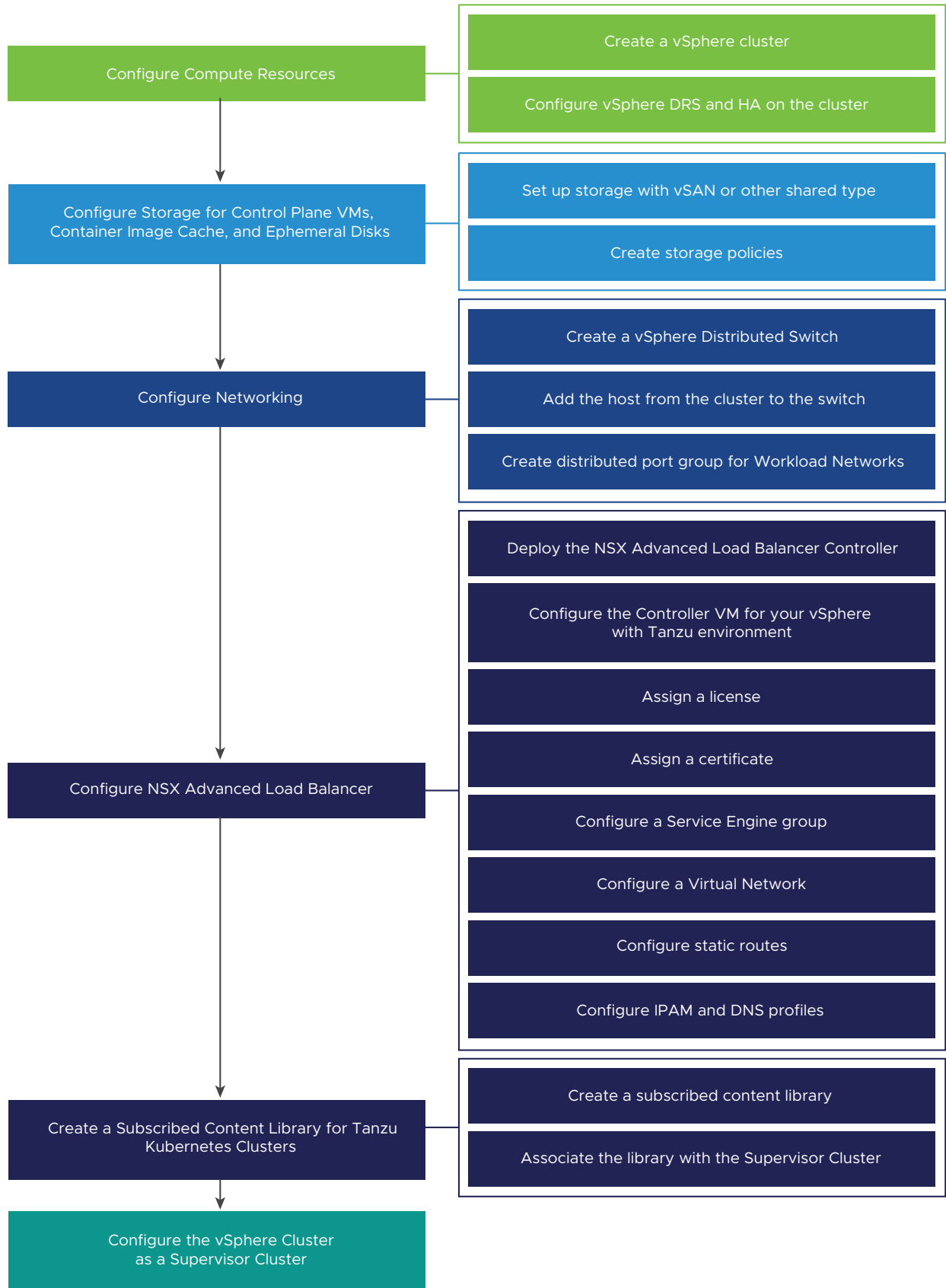
As a vSphere administrator, you can configure a vSphere cluster as a Supervisor Cluster with the vSphere networking stack. For more information about the system requirements, see [System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and HA Proxy Load Balancer](#).

Figure 2-8. Supervisor Cluster with vSphere Networking Stack Configuration Workflow



## Supervisor Cluster with vSphere Networking and NSX Advanced Load Balancer Workflow

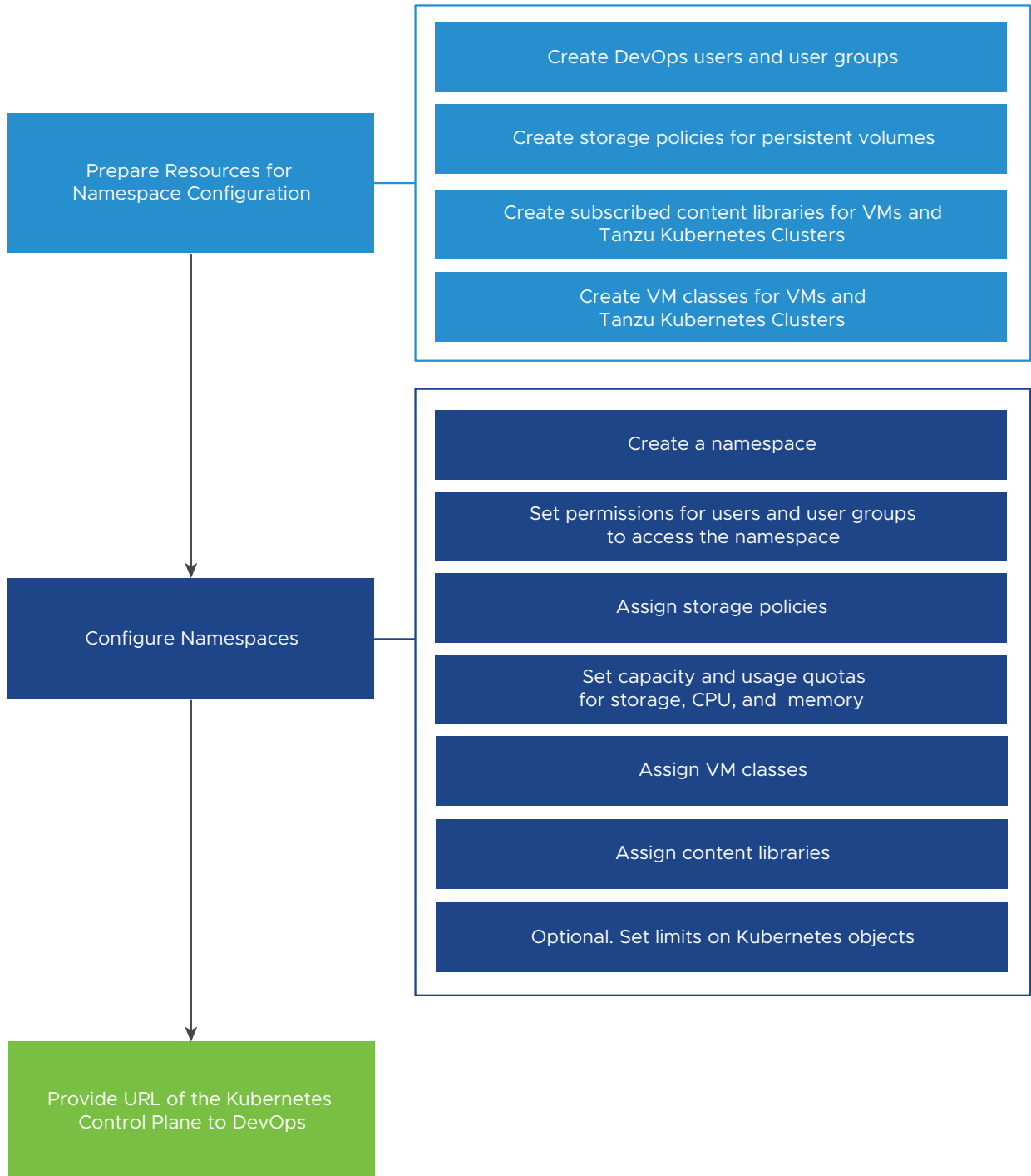
The diagram shows the workflow for configuring vSphere Networking and NSX Advanced Load Balancer for vSphere with Tanzu. For more information, see [Install and Configure the NSX Advanced Load Balancer](#).



## Namespace Creation and Configuration Workflow

As a vSphere administrator, you create and configure namespaces on the Supervisor Cluster. You must gather specific resource requirements from DevOps engineers about the applications and workloads they want to run and configure the namespaces accordingly. For more information see, [Chapter 7 Configuring and Managing vSphere Namespaces](#).

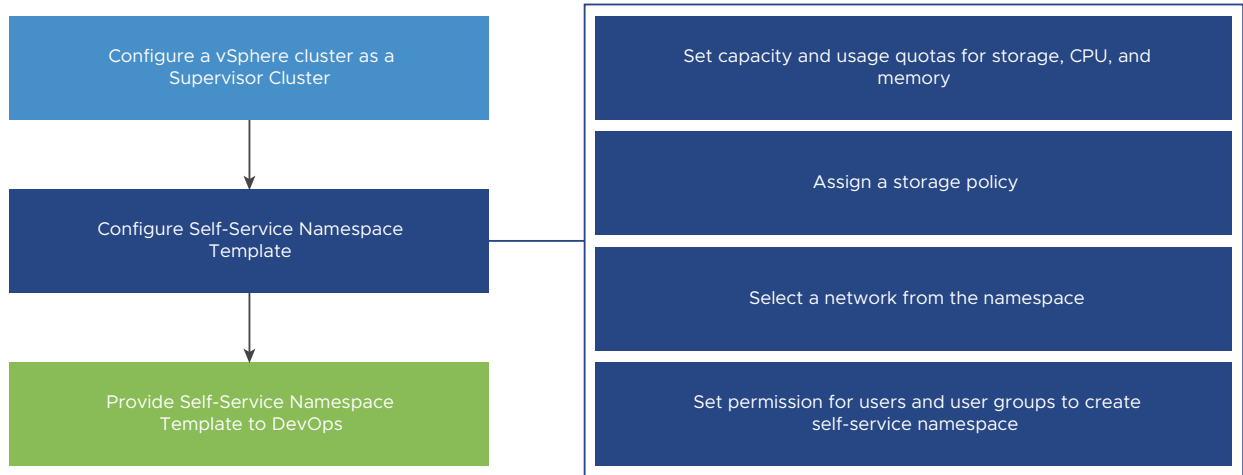
**Figure 2-9. Namespace Configuration Workflow**



## Self-Service Namespace Creation and Configuration Workflow

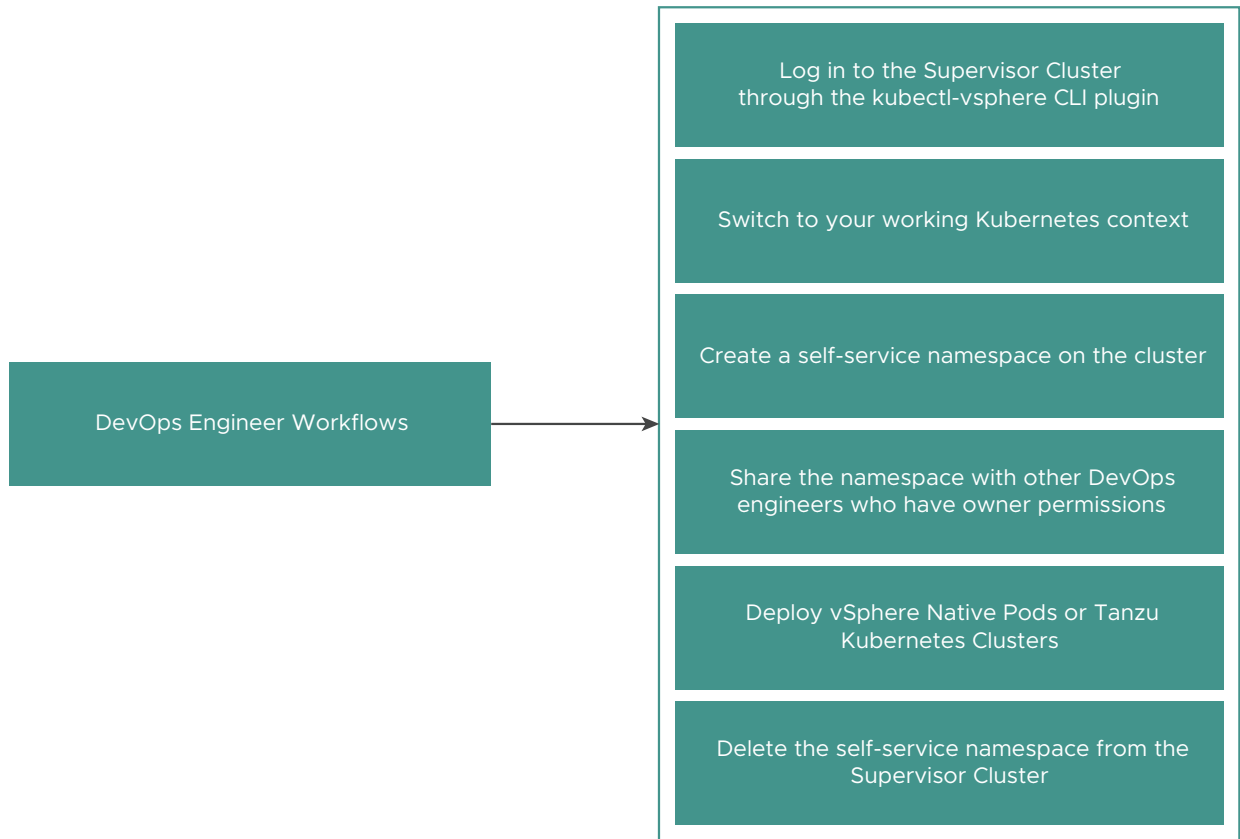
As a vSphere administrator, you can create a Supervisor Namespace, set CPU, memory, and storage limits to the namespace, assign permissions, and provision or activate the namespace service on a cluster as a template.

Figure 2-10. Self-service Namespace Template Provisioning Workflow



As a DevOps engineer, you can create a Supervisor Namespace in a self-service manner and deploy workloads within it. You can share it with other DevOps engineers or delete it when it is no longer required.

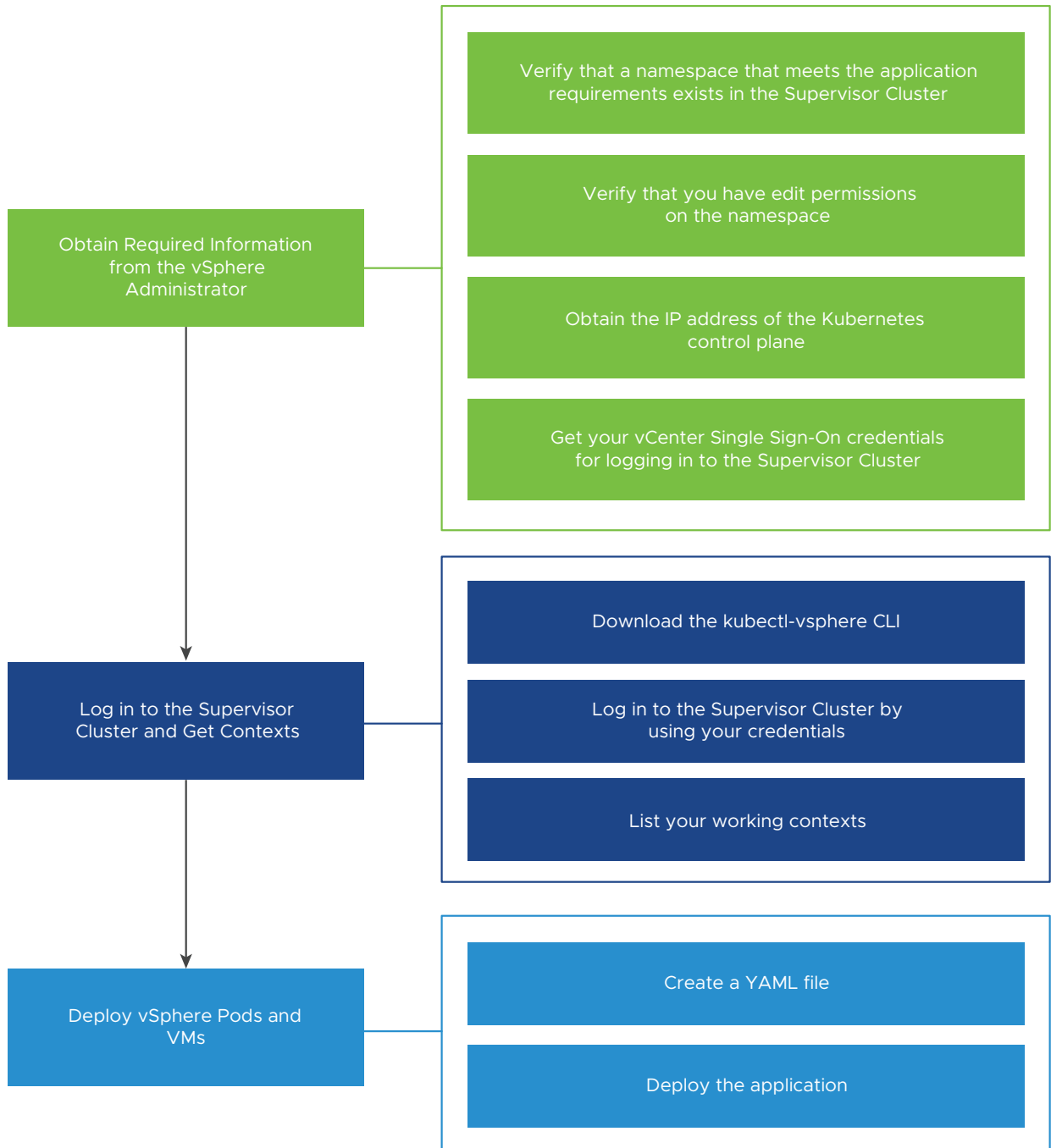
Figure 2-11. Self-service Namespace Creation Workflow



## vSphere Pod and VM Provisioning Workflow

As a DevOps engineer, you can deploy vSphere Pods and VMs within the resources boundaries of a namespace that is running on a Supervisor Cluster. For more information, see [Chapter 11 Deploying Workloads to vSphere Pods](#) and [Chapter 12 Deploying and Managing Virtual Machines in vSphere with Tanzu](#).

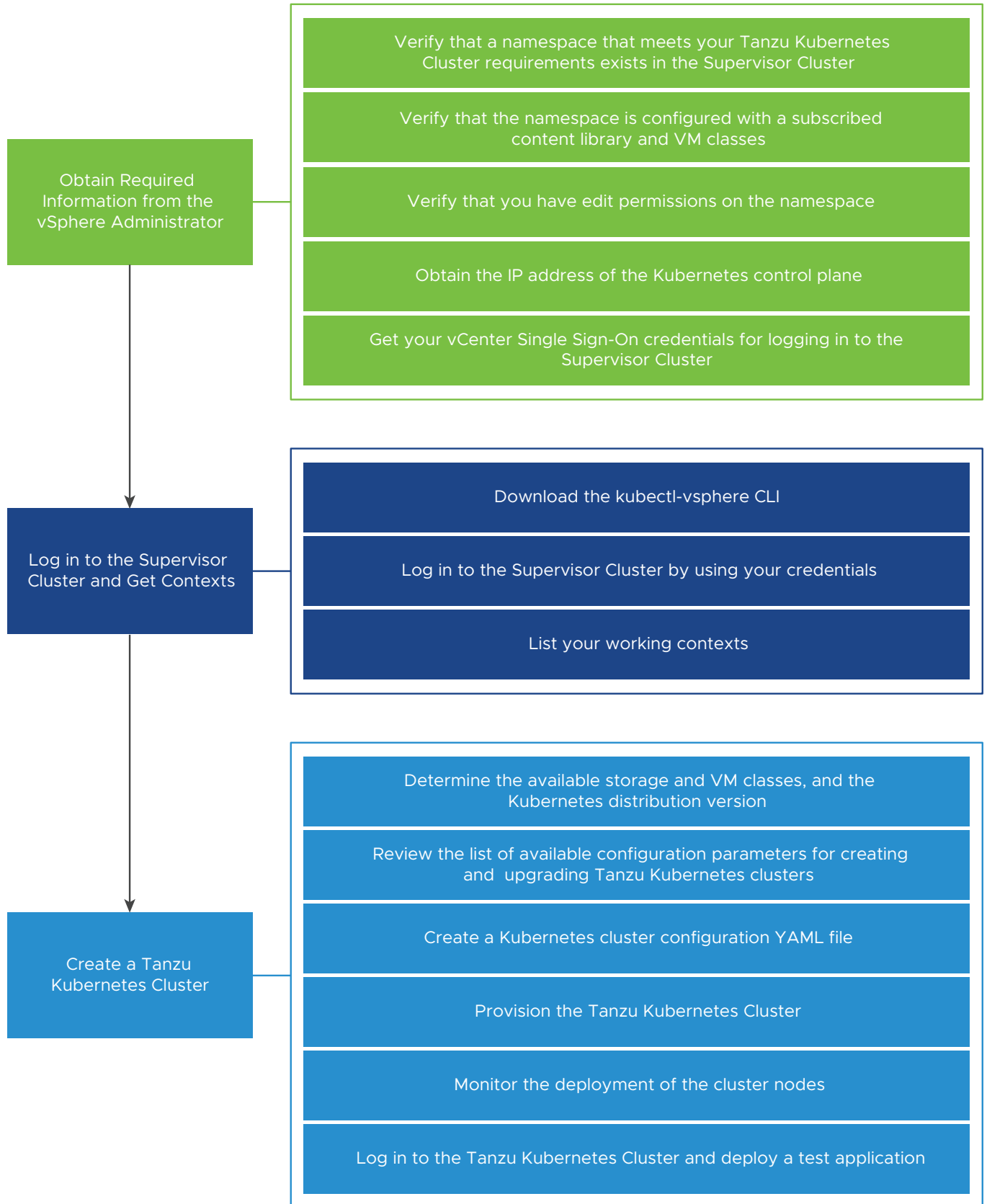
Figure 2-12. vSphere Pods and VM Provisioning Workflow



## Tanzu Kubernetes Cluster Provisioning Workflow

As a DevOps engineer, you create and configure Tanzu Kubernetes clusters on a namespace created and configured by your vSphere administrator. For more information, see [Workflow for Provisioning Tanzu Kubernetes Clusters](#).

Figure 2-13. Tanzu Kubernetes Cluster Provisioning Workflow

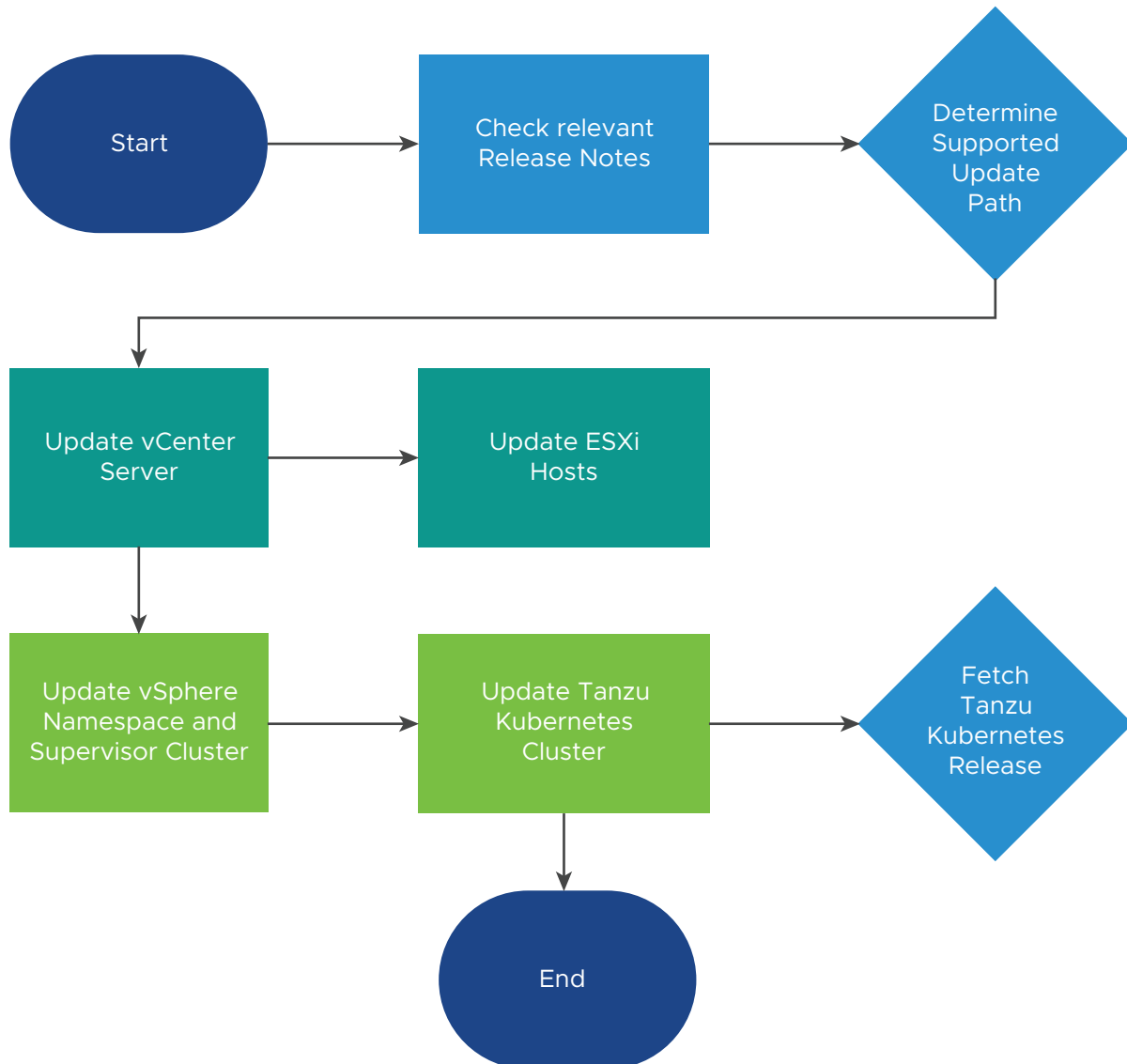




## vSphere with Tanzu Update Workflow

The diagram shows the workflow for updating the vSphere with Tanzu environment, including the Supervisor Cluster and Tanzu Kubernetes clusters. For more information, see [Chapter 17 Updating the vSphere with Tanzu Environment](#).

Figure 2-14. vSphere with Tanzu Update Workflow



## How Does vSphere with Tanzu Change the vSphere Environment?

When a vSphere cluster is configured for Kubernetes workloads, thus becoming a Supervisor Cluster, it adds objects to the vCenter Server inventory, such as namespaces, vSphere Pods, and Tanzu Kubernetes clusters provisioned using the Tanzu Kubernetes Grid Service.

Under each Supervisor Cluster, you can view:

- Namespaces that represent logical applications running in the cluster.
- Resource pools for each namespace on the Supervisor Cluster.

Within every namespace, you can view:

- vSphere Pods.
- Kubernetes clusters created through the Tanzu Kubernetes Grid Service.
- Kubernetes control plane VMs.
- Networking and storage resources.
- User permissions for that namespace.

## Licensing for vSphere with Tanzu

Once you configure a vSphere cluster for vSphere with Tanzu and it becomes a Supervisor Cluster, you must assign the cluster a Tanzu edition license before the 60 day evaluation period expires.

### About the Tanzu Licenses

A Tanzu license enables the Workload Management functionality in vSphere 7.0 Update 1 and later. It is applicable to Supervisor Clusters that are configured with the vSphere networking stack or with NSX-T Data Center. For Supervisor Clusters running on vSphere 7.0, you need the VMware vSphere 7 Enterprise Plus with Add-on for Kubernetes license assigned to each host from the Supervisor Cluster.

As a vSphere administrator, when you assign a Tanzu license to a Supervisor Cluster cluster, you can create and configure namespaces and provide access to these namespaces to DevOps engineers. As a DevOps engineer, you can deploy Tanzu Kubernetes clusters and vSphere Pods inside the namespaces to which you have access. Supervisor Clusters configured with the vSphere networking stack only support Tanzu Kubernetes clusters.

### Licensing a Supervisor Cluster

After you enable **Workload Management** on a vSphere cluster, which deploys a Supervisor Cluster, you can use the full set of capabilities of the cluster within a 60 day evaluation period. You must assign a Tanzu license to the Supervisor Cluster before the 60 day evaluation period expires.

If you configure NSX-T Data Center as the networking stack for the Supervisor Cluster, you must assign an NSX-T Data Center Advanced or higher license to NSX Manager. If you configure the Supervisor Cluster with the vSphere networking stack with NSX Advanced Load Balancer, you need an appropriate license for the load balancer depending on your Tanzu license edition.

If your environment runs on top of vSphere 7.0 and you upgrade the Supervisor Cluster to vSphere 7.0 Update 1 or later, the cluster enters evaluation mode after the upgrade completes. The VMware vSphere 7 Enterprise Plus with Add-on for Kubernetes license that is assigned to the hosts acts as a regular vSphere Enterprise 7 Plus license, it does not enable any vSphere with Tanzu functionality. In that case, you must assign the Supervisor Cluster a Tanzu edition license before the 60 day evaluation period expires.

## Tanzu License Expiration

- vSphere 7.0 Update 3. Starting from vSphere 7.0 Update 3, when a Tanzu edition license expires, you can continue using the full set of capabilities of vSphere with Tanzu until you procure new licenses. To use the full set of capabilities for new Supervisor Clusters however, you need a valid Tanzu edition license the evaluation period expires.
- vSphere 7.0 Update 2 and Update 1. When a Tanzu edition license expires in an environment that runs on vSphere Update 2 or Update 1, as a vSphere administrator you cannot create new namespaces or update the Kubernetes version of the Supervisor Cluster. As a DevOps engineer, you cannot deploy new workloads. You cannot change the configuration of the existing Tanzu Kubernetes clusters such as adding new nodes.

You can still deploy workloads on Tanzu Kubernetes clusters and all existing workloads continue to run as expected. All Kubernetes workloads that are already deployed continue their normal operation.

## Tanzu License Compliance

A Tanzu license key has per CPU capacity with up to 32 cores per CPU, similarly to the ESXi host licenses. When you assign a Tanzu license to a Supervisor Cluster, the amount of capacity consumed is determined by the number of CPUs on the hosts from the cluster and the number of cores in each CPU. You can assign a Tanzu edition license key to multiple Supervisor Clusters at a time, but you cannot assign multiple license keys to one cluster.

- vSphere 7.0 Update 3. Starting from vSphere 7.0 Update 3, if you expand a Supervisor Cluster by adding new hosts for example, and the license key that you have assigned to the cluster runs out of capacity, you can continue using the same license key. To remain in EULA compliant however, you must procure a new license key with sufficient capacity to cover all the CPUs and cores in the Supervisor Cluster.
- vSphere 7.0 Update 2 and Update 1. If your vSphere with Tanzu environment runs on vSphere 7.0 Update 2 and Update 1, the total number of CPUs in a Supervisor Cluster must not exceed the amount of CPU capacity of the Tanzu edition license that is assigned to the cluster.

## Evaluation Period Expiration

When the evaluation period for a Supervisor Cluster expires, as a vSphere administrator you cannot create new namespaces or update the Kubernetes version of the Supervisor Cluster. As a DevOps engineer, you cannot deploy new workloads. You cannot change the configuration of the existing Tanzu Kubernetes clusters such as adding new nodes.

You can still deploy workloads on Tanzu Kubernetes clusters and all existing workloads continue to run as expected. All Kubernetes workloads that are already deployed continue their normal operation.

The evaluation period expiration behavior is valid for both vSphere 7.0 Update 2 and Update 3.

# vSphere with Tanzu Architecture and Components

# 3

A cluster enabled with vSphere with Tanzu is called a Supervisor Cluster. The cluster is at the base of the vSphere with Tanzu providing the necessary components and resources for running workloads that include vSphere Pods, VMs, and Tanzu Kubernetes clusters.

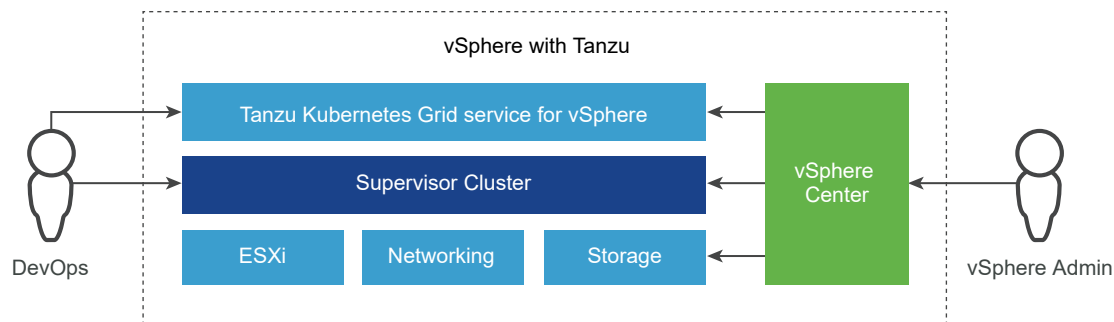
This chapter includes the following topics:

- vSphere with Tanzu Architecture
- Tanzu Kubernetes Grid Service Architecture
- Tanzu Kubernetes Cluster Tenancy Model
- vSphere with Tanzu Authentication
- vSphere with Tanzu Networking
- vSphere with Tanzu Security
- vSphere with Tanzu Storage

## vSphere with Tanzu Architecture

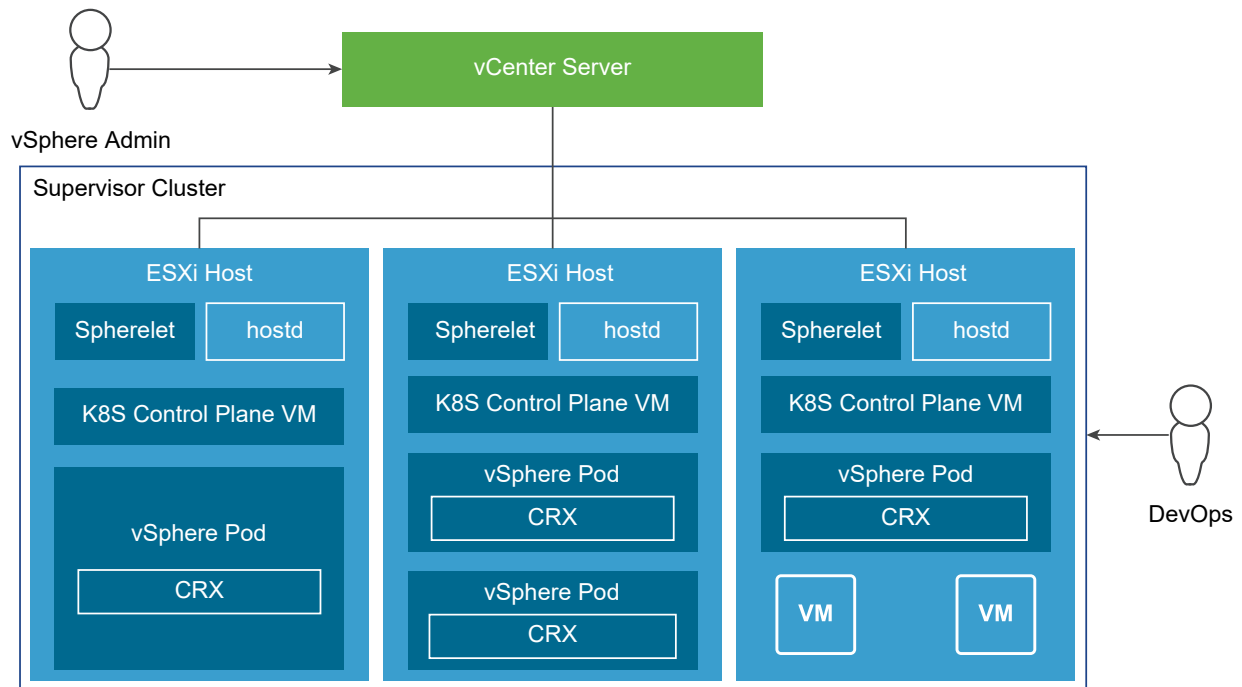
When vSphere with Tanzu is enabled on a vSphere cluster, it creates a Kubernetes control plane inside the hypervisor layer. This layer contains specific objects that enable the capability to run Kubernetes workloads within ESXi.

Figure 3-1. Supervisor Cluster General Architecture



A cluster that is enabled for vSphere with Tanzu is called a Supervisor Cluster. It runs on top of an SDDC layer that consists of ESXi for compute, NSX-T Data Center or vSphere networking, and vSAN or another shared storage solution. Shared storage is used for persistent volumes for vSphere Pods, VMs running inside the Supervisor Cluster, and pods in a Tanzu Kubernetes cluster. After a Supervisor Cluster is created, as a vSphere administrator you can create namespaces within the Supervisor Cluster that are called vSphere Namespaces. As a DevOps engineer, you can run workloads consisting of containers running inside vSphere Pods and create Tanzu Kubernetes clusters.

Figure 3-2. Supervisor Cluster Architecture



- Kubernetes control plane VM. Three Kubernetes control plane VMs in total are created on the hosts that are part of the Supervisor Cluster. The three control plane VMs are load balanced as each one of them has its own IP address. Additionally, a floating IP address is assigned to one of the VMs. vSphere DRS determines the exact placement of the control plane VMs on the ESXi hosts and migrates them when needed. vSphere DRS is also integrated with the Kubernetes Scheduler on the control plane VMs, so that DRS determines the placement of vSphere Pods. When as a DevOps engineer you schedule a vSphere Pod, the request goes through the regular Kubernetes workflow then to DRS, which makes the final placement decision.
- Spherelet. An additional process called Spherelet is created on each host. It is a kubelet that is ported natively to ESXi and allows the ESXi host to become part of the Kubernetes cluster.
- Container Runtime Executive (CRX). CRX is similar to a VM from the perspective of Hostd and vCenter Server. CRX includes a paravirtualized Linux kernel that works together with the

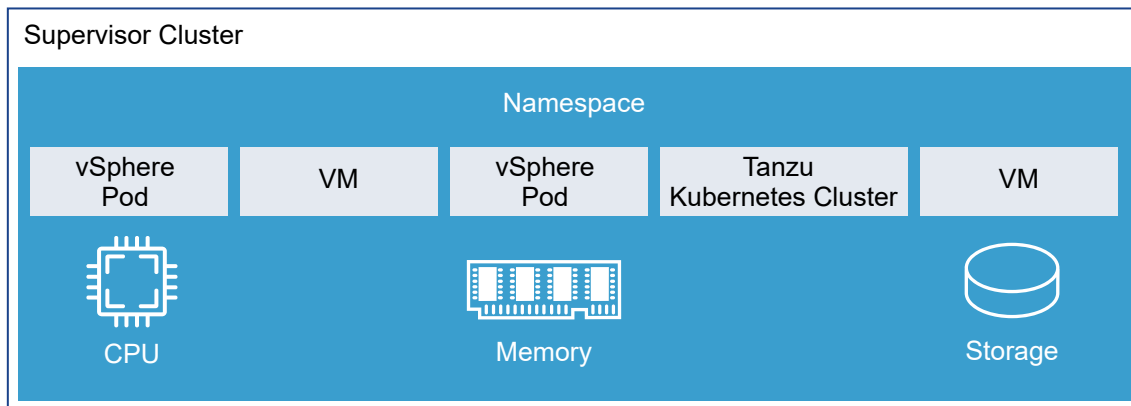
hypervisor. CRX uses the same hardware virtualization techniques as VMs and it has a VM boundary around it. A direct boot technique is used, which allows the Linux guest of CRX to initiate the main init process without passing through kernel initialization. This allows vSphere Pods to boot nearly as fast as containers.

- The Cluster API and VMware Tanzu™ Kubernetes Grid™ Service are modules that run on the Supervisor Cluster and enable the provisioning and management of Tanzu Kubernetes clusters. The Virtual Machine Service module is responsible for deploying and running stand-alone VMs and VMs that make up Tanzu Kubernetes clusters.

## vSphere Namespace

A vSphere Namespace sets the resource boundaries where vSphere Pods and Tanzu Kubernetes clusters created by using the Tanzu Kubernetes Grid Service can run. When initially created, the namespace has unlimited resources within the Supervisor Cluster. As a vSphere administrator, you can set limits for CPU, memory, storage, as well as the number of Kubernetes objects that can run within the namespace. A resource pool is created per each namespace in vSphere. Storage limitations are represented as storage quotas in Kubernetes.

Figure 3-3. vSphere Namespace



To provide access to namespaces to DevOps engineer, as a vSphere administrator you assign permission to users or user groups available within an identity source that is associated with vCenter Single Sign-On.

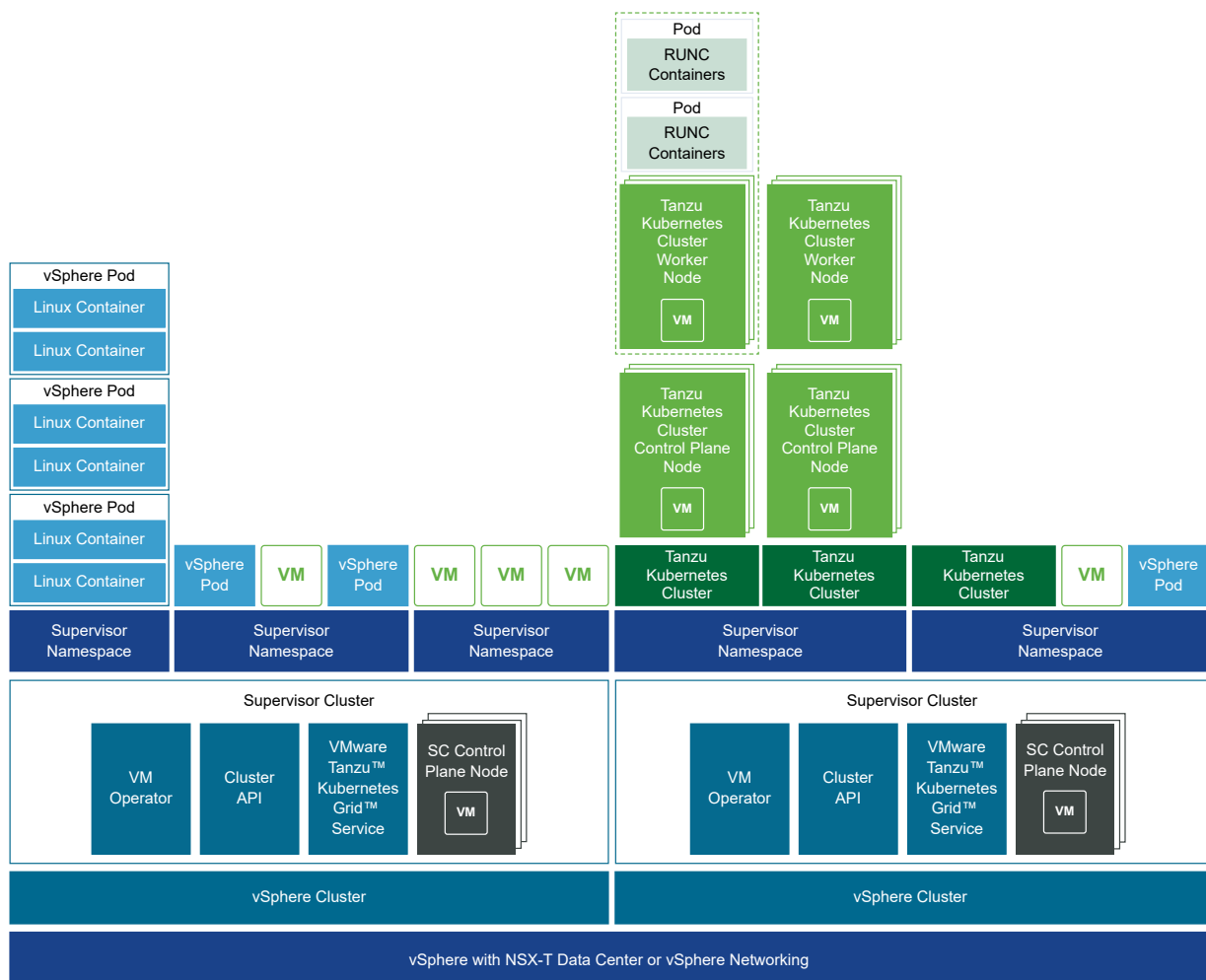
After a namespace is created and configured with resource and object limits as well as with permissions and storage policies, as a DevOps engineer you can access the namespace to run Kubernetes workloads and create Tanzu Kubernetes clusters by using the Tanzu Kubernetes Grid Service.

## Tanzu Kubernetes Clusters

A Tanzu Kubernetes cluster is a full distribution of the open-source Kubernetes software that is packaged, signed, and supported by VMware. In the context of vSphere with Tanzu, you can use the Tanzu Kubernetes Grid Service to provision Tanzu Kubernetes clusters on the Supervisor Cluster. You can invoke the Tanzu Kubernetes Grid Service API declaratively by using kubectl and a YAML definition.

A Tanzu Kubernetes cluster resides in a vSphere Namespace. You can deploy workloads and services to Tanzu Kubernetes clusters the same way and by using the same tools as you would with standard Kubernetes clusters.

Figure 3-4. vSphere with Tanzu Architecture for Tanzu Kubernetes Clusters



## Supervisor Cluster Configured with the vSphere Networking Stack

A Supervisor Cluster that is configured with the vSphere networking stack only supports running Tanzu Kubernetes clusters created by using the Tanzu Kubernetes Grid Service. The cluster also supports the vSphere Network Service and the Storage Service.



A Supervisor Cluster that is configured with the vSphere networking stack does not support vSphere Pods. Therefore, the Spherelet component is not available in such Supervisor Cluster and Kubernetes pods run inside Tanzu Kubernetes clusters only. A Supervisor Cluster that is configured with the vSphere networking stack also does not support the Harbor Registry, because the service is only used with vSphere Pods.

A vSphere Namespace created on a cluster that is configured with the vSphere networking stack also does not support running vSphere Pods, but only Tanzu Kubernetes clusters.

## Tanzu Kubernetes Grid Service Architecture

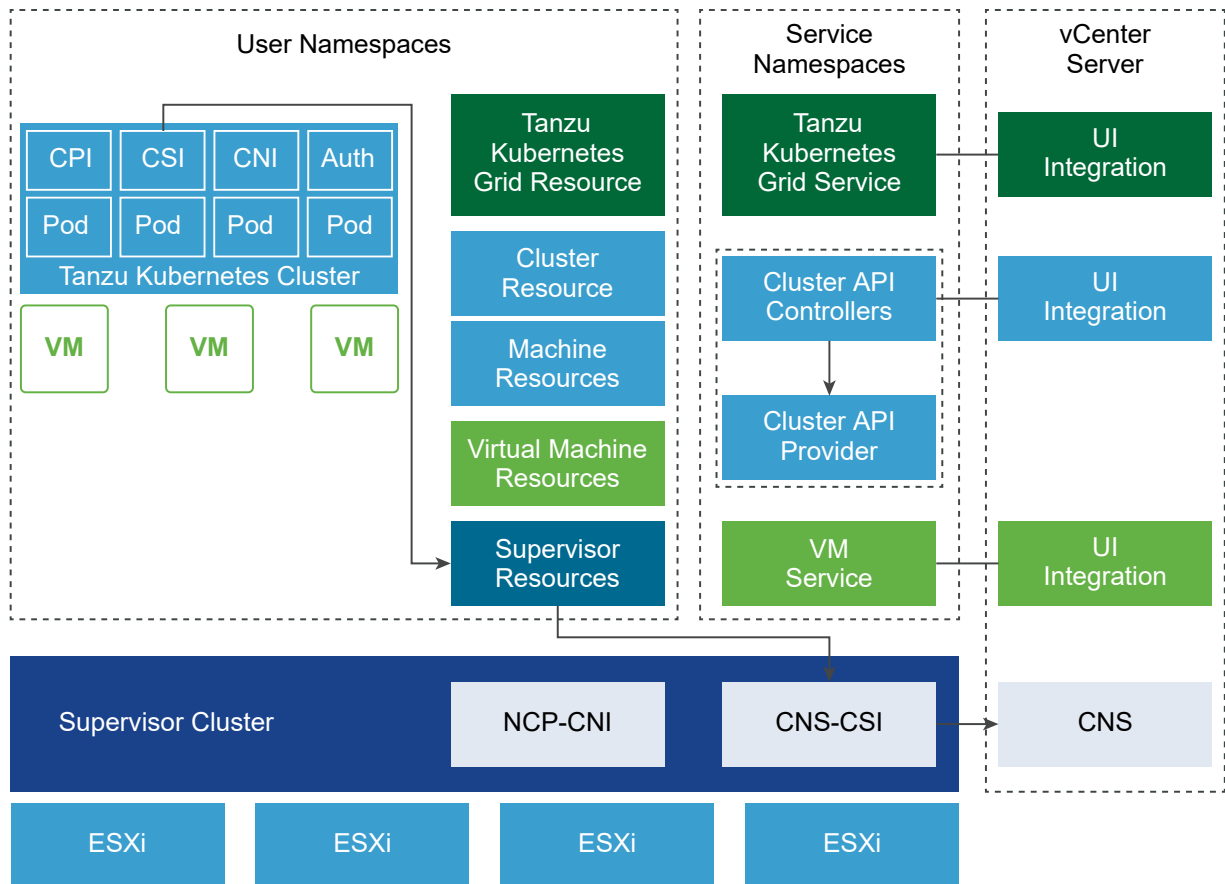
The Tanzu Kubernetes Grid Service provides self-service lifecycle management of Tanzu Kubernetes clusters. You use the Tanzu Kubernetes Grid Service to create and manage Tanzu Kubernetes clusters in a declarative manner that is familiar to Kubernetes operators and developers.

### Tanzu Kubernetes Grid Service Components

The Tanzu Kubernetes Grid Service exposes three layers of controllers to manage the lifecycle of a Tanzu Kubernetes cluster.

- The Tanzu Kubernetes Grid Service provisions clusters that include the components necessary to integrate with the underlying vSphere Namespace resources. These components include a Cloud Provider Plugin that integrates with the Supervisor Cluster. In addition, a Tanzu Kubernetes cluster passes requests for persistent volumes to the Supervisor Cluster, which is integrated with VMware Cloud Native Storage (CNS). See [Chapter 10 Using Persistent Storage in vSphere with Tanzu](#).
- The Cluster API provides declarative, Kubernetes-style APIs for cluster creation, configuration, and management. The inputs to Cluster API include a resource describing the cluster, a set of resources describing the virtual machines that make up the cluster, and a set of resources describing cluster add-ons.
- The Virtual Machine Service provides a declarative, Kubernetes-style API for management of VMs and associated vSphere resources. The Virtual Machine Service introduces the concept of a virtual machine class that represents an abstract reusable hardware configuration. The functionality provided by the Virtual Machine Service is used to manage the lifecycle of the control plane and worker node VMs hosting a Tanzu Kubernetes cluster.

Figure 3-5. Tanzu Kubernetes Grid Service Architecture and Components



## Tanzu Kubernetes Cluster Components

The components that run in a Tanzu Kubernetes cluster span four areas: Authentication and authorization, storage integration, pod networking, and load balancing.

- **Authentication webhook:** A webhook running as a pod inside the cluster to validate user authentication tokens.
- **Container Storage Interface Plugin:** A Paravirtual CSI plug-in that integrates with CNS through the Supervisor Cluster.
- **Container Network Interface Plug-in:** A CNI plugin that provides pod networking.
- **Cloud Provider Implementation:** Supports creating Kubernetes load balancer services.

## Tanzu Kubernetes Grid Service API

You use the Tanzu Kubernetes Grid Service API to provision and manage Tanzu Kubernetes clusters. It is a declarative API that you invoke using `kubectl` and `YAML`.

With a declarative API, instead of making imperative commands to the system, you specify the desired state of the Tanzu Kubernetes cluster: how many nodes, available storage, VM sizes, Kubernetes software version. The Tanzu Kubernetes Grid Service does the work to provision a cluster that matches the desired state.

To call the Tanzu Kubernetes Grid Service API, you invoke `kubectl` using a YAML file, which in turn invokes the API. After the cluster is created, you update the YAML to update the cluster.

## Tanzu Kubernetes Grid Service Interfaces

vSphere administrators use the vSphere Client to configure the vSphere Namespace and grant permissions. They can also monitor the resources used by cluster components and to view relevant information from those resources in the vSphere inventory.

DevOps engineers use the vSphere Plugin for `kubectl` to connect to the vSphere Namespace with their vCenter Single Sign-On credentials. After connecting, DevOps engineers use `kubectl` to provision Tanzu Kubernetes clusters.

Developers can connect to a provisioned cluster using the vSphere Plugin for `kubectl` and their vCenter Single Sign-On credentials. Alternatively, if the cluster administrator configured a supported Kubernetes authentication provider, developers can connect using `kubectl`. To deploy workloads in Kubernetes and interact with the cluster environment, developers use `kubectl`.

## Tanzu Kubernetes Grid Service Demo

Watch the following video to learn how you can use the Tanzu Kubernetes Grid Service to create and operate Tanzu Kubernetes clusters: [vSphere 7 with Kubernetes - Tanzu Kubernetes cluster - Technical Overview](#).

## Tanzu Kubernetes Cluster Tenancy Model

The Supervisor Cluster is the management plane for Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service. The tenancy model is enforced using a vSphere Namespace where Tanzu Kubernetes clusters reside.

### Supervisor Cluster

The Supervisor Cluster provides the management layer on which Tanzu Kubernetes clusters are built. The Tanzu Kubernetes Grid Service is a custom controller manager with a set of controllers that is part of the Supervisor Cluster. The purpose of the Tanzu Kubernetes Grid Service is to provision Tanzu Kubernetes clusters.

While there is a one-to-one relationship between the Supervisor Cluster and the vSphere cluster, there is a one-to-many relationship between the Supervisor Cluster and Tanzu Kubernetes clusters. You can provision multiple Tanzu Kubernetes clusters within a single Supervisor Cluster. The workload management functionality provided by the Supervisor Cluster gives you control over the cluster configuration and lifecycle, while allowing you to maintain concurrency with upstream Kubernetes.

For more information, see [Chapter 5 Configuring and Managing a Supervisor Cluster](#).

## vSphere Namespace

You deploy one or more Tanzu Kubernetes clusters to a vSphere Namespace. Resource quotas and storage policy are applied to a vSphere Namespace and inherited by the Tanzu Kubernetes clusters deployed there.

When you provision a Tanzu Kubernetes cluster, a resource pool and VM folder are created in the vSphere Namespace. The Tanzu Kubernetes cluster control plane and worker node VMs are placed within this resource pool and VM folder. Using the vSphere Client, you can view this hierarchy by selecting the **Hosts and Clusters** perspective, and also by selecting the **VMs and Templates** view.

For more information, see [Chapter 7 Configuring and Managing vSphere Namespaces](#).

## Content Library

A vSphere Content Library provides the virtual machine template used to create the Tanzu Kubernetes cluster nodes. For each Supervisor Cluster where you intend to deploy a Tanzu Kubernetes cluster, you must define a Subscribed Content Library object that sources the OVA used by the Tanzu Kubernetes Grid Service to build cluster nodes. The same Subscribed Content Library can be configured for multiple Supervisor Clusters. There is no relationship between the Subscribed Content Library and the vSphere Namespace. The Subscribed Content Library downloads the latest templates directly from VMware. You upload the OVA templates you want to use to a Local Content Library.

For more information, see [Creating and Managing Content Libraries for Tanzu Kubernetes releases](#).

## vSphere with Tanzu Authentication

As a vSphere administrator, you need privileges to configure a Supervisor Cluster and to manage namespaces. You define permissions on namespaces to determine which DevOps engineers can access them. As a DevOps engineer, you authenticate with the Supervisor Cluster by using your vCenter Single Sign-On credentials, and can access only the namespaces for which you have permissions.

## Permissions for vSphere Administrators

As a vSphere administrator, you need permissions on vSphere clusters to configure them as Supervisor Clusters as well as to create and manage namespaces. You must have at least one of the following privileges associated with your user account on a vSphere cluster:

- **Modify namespace configuration.** Allows you to create and configure namespaces on a Supervisor Cluster.
- **Modify cluster-wide configuration.** Allows you to configure a vSphere cluster as a Supervisor Cluster.

## Setting Permissions for DevOps Engineers

As a vSphere administrator, you grant view, edit, or owner permissions to user accounts on namespace level. The user accounts must be available in an identity source that is connected to vCenter Single Sign-On. One user account can have access to multiple namespaces. Users which are members of the Administrators groups have access to all the namespaces on the Supervisor Cluster.

After you configure a namespace with permissions, resource quotas, and storage, you provide the URL of the Kubernetes control plane to DevOps engineers, who can use it to log in to the control plane. Once logged in, DevOps engineers can access all the namespaces for which they have permissions across all of the Supervisor Clusters that belong to a vCenter Server system. When vCenter Server systems are in Enhanced Linked Mode, DevOps engineers can access all namespaces for which they have permissions across all the Supervisor Clusters available in the Linked Mode group. The IP address of the Kubernetes control plane is a virtual IP generated by NSX-T to serve as an access point to the Kubernetes control plane.

DevOps engineers with owner permissions can deploy workloads. They can share the namespace with other DevOps engineers or groups and delete it when it is no longer required. When DevOps engineers share the namespace, they can assign view, edit, or owner permissions to other DevOps engineers and groups.

## Authentication with the Supervisor Cluster

As DevOps engineer, you use the Kubernetes CLI Tools for vSphere to authenticate to the Supervisor Cluster by using your vCenter Single Sign-On credentials and the Kubernetes control plane IP address. For more information, see [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

When you log in to the Supervisor Cluster, an authentication proxy redirects the request to vCenter Single Sign-On. The vSphere kubectl plug-in establishes a session with vCenter Server and obtains an authentication token from vCenter Single Sign-On. It also fetches a list of namespaces to which you have access, and populates the configuration with these namespaces. The list of namespaces is updated on the next login, if there are changes to the permissions of your user account.

The account that you use to login to the Supervisor Cluster provides you with access only to the namespaces that are assigned to you. You cannot login to vCenter Server with that account. To login to vCenter Server, you will need explicit permissions.

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**Note** The session to kubectl lasts for 10 hours. After the session expires, you must authenticate with the Supervisor Cluster again. At logout, the token is deleted from the configuration file of your user account, but remains valid until the session ends.

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## Authentication with Tanzu Kubernetes Clusters

Tanzu Kubernetes cluster users, including DevOps engineers, developers, and administrators, can authenticate with a cluster in various ways. For more information, see [Authenticating with Tanzu Kubernetes Clusters](#).

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**Note** Tanzu Kubernetes clusters require user and system accounts to have pod security policy to deploy pods and resources to a cluster. For more information, see [Using Pod Security Policies with Tanzu Kubernetes Clusters](#).

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## vSphere with Tanzu Networking

A Supervisor Cluster can either use the vSphere networking stack or VMware NSX-™ Data Center to provide connectivity to Kubernetes control plane VMs, services, and workloads. The networking used for Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service is a combination of the fabric that underlies the vSphere with Tanzu infrastructure and open-source software that provides networking for cluster pods, services, and ingress.

For more information, see [Chapter 4 Networking for vSphere with Tanzu](#)

## vSphere with Tanzu Security

vSphere with Tanzu leverages vSphere security features and provisions Tanzu Kubernetes clusters that are secure by default.

vSphere with Tanzu is an add-on module to vSphere that is able to leverage the security features that are built into vCenter Server and ESXi. For more information, see the [vSphere Security](#) documentation.

The cluster data stored in the Supervisor Cluster database (etcd) is encrypted with a local encryption key file. The same is true for the database (etcd) that is installed on the control plane for each Tanzu Kubernetes cluster. The certificates are automatically renewed when you upgrade that cluster. You cannot manually rotate or update the certificates.

Starting from vSphere 7.0 Update 2, you can run confidential vSphere Pods in a Supervisor Cluster on AMD systems. You can create confidential vSphere Pods by adding Secure Encrypted Virtualization-Encrypted State (SEV-ES) as a security enhancement. For more information, see [Deploy a Confidential vSphere Pod](#).

A Tanzu Kubernetes cluster is secure by default. Restrictive PodSecurityPolicy (PSP) is available for any Tanzu Kubernetes cluster provisioned by the Tanzu Kubernetes Grid Service. If developers need to run privileged pods or root containers, at a minimum a cluster administrator must create a RoleBinding that grants user access to the default privileged PSP. For more information, see [Using Pod Security Policies with Tanzu Kubernetes Clusters](#).

A Tanzu Kubernetes cluster does not have infrastructure credentials. The credentials that are stored within a Tanzu Kubernetes cluster are only sufficient to access the vSphere Namespace where the Tanzu Kubernetes cluster has tenancy. As a result, there is no privilege escalation avenue for cluster operators or users.

The authentication tokens used to access Tanzu Kubernetes clusters are scoped such that the tokens cannot be used to access the Supervisor Cluster. This prevents cluster operators, or individuals who might try to compromise a cluster, from using their root-level access to capture a vSphere administrator's token when they log in to a Tanzu Kubernetes cluster.

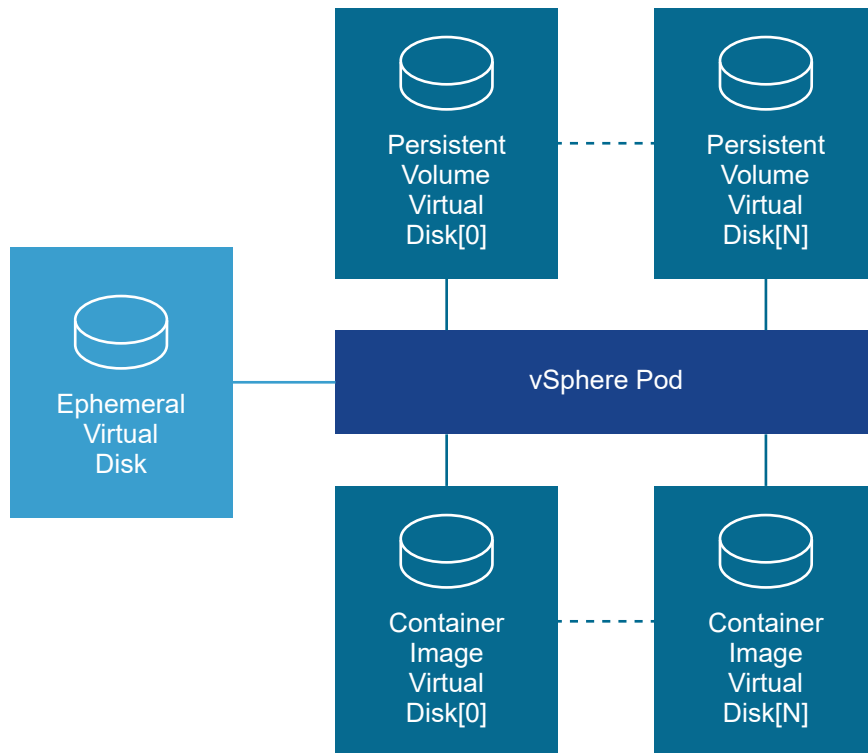
## vSphere with Tanzu Storage

vSphere with Tanzu uses storage policies to integrate with shared datastores available in your environment, including VMFS, NFS, vSAN, or vVols datastores. The policies represent datastores and manage the storage placement of such objects as control plane VMs, pod ephemeral disks, container images, and persistent storage volumes. If you use Tanzu Kubernetes clusters, the storage policies also dictate how the Tanzu Kubernetes cluster nodes are deployed.

Before you enable vSphere with Tanzu, create storage policies to be used by the Supervisor Cluster and namespaces.

Depending on your vSphere storage environment and the needs of DevOps, you can create several storage policies to represent different classes of storage.

For example, if a vSphere Pod mounts all three types of virtual disks and your vSphere storage environment has three classes of datastores, Bronze, Silver, and Gold, you can create storage policies for all datastores. You can then use the Bronze datastore for ephemeral and container image virtual disks, and use the Silver and Gold datastores for persistent volume virtual disks.



For general information about storage policies, see the [Storage Policy Based Management](#) chapter in the *vSphere Storage* documentation. For information about creating storage policies, see [Create Storage Policies for vSphere with Tanzu](#).

## Ephemeral Virtual Disks

A vSphere Pod and a pod that runs in a Tanzu Kubernetes cluster requires ephemeral storage to store such Kubernetes objects as logs, `emptyDir` volumes, and `ConfigMaps` during its operations. This ephemeral, or transient, storage lasts as long as the pod continues to exist. Ephemeral data persists across container restarts, but once the pod reaches the end of its life, the ephemeral virtual disk disappears.

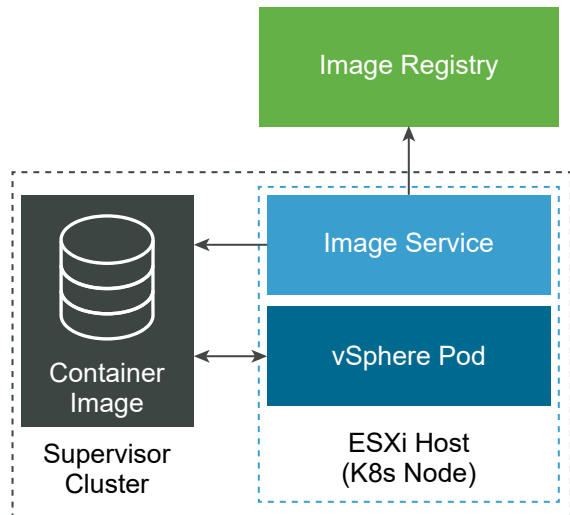
Each pod has one ephemeral virtual disk. A vSphere administrator uses a storage policy to define the datastore location for all ephemeral virtual disks when configuring storage for the Supervisor Cluster.

## Container Image Virtual Disks

Containers inside the pod use images that contain the software to be run. The pod mounts images used by its containers as image virtual disks. When the pod completes its life cycle, the image virtual disks are detached from the pod.

Image Service, an ESXi component, is responsible for pulling container images from the image registry and transforming them into virtual disks to run inside the pod.





ESXi can cache images that are downloaded for the containers running in the pod. Subsequent pods that use the same image pull it from the local cache rather than the external container registry.

As with ephemeral disks, the vSphere administrator specifies the datastore location for the image cache at the Supervisor Cluster level. See [Chapter 5 Configuring and Managing a Supervisor Cluster](#) and [Change Storage Settings on the Supervisor Cluster](#).

For information about working with the container images, see [Chapter 15 Using a Container Registry for vSphere with Tanzu Workloads](#).

## Persistent Storage Virtual Disks

Certain Kubernetes workloads require persistent storage to store data permanently. To provision persistent storage for Kubernetes workloads, vSphere with Tanzu integrates with Cloud Native Storage (CNS), a vCenter Server component that manages persistent volumes.

Persistent storage can be used by vSphere Pods, Tanzu Kubernetes clusters, and VMs. To make persistent storage available to the DevOps team, the vSphere administrators create VM storage policies that describe different storage requirements and classes of services. They can then assign the storage policies to a vSphere Namespace. See [Create and Configure a vSphere Namespace](#) and [Change Storage Settings on a Namespace](#).

For more information and for specifics on how persistent storage is used by the Supervisor Cluster and the Tanzu Kubernetes clusters, see [Chapter 10 Using Persistent Storage in vSphere with Tanzu](#) and [Chapter 13 Provisioning and Operating TKGS Clusters](#).

# Networking for vSphere with Tanzu

# 4

A Supervisor Cluster can either use the vSphere networking stack or VMware NSX-T™ Data Center to provide connectivity to Kubernetes control plane VMs, services, and workloads. The networking used for Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service is a combination of the fabric that underlies the vSphere with Tanzu infrastructure and open-source software that provides networking for cluster pods, services, and ingress.

This chapter includes the following topics:

- [Supervisor Cluster Networking](#)
- [Tanzu Kubernetes Cluster Networking](#)
- [Configuring NSX-T Data Center for vSphere with Tanzu](#)
- [Configuring vSphere Networking and NSX Advanced Load Balancer for vSphere with Tanzu](#)
- [Configuring vSphere Networking and HA Proxy Load Balancer for vSphere with Tanzu](#)

## Supervisor Cluster Networking

In a vSphere with Tanzu environment, a Supervisor Cluster can either use the vSphere networking stack or VMware NSX-T Data Center™ to provide connectivity to Kubernetes control plane VMs, services, and workloads. When a Supervisor Cluster is configured with the vSphere networking stack, all hosts from the cluster are connected to a vSphere Distributed Switch that provides connectivity to Kubernetes workloads and control plane VMs. A Supervisor Cluster that uses the vSphere networking stack requires a load balancer on the vCenter Server management network to provide connectivity to DevOps users and external services. A Supervisor Cluster that is configured with VMware NSX-T Data Center™, uses the software-based networks of the solution as well as an NSX Edge load balancer to provide connectivity to external services and DevOps users.

## Supervisor Cluster Networking with NSX-T Data Center

VMware NSX-T Data Center™ provides network connectivity to the objects inside the Supervisor Cluster and external networks. Connectivity to the ESXi hosts comprising the cluster is handled by the standard vSphere networks.

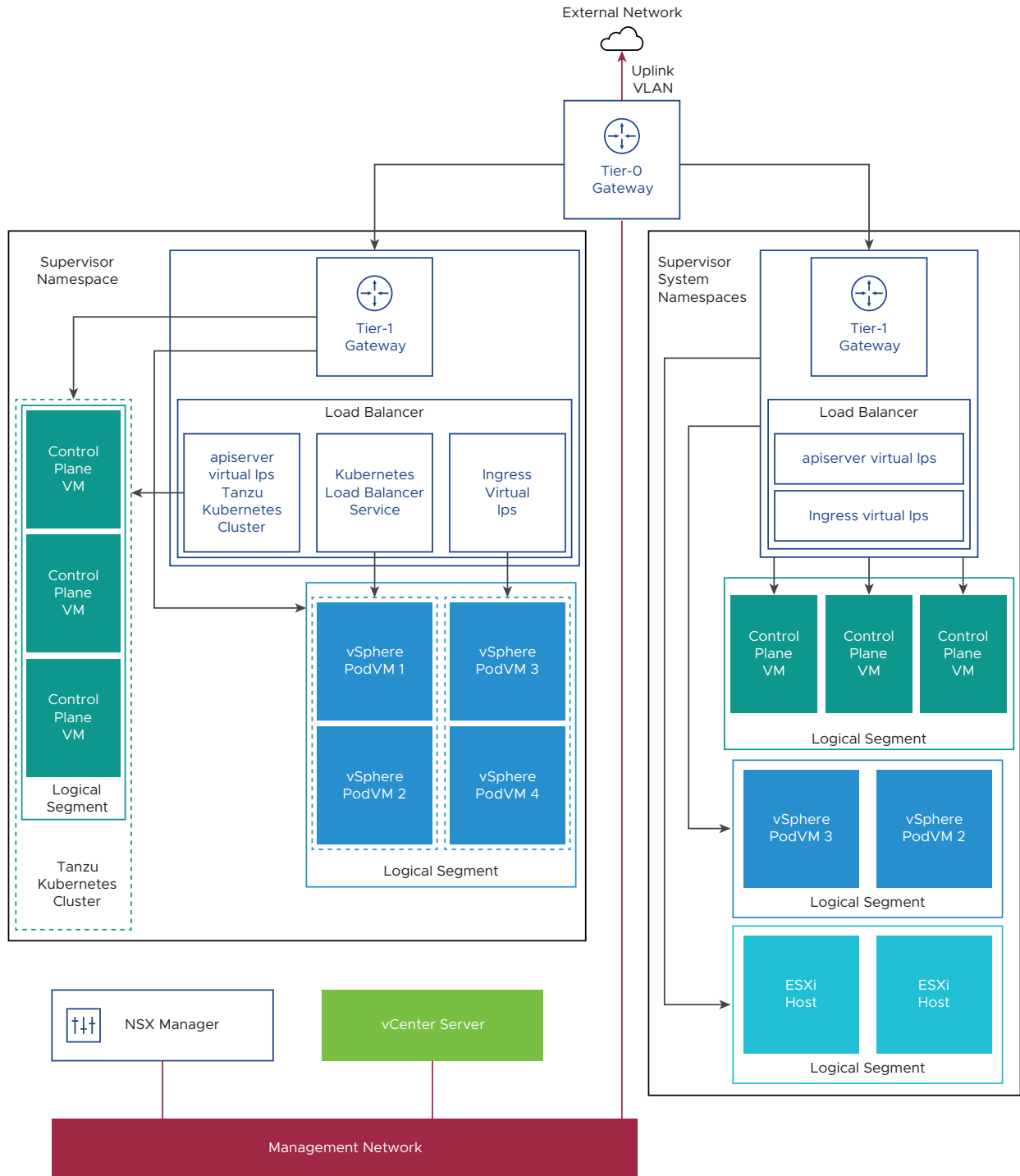
You can also configure the Supervisor Cluster networking manually by using an existing NSX-T Data Center deployment or by deploying a new instance of NSX-T Data Center.

The following table lists the supported NSX-T Data Center versions:

<b>vSphere with Tanzu</b>	<b>NSX-T Data Center</b>
Version 7.0 Update 3	Versions 3.0, 3.0.x, 3.1, 3.1.1, 3.1.2, and 3.1.3.
Version 7.0 Update 2	Versions 3.0, 3.0.x, 3.1, 3.1.1, and 3.1.2.
Version 7.0 Update 1c	Versions 3.0, 3.0.x, 3.1, and 3.1.1.
Version 7.0 Update 1	Versions 3.0, 3.0.1, 3.0.1.1, and 3.0.2.
Version 7.0	Version 3.0.

This section describes the networking topology when you install and configure vSphere with Tanzu Version 7.0 Update 2. For information on the upgrade when you upgrade from vSphere with Tanzu Version 7.0 Update 1 to Version 7.0 Update 2, see [Network Topology Upgrade](#) .

Figure 4-1. Supervisor Cluster Networking



- NSX Container Plug-in (NCP) provides integration between NSX-T Data Center and Kubernetes. The main component of NCP runs in a container and communicates with NSX Manager and with the Kubernetes control plane. NCP monitors changes to containers and other resources and manages networking resources such as logical ports, segments, routers, and security groups for the containers by calling the NSX API.

The NCP creates one shared tier-1 gateway for system namespaces and a tier-1 gateway and load balancer for each namespace, by default. The tier-1 gateway is connected to the tier-0 gateway and a default segment.

System namespaces are namespaces that are used by the core components that are integral to functioning of the supervisor cluster and Tanzu Kubernetes. The shared network resources that include the tier-1 gateway, load balancer, and SNAT IP are grouped in a system namespace.

- NSX Edge provides connectivity from external networks to Supervisor Cluster objects. The NSX Edge cluster has a load balancer that provides a redundancy to the Kubernetes API servers residing on the control plane VMs and any application that must be published and be accessible from outside the Supervisor Cluster.
- A tier-0 gateway is associated with the NSX Edge cluster to provide routing to the external network. The uplink interface uses either the dynamic routing protocol, BGP, or static routing.
- Each vSphere Namespace has a separate network and set of networking resources shared by applications inside the namespace such as, tier-1 gateway, load balancer service, and SNAT IP address.
- Workloads running in Sphere Pods, regular VMs, or Tanzu Kubernetes clusters, that are in the same namespace, share a same SNAT IP for North-South connectivity.
- Workloads running in Sphere Pods or Tanzu Kubernetes clusters will have the same isolation rule that is implemented by the default firewall.
- A separate SNAT IP is not required for each Kubernetes namespace. East west connectivity between namespaces will be no SNAT.
- The segments for each namespace reside on the vSphere Distributed Switch (VDS) functioning in Standard mode that is associated with the NSX Edge cluster. The segment provides an overlay network to the Supervisor Cluster.
- Supervisor clusters have separate segments within the shared tier-1 gateway. For each Tanzu Kubernetes cluster, segments are defined within the tier-1 gateway of the namespace.
- The Spherelet processes on each ESXi hosts communicate with vCenter Server through an interface on the Management Network.

To learn more about Supervisor Cluster networking, watch the video [vSphere 7 with Kubernetes Network Service - Part 1 - The Supervisor Cluster](#).

## Networking Configuration Methods with NSX-T Data Center

The Supervisor Cluster uses an opinionated networking configuration. Two methods exist to configure the Supervisor Cluster networking with NSX-T Data Center that result in deploying the same networking model:

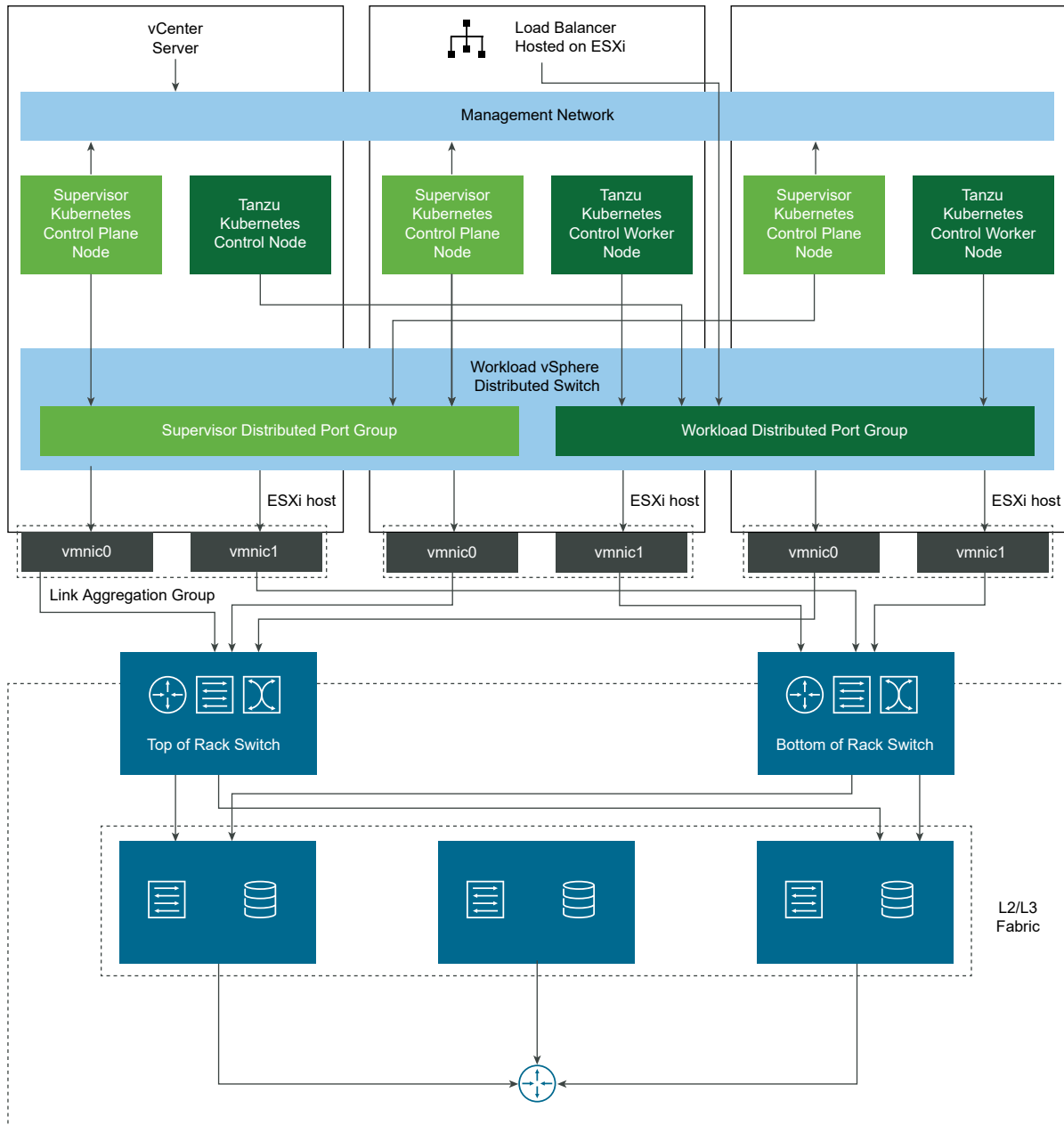
- The simplest way to configure the Supervisor Cluster networking is by using the VMware Cloud Foundation SDDC Manager. For more information, see the VMware Cloud Foundation SDDC Manager documentation. For information, see [Working with Workload Management](#).

- You can also configure the Supervisor Cluster networking manually by using an existing NSX-T Data Center deployment or by deploying a new instance of NSX-T Data Center. See [Install and Configure NSX-T Data Center for vSphere with Tanzu](#) for more information.

## Supervisor Cluster Networking with vSphere Distributed Switch

A Supervisor Cluster that is backed by a vSphere Distributed Switch uses distributed port groups as Workload Networks for namespaces.

Figure 4-2. Namespace Networking with vSphere Distributed Switch



Depending on the topology that you implement for the Supervisor Cluster, you can use one or more distributed port groups as Workload Networks. The network that provides connectivity to the Kubernetes Control Plane VMs is called Primary Workload Network. You can assign this network to all the namespaces on the Supervisor Cluster, or you can use different networks for each namespace. The Tanzu Kubernetes clusters connect to the Workload Network that is assigned to the namespace where the clusters reside.

A Supervisor Cluster that is backed by a vSphere Distributed Switch uses a load balancer for providing connectivity to DevOps users and external services. You can use the NSX Advanced Load Balancer or the HAProxy load balancer.

For more information, see [Configuring vSphere Networking and NSX Advanced Load Balancer for vSphere with Tanzu](#) and [Install and Configure the HAProxy Load Balancer](#).

## Tanzu Kubernetes Cluster Networking

A Tanzu Kubernetes cluster provisioned by the Tanzu Kubernetes Grid Service supports two CNI options: Antrea (default) and Calico. Both are open-source software that provide networking for cluster pods, services, and ingress.

Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service support the following [Container Network Interface](#) (CNI) options:

- [Antrea](#)
- [Calico](#)

Antrea is the default CNI for new Tanzu Kubernetes clusters. If you are using Antrea, you do not have to specify it as the CNI during cluster provisioning. To use Calico as the CNI you have two options:

- Specify the CNI directly in the cluster YAML. See [Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API](#).
- Change the default CNI. See [Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API](#).

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**Note** The use of Antrea as the default CNI requires a minimum version of the OVA file for Tanzu Kubernetes clusters. See [List of Tanzu Kubernetes releases](#).

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The table summarizes Tanzu Kubernetes cluster networking features and their implementation.

**Table 4-1. Tanzu Kubernetes Cluster Networking**

Endpoint	Provider	Description
Pod connectivity	Antrea or Calico	Container network interface for pods. Antrea uses Open vSwitch. Calico uses the Linux bridge with BGP.
Service type: ClusterIP	Antrea or Calico	Default Kubernetes service type that is only accessible from within the cluster.

Table 4-1. Tanzu Kubernetes Cluster Networking (continued)

Endpoint	Provider	Description
Service type: NodePort	Antrea or Calico	Allows external access through a port opened on each worker node by the Kubernetes network proxy.
Service type: LoadBalancer	NSX-T load balancer, NSX Advanced Load Balancer, HAProxy	For NSX-T, one virtual server per service type definition. For NSX Advanced Load Balancer, refer to that section of this documentation.  <b>Note</b> Some load balancing features may not be available with HAProxy, such as support for static IPs.
Cluster ingress	Third-party ingress controller	Routing for inbound pod traffic; you can use any third-party ingress controller.
Network policy	Antrea or Calico	Controls what traffic is allowed to and from selected pods and network endpoints. Antrea uses Open vSwitch. Calico uses Linux IP tables.

## Configuring NSX-T Data Center for vSphere with Tanzu

vSphere with Tanzu requires specific networking configuration to enable connectivity to the Supervisor Clusters, vSphere Namespaces, and all objects that run inside the namespaces, such as vSphere Pods, VMs, and Tanzu Kubernetes clusters. As a vSphere administrator, install and configure NSX-T Data Center for vSphere with Tanzu.

The Supervisor Cluster uses an opinionated networking configuration. Two methods exist to configure the Supervisor Cluster networking that result in deploying the same networking model:

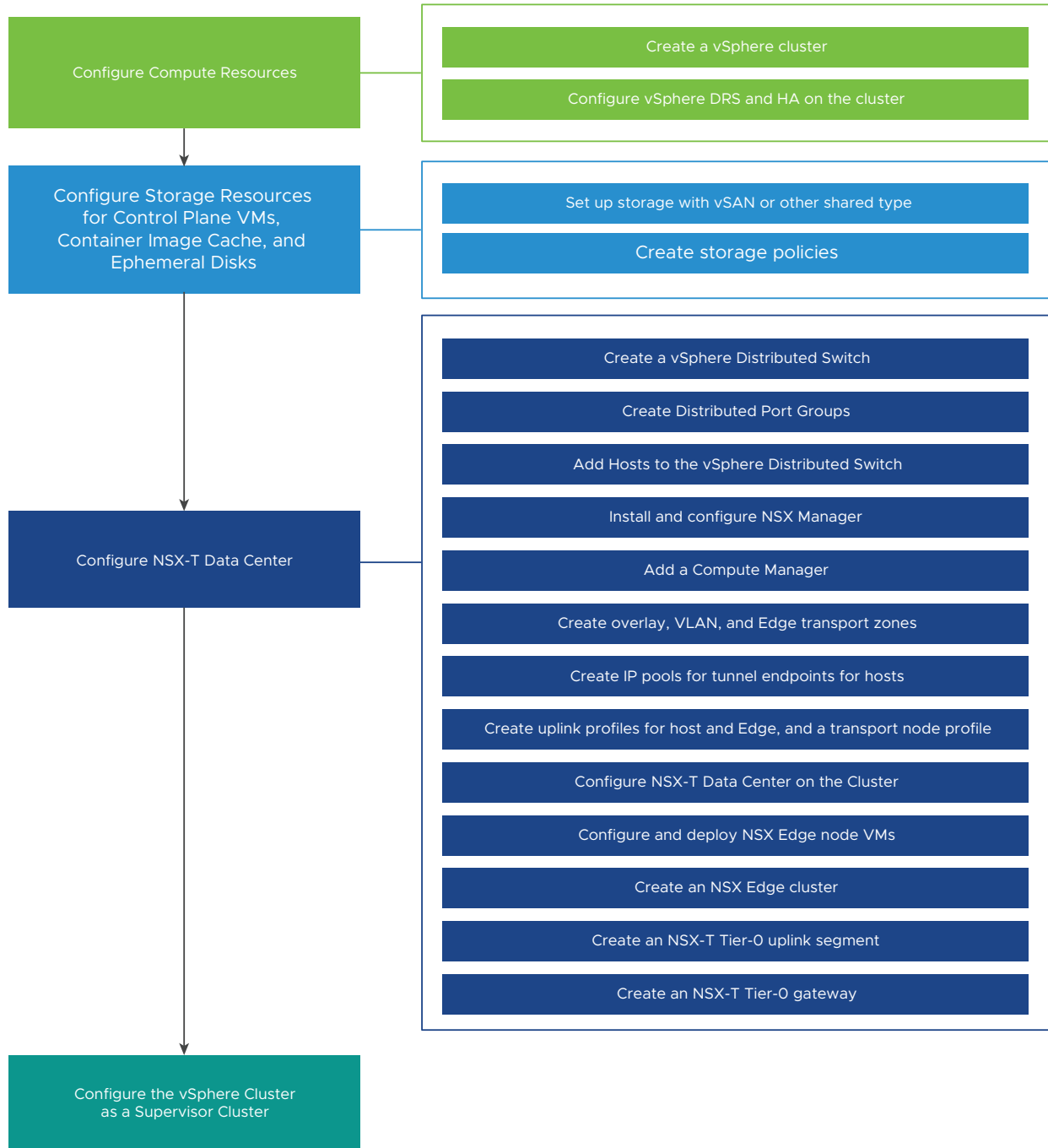
- The simplest way to configure the Supervisor Cluster networking is by using the VMware Cloud Foundation SDDC Manager. For more information, see the VMware Cloud Foundation SDDC Manager documentation. For more information, see [Working with Workload Management](#).
- You can also configure the Supervisor Cluster networking manually by using an existing NSX-T Data Center deployment or by deploying a new instance of NSX-T Data Center.

### Supervisor Cluster with NSX-T Data Center Workflow

As a vSphere administrator, you can configure a vSphere cluster as a Supervisor Cluster with the vSphere networking stack.



Figure 4-3. Supervisor Cluster with NSX-Data Center Networking Workflow



## Procedure

### 1 System Requirements for Setting Up vSphere with Tanzu with NSX-T Data Center

Review the system requirements for configuring vSphere with Tanzu on a vSphere cluster by using the NSX-T Data Center networking stack.

## 2 Topologies for a Supervisor Cluster with NSX-T Data Center

You can apply different topologies to your cluster depending on the needs of your Kubernetes workloads and the underlying networking infrastructure.

## 3 Best Practice Considerations for Configuring the Supervisor Cluster with NSX-T Data Center

Consider these best practices when you configure a vSphere cluster as a Supervisor Cluster using NSX-T Data Center.

## 4 Install and Configure NSX-T Data Center for vSphere with Tanzu

vSphere with Tanzu requires specific networking configuration to enable connectivity to the Supervisor Clusters, vSphere Namespaces, and all objects that run inside the namespaces, such as vSphere Pods, VMs, and Tanzu Kubernetes clusters. As a vSphere administrator, install and configure NSX-T Data Center for vSphere with Tanzu.

# System Requirements for Setting Up vSphere with Tanzu with NSX-T Data Center

Review the system requirements for configuring vSphere with Tanzu on a vSphere cluster by using the NSX-T Data Center networking stack.

## Configuration Limits for vSphere with Tanzu Clusters

VMware provides configuration limits in the [VMware Configuration Maximums](#) tool.

For configuration limits specific to vSphere with Tanzu, including Supervisor Clusters and Tanzu Kubernetes clusters, select **vSphere > vSphere 7.0 > vSphere with Kubernetes > VMware Tanzu Kubernetes Grid Service for vSphere** and click **View Limits**, or follow [this link](#).

## Requirements for a Management, Edge, and Workload Domain Cluster

You can deploy vSphere with Tanzu with combined management, Edge, and workload management functions on a single vSphere cluster.

**Table 4-2. Minimum Compute Requirements for the Management, Edge, and Workload Management Cluster**

System	Minimum Deployment Size	CPU	Memory	Storage
vCenter Server 7.0	Small	2	16 GB	290 GB
ESXi hosts 7.0	<p>3 ESXi hosts with 1 static IP per host.</p> <p>If you are using vSAN: 3 ESXi hosts with at least 2 physical NICs per host is the minimum. However, 4 ESXi hosts are recommended for resiliency during patching and upgrading.</p> <p>The hosts must be joined in a cluster with vSphere DRS and HA enabled. vSphere DRS must be in Fully Automate or Partially Automate mode.</p> <p><b>Caution</b> Do not disable vSphere DRS after you configure the Supervisor Cluster. Having DRS enabled at all times is a mandatory prerequisite for running workloads on the Supervisor Cluster. Disabling DRS leads to breaking your Tanzu Kubernetes clusters.</p>	8	64 GB per host	Not applicable
NSX Manager	Medium	6	24 GB	300 GB
NSX Edge 1	Large	8	32 GB	200 GB
NSX Edge 2	Large	8	32 GB	200 GB
Kubernetes control plane VMs	3	4	16 GB	16 GB

## Topology with Separate Management and Edge Cluster and Workload Management Cluster

You can deploy vSphere with Tanzu in two clusters, one cluster for the Management and Edge functions, and another one dedicated to Workload Management.

**Table 4-3. Minimum Compute Requirements for the Management and Edge Cluster**

<b>System</b>	<b>Minimum Deployment Size</b>	<b>CPU</b>	<b>Memory</b>	<b>Storage</b>
vCenter Server 7.0	Small	2	16 GB	290 GB
ESXi hosts 7.0	2 ESXi hosts	8	64 GB per host	Not applicable
NSX Manager	Medium	6	24 GB	300 GB
NSX Edge 1	Large	8	32 GB	200 GB
NSX Edge 2	Large	8	32 GB	200 GB

Table 4-4. Minimum Compute Requirements for the Workload Management Cluster

System	Minimum Deployment Size	CPU	Memory	Storage
ESXi hosts 7.0	<p>3 ESXi hosts with 1 static IP per host.</p> <p>If you are using vSAN: 3 ESXi hosts with at least 2 physical NICs per host is the minimum; however, 4 ESXi hosts are recommended for resiliency during patching and upgrading.</p> <p>The hosts must be joined in a cluster with vSphere DRS and HA enabled. vSphere DRS must be in Fully Automated mode.</p> <p><b>Caution</b> Do not disable vSphere DRS after you configure the Supervisor Cluster. Having DRS enabled at all times is a mandatory prerequisite for running workloads on the Supervisor Cluster. Disabling DRS leads to breaking your Tanzu Kubernetes clusters.</p>	8	64 GB per host	Not applicable
Kubernetes control plane VMs	3	4	16 GB	16 GB

## Networking Requirements

No matter of the topology that you implement for Kubernetes workload management in vSphere, your deployment must meet the following networking requirements:

Component	Minimum Quantity	Required Configuration
Static IPs for Kubernetes control plane VMs	Block of 5	A block of 5 consecutive static IP addresses to be assigned to the Kubernetes control plane VMs in the Supervisor Cluster.
Management traffic network	1	A Management Network that is routable to the ESXi hosts, vCenter Server, and a DHCP server. The network must be able to access a container registry and have Internet connectivity if the container registry is on the external network. The container registry must be resolvable through DNS, and the Egress setting described below must be able to reach it.
NTP and DNS Server	1	A DNS server and NTP server that can be used for the vCenter Server.  <b>Note</b> Configure NTP on all ESXi hosts, vCenter Server systems, and NSX Manager instances.
DHCP Server	1	Optional. Configure a DHCP server to automatically acquire IP addresses for the management. The DHCP server must support Client Identifiers and provide compatible DNS servers, DNS search domains, and an NTP server.
Image Registry	1	Access to a registry for service.
Management Network Subnet	1	The subnet used for management traffic between ESXi hosts and vCenter Server, NSX Appliances, and the Kubernetes control plane. The size of the subnet must be the following: <ul style="list-style-type: none"> <li>■ One IP address per host VMkernel adapter.</li> <li>■ One IP address for the vCenter Server Appliance.</li> <li>■ One or four IP addresses for NSX Manager. Four when performing NSX Manager clustering of 3 nodes and 1 virtual IP (VIP).</li> <li>■ 5 IP addresses for the Kubernetes control plane. 1 for each of the 3 nodes, 1 for virtual IP, 1 for rolling cluster upgrade.</li> </ul> <b>Note</b> The Management Network and the Workload Network must be on different subnets. Assigning the same subnet to the Management and the Workload networks is not supported and can lead to system errors and problems.
Management Network VLAN	1	The VLAN ID of the Management Network subnet.

Component	Minimum Quantity	Required Configuration
VLANs	3	<p>These VLAN IPs are the IP addresses for the tunnel endpoints (TEPs). The ESXi host TEPs and the Edge TEPs must be routable.</p> <p>VLAN IP addresses are required for the following:</p> <ul style="list-style-type: none"> <li>■ ESXi Host VTEP</li> <li>■ Edge VTEP using the static IP</li> <li>■ Tier 0 gateway and uplink for transport node.</li> </ul> <p><b>Note</b> The ESXi Host VTEP and the Edge VTEP must have MTU size greater than 1600.</p> <p>ESXi hosts and NSX-T Edge nodes act as tunnel end points, and a Tunnel End Point (TEP) IP is assigned to each host and Edge node.</p> <p>As the TEP IPs for ESXi hosts create an overlay tunnel with TEP IPs on the Edge nodes, the VLAN IPs should be routable.</p> <p>An additional VLAN is required to provide North-South connectivity to Tier-0 gateway.</p> <p>IP pools can be shared across clusters. However, host overlay IP pool/VLAN must not be shared with Edge overlay IP pool/VLAN.</p> <p><b>Note</b> If host TEP and Edge TEP are using different physical NICs, they can use the same VLAN.</p>
Tier-0 Uplink IP	/24 Private IP addresses	<p>The IP subnet used for the Tie-0 uplink. The requirements for the IP address of the Tier-0 uplink are as follows:</p> <ul style="list-style-type: none"> <li>■ 1 IP, if you do not use Edge redundancy.</li> <li>■ 4 IPs, if you use BGP and Edge redundancy, 2 IP addresses per Edge.</li> <li>■ 3 IPs, if you use static routes and Edge redundancy.</li> </ul> <p>The Edge Management IP, subnet, gateway, Uplink IP, subnet, gateway must be unique.</p>
Physical Network MTU	1600	<p>The MTU size must be 1600 or greater on any network that carries overlay traffic.</p>
vSphere Pod CIDR range	/23 Private IP addresses	<p>A private CIDR range that provides IP addresses for vSphere Pods. These addresses are also used for the Tanzu Kubernetes cluster nodes.</p> <p>You must specify a unique vSphere Pod CIDR range for each cluster.</p> <p><b>Note</b> The vSphere Pod CIDR range and the CIDR range for the Kubernetes service addresses must not overlap.</p>
Kubernetes services CIDR range	/16 Private IP addresses	<p>A private CIDR range to assign IP addresses to Kubernetes services. You must specify a unique Kubernetes services CIDR range for each Supervisor Cluster.</p>

Component	Minimum Quantity	Required Configuration
Egress CIDR range	/27 Static IP Addresses	<p>A private CIDR annotation to determine the egress IP for Kubernetes services. Only one egress IP address is assigned for each namespace in the Supervisor Cluster. The egress IP is the address that external entities use to communicate with the services in the namespace. The number of egress IP addresses limits the number of egress policies the Supervisor Cluster can have.</p> <p>The minimum is a CIDR of /27 or more. For example, 10.174.4.96/27</p> <hr/> <p><b>Note</b> Egress IP addresses and ingress IP addresses must not overlap.</p>
Ingress CIDR	/27 Static IP Addresses	<p>A private CIDR range to be used for IP addresses of ingresses. Ingress lets you apply traffic policies to requests entering the Supervisor Cluster from external networks. The number of ingress IP addresses limits the number of ingresses the cluster can have.</p> <p>The minimum is a CIDR of /27 or more.</p> <hr/> <p><b>Note</b> Egress IP addresses and ingress IP addresses must not overlap.</p>

## Topologies for a Supervisor Cluster with NSX-T Data Center

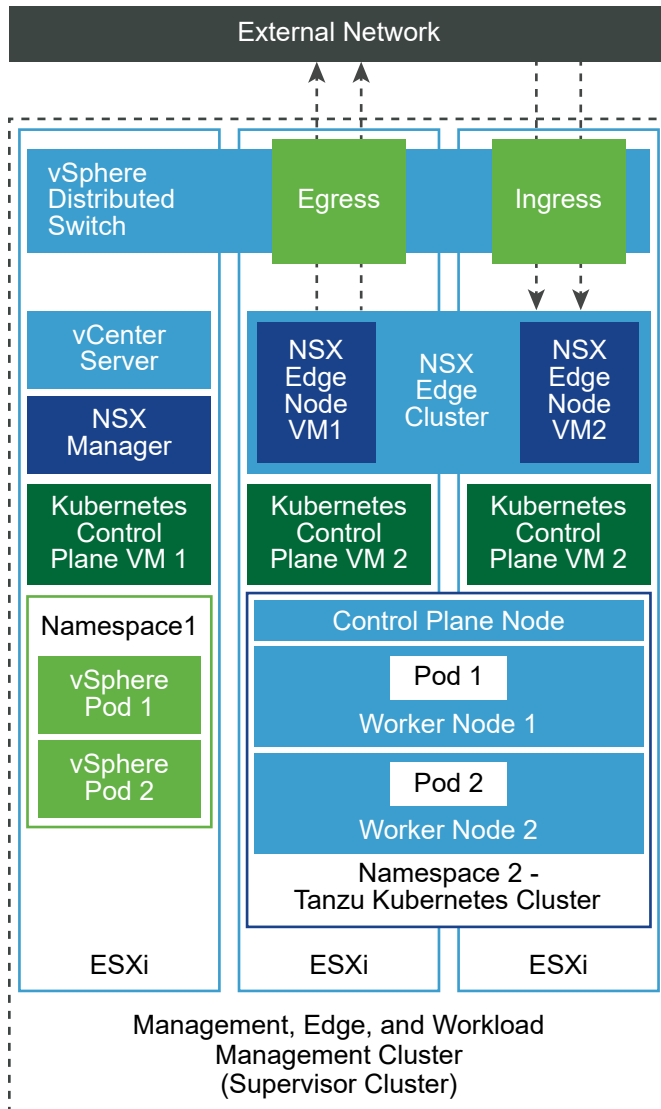
You can apply different topologies to your cluster depending on the needs of your Kubernetes workloads and the underlying networking infrastructure.

### Topology for a Management, Edge, and Workload Domain Cluster

You can deploy vSphere with Tanzu with combined management, Edge, and workload management functions on a single vSphere cluster.



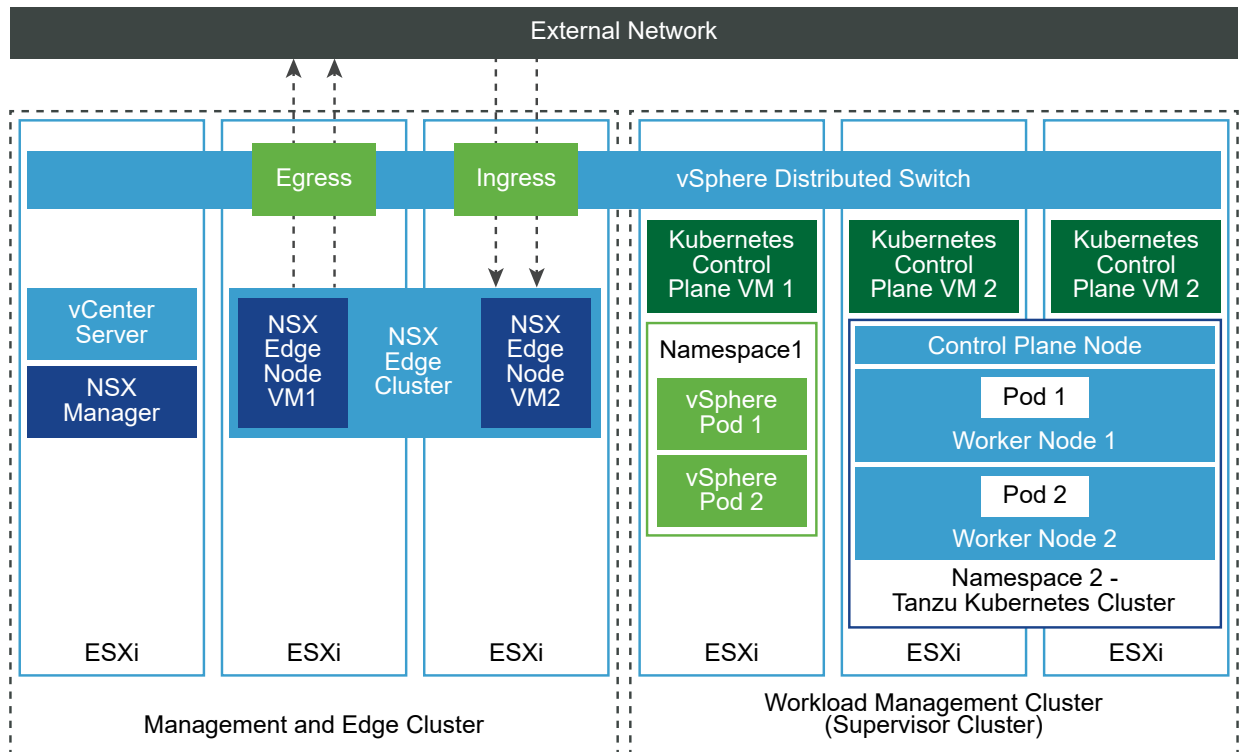
Figure 4-4. Management, Edge, and Workload Management Cluster



### Topology with Separate Management and Edge Cluster and Workload Management Cluster

You can deploy vSphere with Tanzu in two clusters, one cluster for the Management and Edge functions, and another one dedicated to Workload Management.

Figure 4-5. Management and Edge and Workload Management Clusters



## Best Practice Considerations for Configuring the Supervisor Cluster with NSX-T Data Center

Consider these best practices when you configure a vSphere cluster as a Supervisor Cluster using NSX-T Data Center.

- Use vSAN datastore for the NSX Edges.
- If you use a vSAN datastore, ensure that the vSAN environment is properly sized for the workloads. The vSAN setup requires more memory as the kernel memory is used for vSAN. This reduces the memory available to the NSX Edge VMs. Use the vSAN calculator for appropriate sizing. For more information, see [vSAN ReadyNode Sizer](#).
- If you use NFS datastore, verify that it is shared across all hosts in the cluster. Create a unique NFS datastore for each NSX Edge node.
- Configure a dedicated resource pool for each NSX Edge cluster. Do not share the resource pool with other VMs.
- When you configure ESXi host overlay, use VLANs in the range 1-4094.
- When you configure Edge overlay, use VLANs in the range 1-4094.

## Install and Configure NSX-T Data Center for vSphere with Tanzu

vSphere with Tanzu requires specific networking configuration to enable connectivity to the Supervisor Clusters, vSphere Namespaces, and all objects that run inside the namespaces, such

as vSphere Pods, VMs, and Tanzu Kubernetes clusters. As a vSphere administrator, install and configure NSX-T Data Center for vSphere with Tanzu.

This section describes how to configure the Supervisor Cluster networking by deploying a new NSX-T Data Center instance, but the procedures are applicable against an existing NSX-T Data Center deployment as well. This section also provides background to understand what VMware Cloud Foundation SDDC Manager is doing when it sets up the Supervisor Cluster workload domain.

### Prerequisites

- Verify that your environment meets the system requirements for configuring a vSphere cluster as a Supervisor Cluster. For information about requirements, see [System Requirements for Setting Up vSphere with Tanzu with NSX-T Data Center](#).
- Assign the VMware vSphere 7 Enterprise Plus with Add-on for Kubernetes license to all ESXi hosts that will be part of the Supervisor Cluster.
- Create storage policies for the placement of control plane VMs, pod ephemeral disks, and container images.
- Configure shared storage for the cluster. Shared storage is required for vSphere DRS, HA, and storing persistent volumes of containers.
- Verify that DRS and HA is enabled on the vSphere cluster, and DRS is in the fully automated mode.
- Verify that you have the **Modify cluster-wide configuration** privilege on the cluster.

## Create a vSphere Distributed Switch

To handle the networking configuration for all hosts in the Supervisor Cluster, create a vSphere Distributed Switch.

### Procedure

- 1 In the vSphere Client, navigate to a data center.
- 2 In the navigator, right-click the data center and select **Distributed Switch > New Distributed Switch**.
- 3 Enter a name for the new distributed switch.  
For example, `DSwitch`.
- 4 In **Select Version**, enter a version for the distributed switch.  
Select **7.0.0 - ESXi 7.0 and later**.
- 5 In **Configure Settings**, enter the number of uplinks ports.  
Enter a value of 2.
- 6 Review the settings and click **Finish**.
- 7 Right-click the distributed switch you created and select **Settings > Edit settings**.

- 8 On the **Advanced** tab, enter a value of more than 1600 as the MTU (Bytes) value and click **OK**.

The MTU size must be 1600 or greater on any network that carries overlay traffic.

For example, 9000.

#### What to do next

Add distributed port groups. See [Create Distributed Port Groups](#).

## Create Distributed Port Groups

Create distributed port groups for each NSX Edge node uplink, Edge node TEP, management network, and shared storage.

#### Prerequisites

Verify that you have created a vSphere Distributed Switch.

#### Procedure

- 1 In the vSphere Client, navigate to a data center.
- 2 In the navigator, right-click the distributed switch and select **Distributed Port Group > New Distributed Port Group**.
- 3 Create a port group for the NSX Edge uplink.  
For example, `DPortGroup-EDGE-UPLINK`.
- 4 Configure **VLAN Type** as VLAN Trunking.
- 5 Right-click the distributed switch and from the **Actions** menu, select **Distributed Port Group > Manage Distributed Port Groups**.
- 6 Select **Teaming and failover** and click **Next**.
- 7 Configure active and standby uplinks.  
For example, active uplink is `Uplink1` and standby uplink is `Uplink2`.
- 8 Repeat steps 4-7 for the Edge node TEP, management network, and shared storage.  
For example, create the following port groups:

Port group	Name	VLAN Type
Edge node TEP	DPortGroup-EDGE-TEP	Configure <b>VLAN Type</b> as VLAN Trunking. Configure the active uplink as Uplink2 and the standby uplink as Uplink1.  <b>Note</b> The VLAN used for the Edge nodes TEP must be different than the VLAN used for ESXi TEP.
Management	DPortGroup-MGMT	Configure <b>VLAN Type</b> as VLAN and enter the VLAN ID of the management network. For example, 1060.
Shared storage or VSAN	DPortGroup-VSAN	Configure <b>VLAN Type</b> as VLAN and enter the VLAN ID. For example, 3082.

9 (Optional) Create port groups for the following components:

- vSphere vMotion
- VM traffic

#### What to do next

Add hosts to the to the vSphere Distributed Switch. See [Add Hosts to the vSphere Distributed Switch](#).

## Add Hosts to the vSphere Distributed Switch

To manage the networking of your environment by using the vSphere Distributed Switch, you must associate hosts with the switch. Connect the physical NICs, VMkernel adapters, and virtual machine network adapters of the hosts to the distributed switch.

#### Prerequisites

- Verify that enough uplinks are available on the distributed switch to assign to the physical NICs that you want to connect to the switch.
- Verify that at least one distributed port group is available on the distributed switch.
- Verify that the distributed port group has active uplinks configured in its teaming and failover policy.

#### Procedure

- 1 In the vSphere Client, select **Networking** and navigate to the distributed switch.
- 2 From the **Actions** menu, select **Add and Manage Hosts**.
- 3 On the **Select task** page, select **Add hosts**, and click **Next**.

- 4 On the **Select hosts** page, click **New hosts**, select the hosts in your data center, click **OK**, and then click **Next**.
- 5 On the **Manage physical adapters** page, configure physical NICs on the distributed switch.
  - a From the **On other switches/unclaimed** list, select a physical NIC.  
If you select physical NICs that are already connected to other switches, they are migrated to the current distributed switch.
  - b Click **Assign uplink**.
  - c Select an uplink.
  - d To assign the uplink to all the hosts in the cluster, select **Apply this uplink assignment to the rest of the hosts**.
  - e Click **OK**.  
For example, assign Uplink 1 to vmnic0 and Uplink 2 to vmnic1.
- 6 Click **Next**.
- 7 On the **Manage VMkernel adapters** page, configure VMkernel adapters.
  - a Select a VMkernel adapter and click **Assign port group**.
  - b Select a distributed port group.  
For example, **DPortGroup**.
  - c To apply the port group to all hosts in the cluster, select **Apply this port group assignment to the rest of the hosts**.
  - d Click **OK**.
- 8 Click **Next**.
- 9 (Optional) On the **Migrate VM networking** page, select the **Migrate virtual machine networking** check box to configure virtual machine networking.
  - a To connect all network adapters of a virtual machine to a distributed port group, select the virtual machine, or select an individual network adapter to connect only that adapter.
  - b Click **Assign port group**.
  - c Select a distributed port group from the list and click **OK**.
  - d Click **Next**.

#### What to do next

Deploy and configure NSX Manager. See [Deploy and Configure NSX Manager](#)

## Deploy and Configure NSX Manager

You can use the vSphere Client to deploy the NSX Manager to the vSphere cluster and use it with vSphere with Tanzu.

To deploy the NSX Manager using the OVA file, perform the steps in this procedure.

For information about deploying the NSX Manager through the user interface or CLI, see the *NSX-T Data Center Installation Guide*.

### Prerequisites

- Verify that your environment meets the networking requirements. See [System Requirements for Setting Up vSphere with Tanzu with NSX-T Data Center](#) for more details.
- Verify that the required ports are open. For information about port and protocols, see the *NSX-T Data Center Installation Guide*.

### Procedure

- 1 Locate the NSX-T Data Center OVA file on the VMware download portal.  
Either copy the download URL or download the OVA file.
- 2 Right-click and select **Deploy OVF template** to start the installation wizard.
- 3 In the **Select an OVF template** tab, enter the download OVA URL or navigate to the OVA file.
- 4 In the **Select a name and folder** tab, enter a name for the NSX Manager virtual machine (VM).
- 5 In the **Select a compute resource** tab, select the vSphere cluster on which to deploy the NSX Manager.
- 6 Click **Next** to review details.
- 7 In the **Configuration tab**, select the NSX-T deployment size.  
The recommended minimum deployment size is Medium.
- 8 In the **Select storage** tab, select the shared storage for deployment.
- 9 Enable thin provisioning by selecting the **Thin Provision** in **Select virtual disk format**.  
The virtual disks are thick provisioned by default.
- 10 In the **Select networks** tab, select the management port group or destination network for the NSX Manager in **Destination Network**.  
For example, `DPortGroup-MGMT`.
- 11 In the **Customize template** tab, enter the system root, CLI admin, and audit passwords for the NSX Manager. Your passwords must comply with the password strength restrictions.
  - At least 12 characters.
  - At least one lower-case letter.
  - At least one upper-case letter.
  - At least one digit.
  - At least one special character.
  - At least five different characters.

- Default password complexity rules are enforced by the Linux PAM module.
- 12 Enter the default IPv4 gateway, management network IPv4, management network netmask, DNS server, domain search list, and NTP IP address.
  - 13 Enable SSH and allow root SSH login to the NSX Manager command line.  
By default, the SSH options are disabled for security reasons.
  - 14 Verify that your custom OVF template specification is accurate, and click **Finish** to initiate the installation.
  - 15 After the NSX Manager boots, log in to the CLI as admin and run the `get interface eth0` command to verify that the IP address was applied as expected.
  - 16 Enter the `get services` command to verify that all the services are running.

## Deploy NSX Manager Nodes to Form a Cluster

An NSX Manager cluster provides high availability. You can deploy NSX Manager nodes using the user interface only on ESXi hosts managed by vCenter Server. To create an NSX Manager cluster, deploy two additional nodes to form a cluster of three nodes total. When you deploy a new node from the UI, the node connects to the first deployed node to form a cluster. All the repository details and the password of the first deployed node are synchronized with the newly deployed node.

### Prerequisites

- Verify that an NSX Manager node is installed.
- Verify that a compute manager is configured.
- Verify that the required ports are open.
- Verify that a datastore is configured on the ESXi host.
- Verify that you have the IP address and gateway, DNS server IP addresses, domain search list, and the NTP server IP address for the NSX Manager to use.
- Verify that you have a target VM port group network. Place the NSX-T Data Center appliances on a management VM network.

### Procedure

- 1 From a browser, log in with admin privileges to the NSX Manager at `https://<manager-ip-address>`.
- 2 To deploy an appliance, select **System > Appliances > Add NSX Appliance**.
- 3 Enter the appliance details.

Option	Description
Hostname	Enter the host name or FQDN to use for the node.
Management IP/Netmask	Enter an IP address to be assigned to the node.



Option	Description
<b>Management Gateway</b>	Enter a gateway IP address to be used by the node.
<b>DNS servers</b>	Enter the list of DNS server IP addresses to be used by the node.
<b>NTP server</b>	Enter the list of NTP server IP addresses
<b>Node Size</b>	Select <b>Medium (6 vCPU, 24 GB RAM, 300 GB storage)</b> form factor from the options.

#### 4 Enter the appliance configuration details

Option	Description
<b>Compute Manager</b>	Select the vCenter Server that you configured as compute manager.
<b>Compute Cluster</b>	Select the cluster that the node must join.
<b>Datastore</b>	Select a datastore for the node files.
<b>Virtual Disk Format</b>	Select <b>Thin Provision</b> format.
<b>Network</b>	Click <b>Select Network</b> to select the management network for the node.

#### 5 Enter the access and credentials details.

Option	Description
<b>Enable SSH</b>	Toggle the button to allow SSH login to the new node.
<b>Enable Root Access</b>	Toggle the button to allow root access to the new node.
<b>System Root Credentials</b>	<p>Set and confirm the root password for the new node.</p> <p>Your password must comply with the password strength restrictions.</p> <ul style="list-style-type: none"> <li>■ At least 12 characters.</li> <li>■ At least one lower-case letter.</li> <li>■ At least one upper-case letter.</li> <li>■ At least one digit.</li> <li>■ At least one special character.</li> <li>■ At least five different characters.</li> <li>■ Default password complexity rules are enforced by the Linux PAM module.</li> </ul>
<b>Admin CLI Credentials and Audit CLI Credentials</b>	Select the <b>Same as root password</b> check box to use the same password that you configured for root, or deselect the check box and set a different password.

#### 6 Click **Install Appliance**.

The new node is deployed. You can track the deployment process in the **System > > Appliances** page. Do not add additional nodes until the installation is finished and the cluster is stable.

#### 7 Wait for the deployment, cluster formation, and repository synchronization to finish.

The joining and cluster stabilizing process might take from 10 to 15 minutes. Verify that the status for every cluster service group is UP before making any other cluster changes.

- 8 After the node boots, log in to the CLI as admin and run the `get interface eth0` command to verify that the IP address was applied as expected.
- 9 If your cluster has only two nodes, add another appliance. Select **System > Appliances > Add NSX Appliance** and repeat the configuration steps.

## Add a License

Add a license using the NSX Manager.

### Prerequisites

Obtain an NSX-T Data Center Advanced or higher license.

### Procedure

- 1 Log in to the NSX Manager.
- 2 Select **System > Licenses > Add**.
- 3 Enter the license key.
- 4 Click **Add**.

## Add a Compute Manager

A compute manager is an application that manages resources such as hosts and virtual machines. Configure the vCenter Server that is associated with the NSX-T Data Center as a compute manager in the NSX Manager.

### Procedure

- 1 Log in to the NSX Manager.
- 2 Select **System > Fabric > Compute Managers > Add**
- 3 Enter the compute manager details.

Option	Description
<b>Name and Description</b>	Enter the name and description of the vCenter Server.
<b>FQDN or IP Address</b>	Enter the FQDN or the IP address of the vCenter Server.
<b>User name and Password</b>	Enter the vCenter Server login credentials.

- 4 Select **Enable Trust** to allow vCenter Server to communicate with NSX-T Data Center .
- 5 If you did not provide a thumbprint value for NSX Manager, the system identifies the thumbprint and displays it.
- 6 Click **Add** to accept the thumbprint.

## Results

After some time, the compute manager is registered with vCenter Server and the connection status changes to `Up`. If the FQDN/PNID of vCenter Server changes, you must re-register it with the NSX Manager. For more information, see [Register vCenter Server with NSX Manager](#).

---

**Note** After the vCenter Server is successfully registered, do not power off and delete the NSX Manager VM without deleting the compute manager first. Otherwise, when you deploy a new NSX Manager, you will not be able to register the same vCenter Server again. You will get an error stating that the vCenter Server is already registered with another NSX Manager.

---

You can click the compute manager name to view the details, edit the compute manager, or to manage tags that apply to the compute manager.

## Create Transport Zones

Transport zones indicate which hosts and VMs can use a particular network. A transport zone can span one or more host clusters.

As a vSphere administrator, you use the default transport zones or create the following ones:

- An overlay transport zone that is used by the Supervisor Cluster Control Plane VMs.
- A VLAN transport zone for the NSX Edge nodes to use for uplinks to the physical network.

### Procedure

- 1 Log in to the NSX Manager.
- 2 Select **System > Fabric > Transport Zones > Add**.
- 3 Enter a name for the transport zone and optionally a description.
- 4 Select a traffic type.

You can select **Overlay** or **VLAN**.

The following transport zones exist by default:

- A VLAN transport zone with name `nsx-vlan-transportzone`.
- An overlay transport zone with name `nsx-overlay-transportzone`.

- 5 (Optional) Enter one or more uplink teaming policy names.

The segments attached to the transport zones use these named teaming policies. If the segments do not find a matching named teaming policy, then the default uplink teaming policy is used.

## Results

The new transport zone appears on the **Transport Zones** page.

## Create an IP Pool for Host Tunnel Endpoint IP Addresses

Create IP pools for the ESXi host tunnel endpoints (TEPs) and the Edge nodes. TEPs are the source and destination IP addresses used in the external IP header to identify the ESXi hosts that originate and end the NSX-T encapsulation of overlay frames. You can use DHCP or manually configured IP pools for TEP IP addresses.

### Procedure

- 1 Log in to the NSX Manager.
- 2 Select **Networking > IP Address Pools > Add IP Address Pool**.
- 3 Enter the following IP pool details.

Option	Description
<b>Name and Description</b>	Enter the IP pool name and optional description. For example, <code>ESXI-TEP-IP-POOL</code> .
<b>IP Ranges</b>	Enter the IP allocation range. For example, <code>10.197.79.158 - 10.197.79.160</code>
<b>Gateway</b>	Enter the gateway IP address. For example, <code>10.197.79.253</code> .
<b>CIDR</b>	Enter the network address in a CIDR notation. For example, <code>10.197.79.0/24</code> .

- 4 Click **Add** and **Apply**.
- 5 Repeat steps 2 - 4 to create an IP pool for the Edge nodes.  
For example, `EDGE-TEP-IP-POOL`.
- 6 Verify that the TEP IP pools you created are listed in the **IP Pool** page.

## Create a Host Uplink Profile

A host uplink profile defines policies for the uplinks from the ESXi hosts to NSX-T Data Center segments.

### Procedure

- 1 Log in to the NSX Manager.
- 2 Select **System > Fabric > Profiles > Uplink Profiles > Add**.
- 3 Enter an uplink profile name, and optionally, an uplink profile description.  
For example, `ESXI-UPLINK-PROFILE`.
- 4 In the **Teaming** section, click **Add** to add a naming teaming policy, and configure a **Failover Order** policy.

A list of active uplinks is specified, and each interface on the transport node is pinned to one active uplink. This configuration allows use of several active uplinks at the same time.

**5** Configure active and standby uplinks.

For example, configure `uplink-1` as the active uplink and `uplink-2` as the standby uplink.

**6** Enter a transport VLAN value.

The transport VLAN set in the uplink profile tags overlay traffic and the VLAN ID is used by the tunnel endpoint (TEP).

For example, `1060`.

**7** Enter the MTU value.

The default value for uplink profile MTU is 1600.

---

**Note** The value must be at least 1600 but not higher than the MTU value on the physical switches and the vSphere Distributed Switch.

---

## Create an Edge Uplink Profile

Create an uplink profile with the failover order teaming policy with one active uplink for edge virtual machine overlay traffic.

### Procedure

**1** Log in to the NSX Manager.

**2** Select **System > Fabric > Profiles > Uplink Profiles > Add**.

**3** Enter an uplink profile name, and optionally, add an uplink profile description.

For example, `EDGE-UPLINK-PROFILE`.

**4** In the **Teaming** section, click **Add** to add a naming teaming policy, and configure a **Failover** policy.

A list of active uplinks is listed, and each interface on the transport node is pinned to one active uplink. This configuration allows use of several active uplinks at the same time.

**5** Configure an active uplinks.

For example, configure `uplink-1` as active uplink.

**6** View the uplinks in the **Uplink Profile** page.

## Create a Transport Node Profile

A transport node profile defines how NSX-T Data Center is installed and configured on the hosts in a particular cluster the profile is attached to.

### Prerequisites

Verify that you have created an overlay transport zone.

### Procedure

**1** Log in to the NSX Manager.

- 2 Select **System > Fabric > Profiles > Transport Node Profiles > Add**.
- 3 Enter a name for the transport node profile and optionally a description.  
For example, `HOST-TRANSPORT-NODE-PROFILE`.
- 4 In the **New Node Switch** section, Select **Type** as `VDS`.
- 5 Select **Mode** as `Standard`.
- 6 Select the vCenter Server and the Distributed Switch names from the list.  
For example, `DSwitch`
- 7 Select the overlay transport zone created previously.  
For example, `NSX-OVERLAY-TRANSPORTZONE`.
- 8 Select the host uplink profile created previously.  
For example, `ESXI-UPLINK-PROFILE`.
- 9 Select **Use IP Pool** from the **IP Assignment** list.
- 10 Select the host TEP pool created previously.  
For example, `ESXI-TEP-IP-POOL`.
- 11 In the **Teaming Policy Switch Mapping**, click the edit icon and map the uplinks defined in the NSX-T uplink profile with the vSphere Distributed Switch uplinks.  
For example, map `uplink-1 (active)` to `Uplink 1` and `uplink-2 (standby)` to `Uplink 2`.
- 12 Click **Add**.
- 13 Verify that the profile that you created is listed in the **Transport Node Profiles** page.

## Configure NSX-T Data Center on the Cluster

To install NSX-T Data Center and prepare the overlay TEPs, apply the transport node profile to the vSphere cluster.

### Prerequisites

Verify that you have created a transport node profile.

### Procedure

- 1 Log in to the NSX Manager.
- 2 Select **System > Fabric > Nodes > Host Transport Nodes**.
- 3 From the **Managed By** drop-down menu, select an existing vCenter Server.  
The page lists the available vSphere clusters.
- 4 Select the compute cluster on which you want to configure NSX-T Data Center.
- 5 Click **Configure NSX**.

- 6 Select the transport node profile created previously and click **Apply**.

For example, `HOST-TRANSPORT-NODE-PROFILE`.

- 7 From the **Host Transport Node** page, verify that the NSX-T Data Center configuration state is `Success` and NSX Manager connectivity status of hosts in the cluster is `Up`.

## Results

The transport node profile created previously is applied to the vSphere cluster to install NSX-T Data Center and prepare the overlay TEPs.

## Configure and Deploy an NSX Edge Transport Node

You can add an NSX Edge virtual machine (VM) to the NSX-T Data Center fabric and proceed to configure it as an NSX Edge transport node VM.

### Prerequisites

Verify that you have created transport zones, edge uplink profile, and edge TEP IP pool.

### Procedure

- 1 Log in to the NSX Manager.
- 2 Select **System > Fabric > Nodes > Edge Transport Nodes > Add Edge VM**.
- 3 In **Name and Description**, enter a name for the NSX Edge.  
For example, `nsx-edge-1`
- 4 Enter the host name or FQDN from vCenter Server.  
For example, `nsx-edge-1.lab.com`.
- 5 Select `Large` form factor.
- 6 In **Credentials**, enter the CLI and the root passwords for the NSX Edge. Your passwords must comply with the password strength restrictions.
  - At least 12 characters.
  - At least one lower-case letter.
  - At least one upper-case letter.
  - At least one digit.
  - At least one special character.
  - At least five different characters.
  - Default password complexity rules are enforced by the Linux PAM module.
- 7 Enable **Allow SSH Login** for CLI and Root credentials.

**8** In **Configure Deployment**, configure the following properties:

Option	Description
<b>Compute Manager</b>	Select the compute manager from the drop-down menu. For example, select <code>vCenter</code> .
<b>Cluster</b>	Select the cluster from drop-down menu. For example, select <code>Compute-Cluster</code> .
<b>Datastore</b>	Select the shared datastore from the list. For example, <code>vsanDatastore</code> .

**9** Configure the node settings.

Option	Description
<b>IP Assignment</b>	Select Static. Enter the values for: <ul style="list-style-type: none"> <li>■ <b>Management IP:</b> Enter the IP address on the same VLAN as the vCenter Server management network. For example, <code>10.197.79.146/24</code>.</li> <li>■ <b>Default gateway:</b> The default gateway of the management network. For example, <code>10.197.79.253</code>.</li> </ul>
<b>Management Interface</b>	Click <b>Select interface</b> , and select the vSphere Distributed Switch port group on the same VLAN as the management network from the drop-down menu that you created previously. For example, <code>DPortGroup-MGMT</code> .

**10** In **Configure NSX**, click **Add Switch** to configure the switch properties.

**11** Use the default name for the **Edge Switch Name**.

For example, `nvds1`.

**12** Select the transport zone to which the transport node belongs.

Select the overlay transport zones created previously.

For example, `nsx-overlay-transportzone`.

**13** Select the edge uplink profile created previously.

For example, `EDGE-UPLINK-PROFILE`.

**14** Select **Use IP Pool** in **IP Assignment**.

**15** Select the edge TEP IP pool created previously.

For example, `EDGE-TEP-IP-POOL`.

**16** In the **Teaming Policy Switch Mapping** section, the uplink to the edge uplink profiles created previously.

For example, for `Uplink1`, select `DPortGroup-EDGE-TEP`.



- 17 Repeat steps 10-16, to add a new switch.

For example, configure the following values:

Property	Value
Edge Switch Name	nvds2
Transport Zone	nsx-vlan-transportzone
Edge uplink profile	EDGE-UPLINK-PROFILE
Teaming Policy Switch Mapping	DPortGroup-EDGE-UPLINK

- 18 Click **Finish**.
- 19 Repeat steps 2–18 for a second NSX Edge VM.
- 20 View the connection status on the **Edge Transport Nodes** page.

## Create an NSX Edge Cluster

To ensure that at least one NSX Edge is always available, create an NSX Edge cluster.

### Procedure

- 1 Log in to the NSX Manager.
- 2 Select **System > Fabric > Nodes > Edge Clusters > Add**.
- 3 Enter the NSX Edge cluster name.  
For example, `EDGE-CLUSTER`.
- 4 Select the default NSX Edge cluster profile from the drop-down menu.  
Select **nsx-default-edge-high-availability-profile**.
- 5 In **Member Type** drop-down menu, select the **Edge Node**.
- 6 From the **Available** column, select the NSX Edge VMs previously created, and click the right-arrow to move them to the **Selected** column.
- 7 For example, `nsx-edge-1` and `nsx-edge-2`.
- 8 Click **Save**.

## Create a Tier-0 Uplink Segment

The tier-0 uplink segment provides the North-South connectivity from NSX-T Data Center to the physical infrastructure.

### Prerequisites

Verify that you have created a Tier-0 gateway.

### Procedure

- 1 Log in to the NSX Manager.

- 2 Select **Networking > Segments > Add Segment**.
- 3 Enter a name for the segment.  
For example, `TIER-0-LS-UPLINK`.
- 4 Select the transport zone previously created.  
For example, select `nsx-vlan-transportzone`.
- 5 Toggle the **Admin Status** to enable it.
- 6 Enter a VLAN ID of the Tier-0 gateway.  
For example, `1089`.
- 7 Click **Save**.

## Create a Tier-0 Gateway

The tier-0 gateway is the NSX-T Data Center logical router that provides the North-South connectivity for the NSX-T Data Center logical networking to the physical infrastructure. vSphere with Tanzu supports multiple tier-0 gateways on multiple NSX Edge clusters in the same transport zone.

### Prerequisites

Verify that you have created an NSX Edge cluster.

### Procedure

- 1 Log in to the NSX Manager.
- 2 Select **Networking > Tier-0 Gateways**.
- 3 Click **Add Tier-0 Gateway**.
- 4 Enter a name for the tier-0 gateway.  
For example, `Tier-0_VWT`.
- 5 Select an active-standby HA mode.  
In active-standby mode, the elected active member processes all traffic. If the active member fails, a new member is elected to be active.
- 6 Select the NSX Edge cluster previously created.  
For example, select `EDGE-CLUSTER`.
- 7 Click **Save**.  
The tier-0 gateway is created.
- 8 Select **Yes** to continue with the configuration.

**9** Configure interfaces.

a Expand **Interfaces** and click **Set**.

b Click **Add Interface**.

c Enter a name.

For example, enter the name `TIER-0_VWT-UPLINK1`.

d Select **Type** as **External**.

e Enter an IP address from the Edge Logical Router – Uplink VLAN. The IP address must be different from the management IP address configured for the NSX Edge VMs previously created.

For example, `10.197.154.1/24`.

f In **Connected To**, select the tier-0 uplink segment previously created.

For example, `TIER-0-LS-UPLINK`

g Select an NSX Edge node from the list.

For example, `nsx-edge-1`.

h Click **Save**.

i Repeat steps a - h for the second interface.

For example, create a second uplink `TIER-0_VWT-UPLINK2` with IP address `10.197.154.2/24` connected to `nsx-edge-2` Edge node.

j Click **Close**.

**10** To configure high availability, click **Set** in **HA VIP Configuration**.

a Click **ADD HA VIP CONFIGURATION**.

b Enter the IP address.

For example, `10.197.154.3/24`

c Select the interfaces.

For example, `TIER-0_VWT-UPLINK1` and `TIER-0_VWT-UPLINK2`

d Click **Add** and **Apply**.

**11** To configure routing, click **Routing**.

a Click **Set** in Static Routes.

b Click **ADD STATIC ROUTE**.

c Enter a name.

For example, `DEFAULT-STATIC-ROUTE`.

d Enter `0.0.0.0/0` for network IP address.

- e To configure next hops, click **Set Next Hops** and then **Add Next Hop**.
  - f Enter the IP address of the next hop router. Typically, this is the default gateway of the management network VLAN from the NSX Edge logical router uplink VLAN.  
For example, 10.197.154.253.
  - g Click **Add** and **Apply** and **SAVE**.
  - h Click **Close**.
- 12** To verify connectivity, make sure that an external device in the physical architecture can ping the uplinks that you configured.

#### What to do next

Configure a Supervisor Cluster. See [Enable Workload Management with NSX-T Data Center Networking](#)

## Configuring vSphere Networking and NSX Advanced Load Balancer for vSphere with Tanzu

vSphere with Tanzu supports the NSX Advanced Load Balancer, also known as Avi Load Balancer, Essentials Edition. If you are using vSphere Distributed Switch (VDS) networking for **Workload Management**, you can install and configure the NSX Advanced Load Balancer in your vSphere with Tanzu environment.

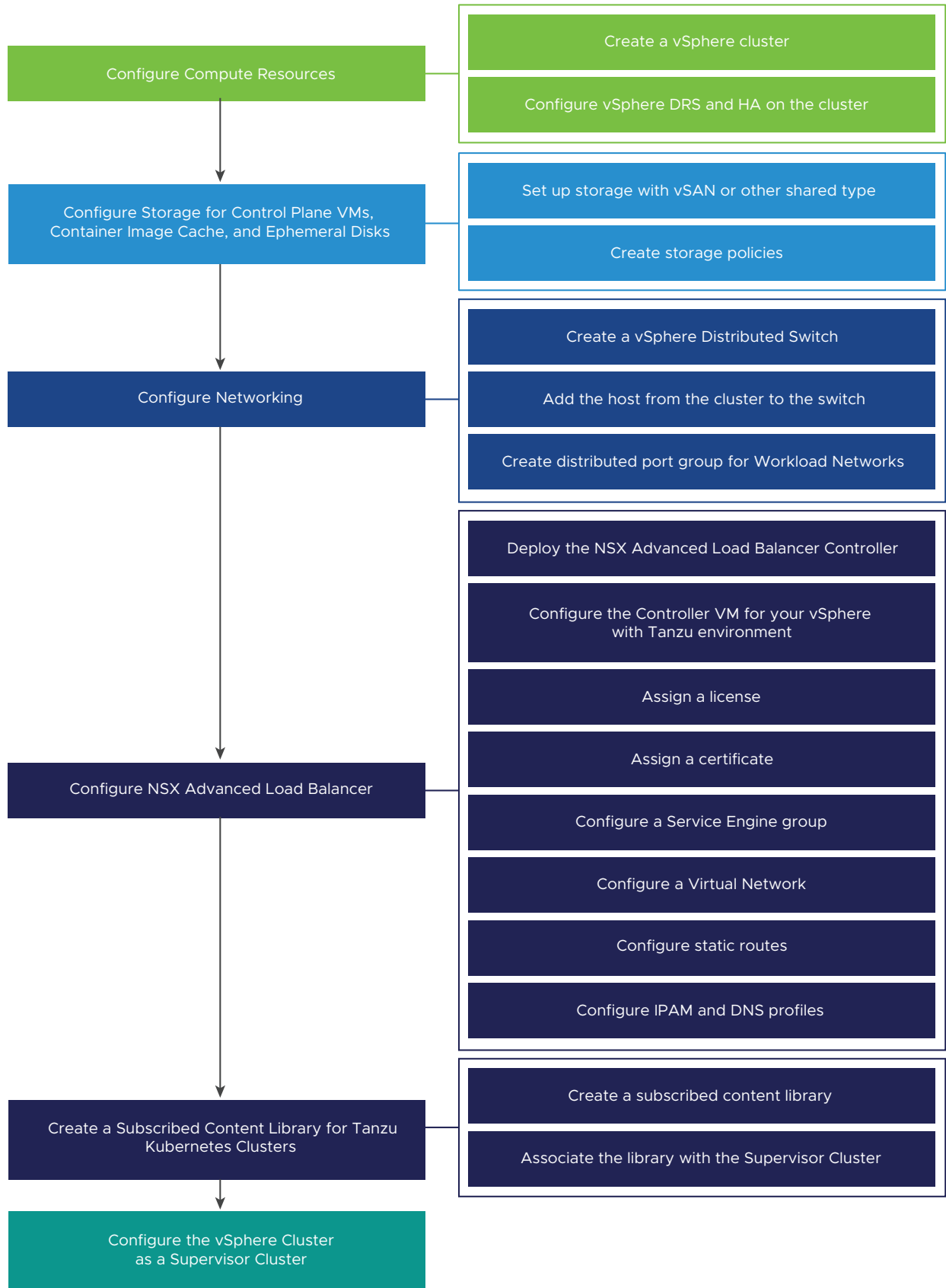
### How the Load Balancer Works with Tanzu Kubernetes Clusters

The NSX Advanced Load Balancer provides dynamically scaling load balancing endpoints for Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service. You install and configure the Avi Controller VM. Once you have configured the Controller, it automatically provisions load balancing endpoints for you. For example, when you provision a Tanzu Kubernetes cluster, the Controller creates a virtual service and deploys a Service Engine VM to host that service. This virtual service provides load balancing for the Kubernetes control plane.

When you create a Kubernetes service of type load balancer for that cluster, the Controller automatically creates a virtual service and deploys it to the Service Engine. The first Service Engine is created only after the first virtual service is configured. Any subsequent virtual services that are configured use the existing Service Engine. You can deploy multiple virtual services on a VM.

### Supervisor Cluster with vSphere Networking and NSX Advanced Load Balancer Workflow

This diagram shows the workflow for configuring vSphere Networking and NSX Advanced Load Balancer for vSphere with Tanzu.



## Procedure

### 1 NSX Advanced Load Balancer Components

The components of the NSX Advanced Load Balancer, also known as Avi Load Balancer, include the control plane cluster, data plane VMs, virtual services, and IP address management.

### 2 System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and NSX Advanced Load Balancer

To configure vSphere with Tanzu with the NSX Advanced Load Balancer, also known as the Avi Load Balancer, your environment must meet certain requirements. vSphere with Tanzu supports multiple topologies for Avi networking: a single VDS network for the Avi Service Engine and load balancer services, and a VDS for the Avi management plane and another VDS for the NSX Advanced Load Balancer.

### 3 Topology for Supervisor Cluster with vSphere Networking and NSX Advanced Load Balancer

The Controller is deployed to the Management Network where it can interface with the vCenter Server, ESXi hosts, and Supervisor Cluster control plane nodes. The Service Engines are deployed with interfaces to the Management network and the Data network.

### 4 Install and Configure the NSX Advanced Load Balancer

If you are using vSphere Distributed Switch (VDS) networking, you can install and configure the NSX Advanced Load Balancer in your vSphere with Tanzu environment.

## NSX Advanced Load Balancer Components

The components of the NSX Advanced Load Balancer, also known as Avi Load Balancer, include the control plane cluster, data plane VMs, virtual services, and IP address management.

### Controller

The Avi Controller, also called the Controller, is responsible for provisioning service engines, coordinating resources across service engines, and aggregating service engine metrics and logging. The Controller provides a web interface, command-line interface, and API for user operation and programmatic integration.

The Controller is deployed standalone or in a redundant 3-node cluster for high-availability. Once you have deployed and configured the Controller VM as described here, see [Deploying a Controller Cluster](#) for details on how to set up the control plane cluster for HA.

### Service Engine

The Avi Service Engine, also called the Service Engine, is the data plane virtual machine. A Service Engine VM is a load balancing endpoint. A Service Engine runs one or more virtual services. A Service Engine is managed by the controller. The controller provisions Service Engines to host virtual services.

The Service Engine has two network interfaces:

- One network interface connects to the Management network where it can connect to vCenter, ESXi, and Supervisor Clusters.
- The second interface connects to the Workload network where virtual services run.

Each Service Engine can support up to 1000 virtual services. Scale out is dynamic depending on traffic load.

## Virtual Service

A virtual service provides layer 4 load balancing services for Tanzu Kubernetes cluster workloads. A virtual service is configured with one virtual IP and multiple ports. When a virtual service is deployed, the Controller automatically selects an ESX server, spins up a Service Engine, and connects it to the correct networks (port groups).

The first Service Engine is created only after the first virtual service is configured. Any subsequent virtual services that are configured use the existing Service Engine.

## IP Address Management

Each virtual server exposes a layer 4 load balancer with a distinct IP address of type load balancer for a Tanzu Kubernetes cluster. The IP address assigned to each virtual server is chosen from the IP address block given to the Controller when you configure it.

AVI comes with native IPAM and external IPAM provider support. In vSphere, AVI native IPAM is leveraged.

## Kubernetes Operator

The Kubernetes operator (AKO) watches Kubernetes resources and communicates with the Controller to request the corresponding load balancing resources.

The Tanzu Kubernetes Grid Service automatically installs the Kubernetes operator on the Tanzu Kubernetes cluster.

## System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and NSX Advanced Load Balancer

To configure vSphere with Tanzu with the NSX Advanced Load Balancer, also known as the Avi Load Balancer, your environment must meet certain requirements. vSphere with Tanzu supports multiple topologies for Avi networking: a single VDS network for the Avi Service Engine and load balancer services, and a VDS for the Avi management plane and another VDS for the NSX Advanced Load Balancer.

## Workload Networks

To configure a Supervisor Cluster with the vSphere networking stack, you must connect all hosts from the cluster to a vSphere Distributed Switch. Depending on the topology that you implement for the Supervisor Cluster, you create one or more distributed port groups. You designate the port groups as Workload Networks to vSphere Namespaces.

Before you add a host to a Supervisor Cluster, you must add it to all the vSphere Distributed Switches that are part of the cluster.

Workload Networks provide connectivity to the nodes of Tanzu Kubernetes clusters and to Supervisor Cluster control plane VMs. The Workload Network that provides connectivity to Kubernetes control plane VMs is called a Primary Workload Network. Each Supervisor Cluster must have one Primary Workload Network. You must designate one of the distributed port group as the Primary Workload Network to the Supervisor Cluster.

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**Note** Workload Networks are only added when you enable the Supervisor Cluster and cannot be added later.

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The Kubernetes control plane VMs on the Supervisor Cluster use three IP addresses from the IP address range that is assigned to the Primary Workload Network. Each node of a Tanzu Kubernetes cluster has a separate IP address assigned from the address range of the Workload Network that is configured with the namespace where the Tanzu Kubernetes cluster runs.

## Networking Requirements

The NSX Advanced Load Balancer requires two routable subnets:

- The Management network. The Management network is where the Avi Controller, also called the Controller, resides. The Management network provides the Controller with connectivity to the vCenter Server, ESXi hosts, and the Supervisor Cluster control plane nodes. This network can use a vSphere Standard Switch (vSS), or a vSphere Distributed Switch (VDS).
- The Data network. The Avi Service Engines, also called Service Engines, run on this network. This network requires a vSphere Distributed Switch (VDS) and distributed portgroup. You must configure the VDS and port groups before installing the load balancer.

## Allocation of IP Addresses

The Controller and the Service Engine are connected to the Management network. When you install and configure the NSX Advanced Load Balancer, provide a static, routable IP address for each Controller VM.

The Service Engines can use DHCP. If DHCP is unavailable, you can configure a pool of IP addresses for the Service Engines.

For more information, see [Configure Static Routes](#).

## Minimum Compute Requirements

The table lists the minimum compute requirements for vSphere networking with NSX Advanced Load Balancer.

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**Caution** Do not disable vSphere DRS after you configure the Supervisor Cluster. Having DRS enabled at all times is a mandatory prerequisite for running workloads on the Supervisor Cluster. Disabling DRS leads to breaking your Tanzu Kubernetes clusters.

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Table 4-5. Minimum Compute Requirements

System	Minimum Deployment Size	CPU	Memory	Storage
vCenter Server 7.0 7.0.2	Small	2	16 GB	290 GB
ESXi hosts 7.0	<p>3 ESXi hosts with 1 static IP per host.</p> <p>If you are using vSAN: 3 ESXi hosts with at least 2 physical NICs is the minimum; however, 4 ESXi hosts are recommended for resiliency during patching and upgrading.</p> <p>The hosts must be joined in a cluster with vSphere DRS and HA enabled. vSphere DRS must be in Fully Automate or Partially Automate mode.</p> <p><b>Note</b> Make sure that the names of the hosts that join the cluster use lower case letters. Otherwise, the enablement of the cluster for Workload Management might fail.</p>	8	64 GB per host	Not applicable
Kubernetes control plane VMs	3	4	16 GB	16 GB

## Minimum Network Requirements

The table lists the minimum network requirements for vSphere networking with NSX Advanced Load Balancer.

Table 4-6. Minimum Networking Requirements

Component	Minimum Quantity	Required Configuration
Static IPs for Kubernetes control plane VMs	Block of 5	A block of 5 consecutive static IP addresses to be assigned to the Kubernetes control plane VMs in the Supervisor Cluster.
Management traffic network	1	A Management Network that is routable to the ESXi hosts, vCenter Server, the Supervisor Cluster and load balancer. The network must be able to access an image registry and have Internet connectivity if the image registry is on the external network. The image registry must be resolvable through DNS.
vSphere Distributed Switch	1	All hosts from the cluster must be connected to a vSphere Distributed Switch.

Table 4-6. Minimum Networking Requirements (continued)

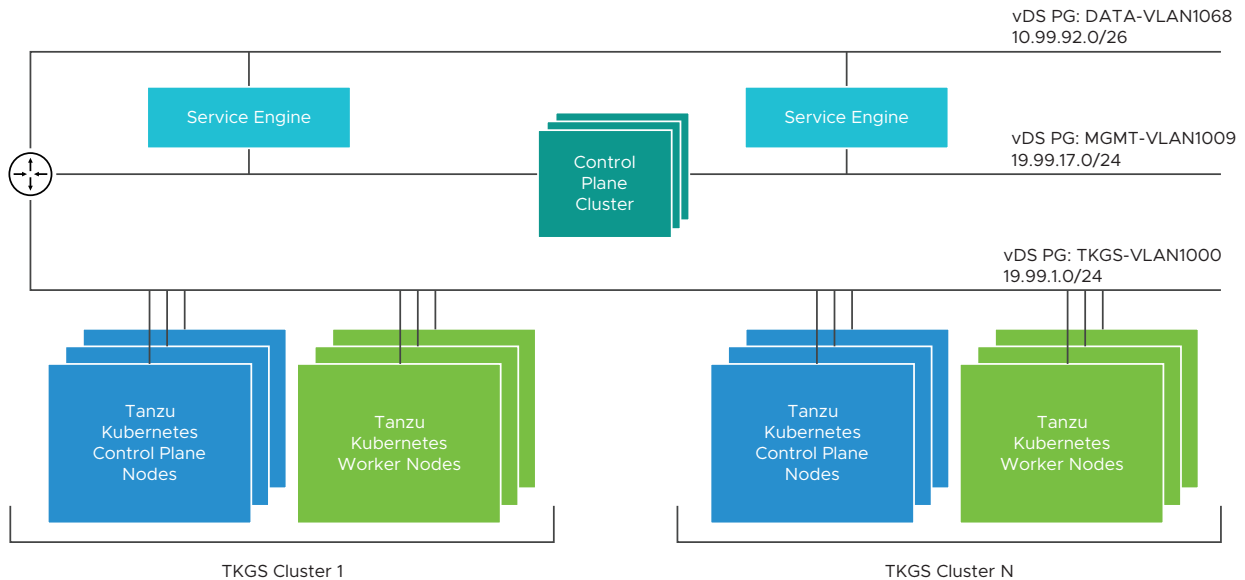
Component	Minimum Quantity	Required Configuration
Workload Networks	1	<p>At least one distributed port group must be created on the vSphere Distributed Switch that you configure as the Primary Workload Network. Depending on the topology of choice, you can use the same distributed port group as the Workload Network of namespaces or create more port groups and configure them as Workload Networks. Workload Networks must meet the following requirements:</p> <ul style="list-style-type: none"> <li>■ Workload Networks that are used for Tanzu Kubernetes cluster traffic must be routable between each other and the Supervisor Cluster Primary Workload Network.</li> <li>■ Routability between any Workload Network with the network that the NSX Advanced Load Balancer uses for virtual IP allocation.</li> <li>■ No overlapping of IP address ranges across all Workload Networks within a Supervisor Cluster.</li> </ul>
NTP and DNS Server	1	<p>A DNS server and NTP server that can be used with vCenter Server.</p> <p><b>Note</b> Configure NTP on all ESXi hosts and vCenter Server .</p>
DHCP Server	1	<p>Optional. Configure a DHCP server to automatically acquire IP addresses for the management and workload networks as well as floating IPs. The DHCP server must support Client Identifiers and provide compatible DNS servers, DNS search domains, and an NTP server.</p> <p>For the management network, all the IP addresses, such as control plane VM IPs, a Floating IP, DNS servers, DNS, search domains, and NTP server are acquired automatically from the DHCP server.</p> <p>The DHCP configuration is used by the Supervisor Cluster. Load balancers may require static IP addresses for Management. DHCP Scopes should not overlap these static IP's. DHCP is not used for virtual IPs. (VIPs)</p>

Table 4-6. Minimum Networking Requirements (continued)

Component	Minimum Quantity	Required Configuration
Management Network Subnet	1	<p>The Management network is where the Avi Controller, also called the Controller, resides. The subnet used for management traffic between ESXi hosts and vCenter Server, and the Kubernetes control plane. The size of the subnet must be the following:</p> <ul style="list-style-type: none"> <li>■ One IP address per host VM kernel adapter.</li> <li>■ One IP address for the vCenter Server Appliance.</li> <li>■ 5 IP addresses for the Kubernetes control plane. 1 for each of the 3 nodes, 1 for virtual IP, 1 for rolling cluster upgrade.</li> </ul> <p><b>Note</b> The Management Network and the Workload Network must be on different subnets. Assigning the same subnet to the Management and the Workload networks is not supported and can lead to system errors and problems.</p>
Data Network Subnet	1	The Avi Service Engines, also called Service Engines, run on this network. Configure a pool of IP addresses for the Service Engines.
Management Network VLAN	1	The VLAN ID of the Management Network subnet.
Physical Network MTU	1600	The MTU size must be 1600 or greater on any network that carries overlay traffic.
Kubernetes services CIDR range	/16 Private IP addresses	A private CIDR range to assign IP addresses to Kubernetes services. You must specify a unique Kubernetes services CIDR range for each Supervisor Cluster.

## Topology for Supervisor Cluster with vSphere Networking and NSX Advanced Load Balancer

The Controller is deployed to the Management Network where it can interface with the vCenter Server, ESXi hosts, and Supervisor Cluster control plane nodes. The Service Engines are deployed with interfaces to the Management network and the Data network.



The Management network, such as `MGMT-VLAN1009`, is where the Controller resides.

The Data network, such as `DATA-VLAN1068`, is where the Service Engine interfaces connect to the VIP. The load balanced traffic reaches the Service Engines through this network.

The Workload network, such as `TKGS-VLAN1000`, is where the Tanzu Kubernetes clusters run. The Service Engines do not require interfaces to the Workload network. The Service Engines route the load balanced traffic over the router to the Workload network.

## Install and Configure the NSX Advanced Load Balancer

If you are using vSphere Distributed Switch (VDS) networking, you can install and configure the NSX Advanced Load Balancer in your vSphere with Tanzu environment.

- Verify that your environment meets the requirements to configure vSphere with Tanzu with the NSX Advanced Load Balancer. See [System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and NSX Advanced Load Balancer](#).
- Download the NSX Advanced Load Balancer OVA. VMware provides an NSX Advanced Load Balancer OVA file that you deploy in your vSphere environment where you enable Workload Management. Download the latest version of the OVA file from the [product downloads page](#).

## Create a vSphere Distributed Switch for a Supervisor Cluster for Use with NSX Advanced Load Balancer

To configure a vSphere cluster as a Supervisor Cluster that uses the vSphere networking stack and the NSX Advanced Load Balancer load balancer, you must add the hosts to a vSphere Distributed Switch. You must create port groups on the distributed switch that you configure as Workload Networks to the Supervisor Cluster.

## Prerequisites

Review the system requirements and network topologies for using vSphere networking for the Supervisor Cluster with the NSX Advanced Load Balancer. See [System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and NSX Advanced Load Balancer](#).

## Procedure

- 1 In the vSphere Client, navigate to a data center.
- 2 Right click the data center and select **Distributed Switch > New Distributed Switch**.
- 3 Enter a name for the switch, for example **Workload Distributed Switch** and click **Next**.
- 4 Select version 7.0 for the switch and click **Next**.
- 5 In **Port group name**, enter **Primary Workload Network**, click **Next**, and click **Finish**.

A new distributed switch with one port group is created on the data center. You can use this port group as the Primary Workload Network for the Supervisor Cluster that you will create. The Primary Workload Network handles the traffic for Kubernetes control plane VMs.

- 6 Create distributed port groups for Workload Networks.

The number of port groups that you create depends on the topology that you want to implement for the Supervisor Cluster. For a topology with one isolated Workload Network, create one distributed port group that you will use as a network for all namespaces on the Supervisor Cluster. For a topology with isolated networks for each namespace, create the same number of port groups as the number of namespaces that you will create.

- a Navigate to the newly-created distributed switch.
  - b Right-click the switch and select **Distributed Port Groups > New Distributed Port Group**.
  - c Enter a name for the port group, for example **Workload Network** and click **Next**.
  - d Leave the defaults, click **Next** and click **Finish**.
- 7 Add hosts from the vSphere clusters that you will configure as Supervisor Cluster to the distributed switch.
    - a Right-click the distributed switch and select **Add and Manage Hosts**.
    - b Select **Add Hosts**.
    - c Click **New Hosts**, select the hosts from the vSphere cluster that you will configure as a Supervisor Cluster, and click **Next**.
    - d Select a physical NIC from each host and assign it an uplink on the distributed switch.
    - e Click **Next** through the remaining screens of the wizard and click **Finish**.

## Results

The hosts are added to the distributed switch. You can now use the port groups that you created on the switch as Workload Networks of the Supervisor Cluster.

## Deploy the Controller

Deploy the Controller VM to the vSphere Management network in your vSphere with Tanzu environment.

Install the Controller on your vSphere Management network.

### Prerequisites

- Verify that the NSX Advanced Load Balancer is able to communicate with the vCenter Server and the ESXi hosts over port 443. Typically this communication is over a vSphere Management network.
- Verify that you have a Management network on which to deploy the NSX Advanced Load Balancer. This can be a vSphere Distributed Switch (vDS) or a vSphere Standard Switch (vSS).
- Verify that you have created a vDS switch and portgroup for **Workload Management**. See [Create a vSphere Distributed Switch for a Supervisor Cluster for Use with HAProxy Load Balancer](#).
- Verify that you have completed the prerequisites. See [System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and NSX Advanced Load Balancer](#).

### Procedure

- 1 Log in to the vCenter Server using the vSphere Client.
- 2 Select the vCenter cluster that is designated for management components.
- 3 Create a resource pool named **AVI-LB**.
- 4 Right-click the resource pool and select **Deploy OVF Template**.
- 5 Select **Local File** and click **Upload Files**.
- 6 Browse to and select the `controller-VERSION.ova` file you downloaded as a prerequisite.
- 7 Enter a name and select a folder for the Controller.

Option	Description
Virtual machine name	avi-controller-1
Location for the virtual machine	Datacenter

- 8 Select the **AVI-LB** resource pool as a compute resource.
- 9 Review the configuration details and click **Next**.
- 10 Select a **VM Storage Policy**, such as **vsanDatastore**.
- 11 Select the Management network, such as **MGMT-VLAN1009**.

12 Customize the configuration as follows and click **Next** when you are done.

Option	Description
<b>Management Interface IP Address</b>	Enter the IP address for the Controller VM, such as <code>10.999.17.51</code> .
<b>Management Interface Subnet Mask</b>	Enter the subnet mask, such as <code>255.255.255.0</code> .
<b>Default Gateway</b>	Enter the default gateway for the Management network, such as <code>10.199.17.235</code> .
<b>Sysadmin login authentication key</b>	Paste the contents of a private key (optional).

13 Review the deployment settings.

14 Click **Finish** to complete the configuration.

15 Use vSphere Client to monitor the provisioning of the Controller VM in the **Tasks** panel.

16 Use vSphere Client to power on the Controller VM after it is deployed.

## Take a Snapshot of the Controller

You can take a snapshot of the Controller VM to preserve the state of the VM so that you can return to that state. You can take a snapshot of the controller VM once it is deployed so that you can revert to its initial state if the configuration does not work as expected.

### Prerequisites

- Verify that you have deployed the Controller.
- Verify that the Controller is powered off.

### Procedure

- 1 In the vCenter cluster, right click the `avi-controller-1` that you deployed.
- 2 Click **Snapshots > Take Snapshot**.
- 3 Enter a name for the snapshot and optionally, a description. For example, you can create a snapshot that is named `root`.
- 4 Click **Create** to take the snapshot.

## Power On the Controller

Once you deploy the Controller VM, you can power it on. During the boot up process, the IP address specified during the deployment gets assigned to the VM.

Once you power it on, the first boot process of the Controller VM can take up to 10 minutes.

### Prerequisites

Verify that you have deployed the Controller.

### Procedure

- 1 In the vCenter cluster, right click the `avi-controller-1` that you deployed.

**2** Select **Power > Power On**.

The VM is assigned the IP address that you specified during deployment.

**3** To verify if the VM is powered on, access the the IP address in a browser.

When the VM comes online, TLS certificate and connection not private warnings appear.

**4** In the **This Connection Is Not Private** warning, click **Show Details**.**5** Click **visit this website**.**6** Click **Visit Website** in the window that appears.

You are prompted for user credentials.

For more information about use roles, see the [Avi documentation](#).

**7** Enter your password and click **Create Account**.

The Avi Controller **Welcome Screen** appears.

## Configure the Controller

Configure the Controller VM for your vSphere with Tanzu environment.

The Controller requires several post-deployment configuration parameters for the load balancer control plane.

### Prerequisites

- Verify that your environment meets the system requirements for configuring the NSX Advanced Load Balancer. For more information, see [System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and NSX Advanced Load Balancer](#).
- Verify that you have deployed the Controller. See [Deploy the Controller](#)

### Procedure

- 1** Using a browser, navigate to the IP address that you specified when deploying the Controller.
- 2** Create an **Administrator Account**.

Option	Description
<b>Username</b>	Enter an administrator user name for the Controller VM.
<b>Password</b>	Enter an administrator password for the Controller VM.
<b>Email Address (optional)</b>	Enter an administrator email address.



### 3 Configure **System Settings**.

Option	Description
<b>Passphrase</b>	Enter a passphrase for the Controller backup. The Controller configuration is automatically backed up to the local disk on a periodic basis. For more information, see <a href="#">Backup and Restore</a> .
<b>DNS Resolver</b>	Enter an IP address for the DNS server you are using in the vSphere with Tanzu environment. For example, 10.14.7.12.
<b>DNS Search Domain</b>	Enter a domain string. The string can be any value and is required but not relevant for layer 4 load balancing.

### 4 (Optional) Configure **Email/SMTP**

Option	Description
<b>SMTP Source</b>	None, Local Host, SMTP Server, or Anonymous Server
<b>From Address</b>	Email address

### 5 Configure the tenant settings.

- a Retain the default tenant access.
- b Select **Setup Cloud After** and set up **Default-Cloud**.
- c Select **VMware vCenter/vSphere ESX** as the infrastructure type.
- d Provide the **vCenter/vSphere Login** information.

Option	Description
<b>Username</b>	Enter the vCenter administrator user name, such as <a href="#">administrator@vsphere.local</a> . To use lesser permissions, create a dedicated role. See <a href="#">VMware User Role</a> for details.
<b>Password</b>	Enter the user password.
<b>vCenter Address</b>	Enter the vCenter Server IP address for the vSphere with Tanzu environment.
<b>Access Permissions</b>	<b>Read:</b> You create and manage the service engine VMs. <b>Write:</b> Controller creates and manages the service engine VMs. You must select Write.
<b>SDN Integration</b>	<b>None</b> is the supported option. <b>VMware NSX</b>

## 6 Configure the **Data Center** settings.

- a Select the vSphere **Data Center** where you want to enable **Workload Management**.
- b Select the **Default Network IP Address Management** mode.
  - Select DHCP to connect to the Management network.
  - Leave the option unselected if any network requires static IP addresses. You can configure them individually for each network.

For more information, see [Configure a Virtual IP Network](#).

### c Configure the **Virtual Service Placement Settings**.

Option	Description
<b>Prefer Static Routes vs Directly Connected Network for Virtual Service Placement</b>	Check this option to force the Service Engine VM to access the server network, which is the Management network, by layer 3 and configure a static route for the server IP address.  By default, the Controller directly connects a NIC to the server network and you must force the Service Engine to connect only to the Data network and route to the Workload network.
<b>Use Static for Network Resolution of VIP for Virtual Service Placement</b>	Leave this option unselected.

## 7 Configure the **Network** settings and click **Save**.

Option	Description
<b>Management Network</b>	Select the Management network. This network interface is used by the Service Engines to connect with the Controller. For example, <code>MGMT-VLAN1009</code> .
<b>Management Network IP Address Management</b>	Select <b>DHCP</b> .
<b>IP Subnet</b>	Enter the IP subnet for the Management network. For example, <code>192.168.110.0/24</code> .
<b>Add Static IP Address Pool</b>	Enter one or more IP addresses or IP address range. For example, <code>192.168.110.66-192.168.110.90</code> .
<b>Default Gateway</b>	Enter the default gateway for the Management network, such as <code>192.168.110.1</code> .

## 8 (Optional) Configure NTP settings if you want to use an internal NTP server.

- a Select **Administration > Settings > DNS/NTP**.
- b Delete existing NTP servers if any and enter the IP address for the DNS server you are using. For example, `192.168.100.1`.

### Results

Once you complete the configuration, you see the Controller **Dashboard**. Select the **Networks** tab and verify the IP address pool allocation.

## Add a License

Once you configure the NSX Advanced Load Balancer, you add a license to it. The Controller boots in the Enterprise edition with an evaluation license. Assign the Enterprise license to it.

### Prerequisites

Verify that you have the Enterprise license.

### Procedure

- 1 In the Avi Controller dashboard, click the menu in the upper-left hand corner and select **Administration**.
- 2 Select **Settings > Licensing**.
- 3 To add the license, select **Upload from Computer**.

After the license file is uploaded, it appears in the Controller's license list. The system displays the information about the license, including the start date and expiration date.

## Assign a Certificate to the Controller

The Controller must send a certificate to clients to establish secure communication.

The Controller has a default self-signed certificate. You must delete it and upload a new certificate or create a self-signed certificate.

For more information about certificates, see the [Avi documentation](#).

### Procedure

- 1 In the Avi Controller dashboard, click the menu in the upper-left hand corner and select **Templates > Security**.
- 2 Select **SSL/TLS Certificate**.
- 3 To delete the default self-signed certificates, click the edit icon against the certificates and delete them.
- 4 To create a certificate, click **Create**.

The **Add Certificate (SSL/TLS)** window appears.

- 5 Enter a name for the certificate.

6 To add a self-signed certificate, select **Type** as *Self Signed*.

a Enter the following details:

Option	Description
<b>Common Name</b>	Specify the fully-qualified name of the site. For the site to be considered trusted, this entry must match the hostname that the client entered in the browser.
<b>Subject Alternate Name (SAN)</b>	Enter the cluster IP address or FQDN of the Controller.
<b>Algorithm</b>	Select either EC (elliptic curve cryptography) or RSA. EC is recommended.
<b>Key Size</b>	Select the level of encryption to be used for handshakes: <ul style="list-style-type: none"> <li>■ SECP256R1 is used for EC certificates.</li> <li>■ 2048-bit is recommended for RSA certificates.</li> </ul>

b Click **Save**.

You need this certificate when you enable workload management.

7 Download the self-signed certificate that you create.

a Select **Security > SSL/TLS Certificates**.

To view the certificate you saved, you might need to refresh the page.

b Select the certificate you created and click the download icon.

c In the **Export Certificate** page that appears, click **Copy to clipboard**.

8 To upload a certificate, select **Type** as *Import*.

a In **Certificate**, click **Upload File** and import the certificate.

The SAN field of the certificate you upload must have the cluster IP address or FQDN of the Controller.

---

**Note** Make sure that you upload or paste the contents of the certificate only once.

---

b In **Key (PEM) or PKCS12**, click **Upload File** and import the key.

c Click **Validate** to validate the certificate and key.

d Click **Save**.

## Configure a Service Engine Group

You can create Service Engines within a group which defines the placement and number of Service Engine VMs within vCenter. You can also configure high availability.

For information on how you can provision excess capacity in the event of a failover, see the [Avi documentation](#).

### Procedure

1 In the Avi Controller dashboard, click the menu in the upper-left hand corner and select **Infrastructure**.

2 In the **Infrastructure** settings page, click **Service Engine Group**.

3 In the **Service Engine Group** page, click the edit icon in the **Default-Group**.

The **Basic Settings** page appears.

4 In the **High Availability & Placement Settings** section, select the **High Availability Mode**.

The default option with the Essentials license is `Active/Standby`. If you use the Enterprise license, you can also configure the `Elastic HA N + M Mode` OR `Elastic HA Active/Active Mode` modes.

5 Click the **Advanced** tab.

6 (Optional) In the **Host & Data Store Scope** section, configure the following settings:

a Click **Include** and select the vSphere cluster from the list in **Cluster**.

b Click **Include** and select the vSphere cluster from the list in **Host**.

7 (Optional) In the **Advanced HA & Placement** section, you can configure excess capacity for the Service Engine group only if you use the Enterprise license.

To configure excess capacity, specify a value in the **Buffer Service Engines**. The value you specify is the number of VMs that are deployed to ensure excess capacity in the event of a failover.

For example, set the value as 0.

8 Click **Save**.

## Configure a Virtual IP Network

Configure a virtual IP subnet for the Data network. You can place virtual services on a specific virtual IP network. Configure static IP addresses for the Controller and Service Engines. You can configure DHCP for the Service Engines. If DHCP is unavailable, configure a pool of IP addresses.

### Procedure

1 In the Avi Controller dashboard, click menu in the upper-left hand corner and select **Infrastructure**.

2 Click **Network**, to display the list of networks on vCenter.

3 Locate the network that provides the virtual IP addresses and click the edit icon to edit the network settings.

For example, `Data-VLAN1068`.

4 Deselect **DHCP Enabled** as IPAM provides the addresses for the virtual IP network.

If DHCP is available on the `Data-VLAN1068` portgroup, select this option.

- 5 Deselect the **Exclude Discovered Subnets for Virtual Service Placement**. Deselecting this option enables you to use the configured subnet for virtual IP address placement.

The Controller discovers the networks and the IP subnets.

- 6 If the controller discovers an IP subnet and its type, perform the following steps:

- a Click the edit icon of the discovered network.
- b Select **Add Static IP Address Pool**.
- c Enter one or more IP addresses or IP address ranges.

For example, 10.202.35.1-10.202.35.254.

---

**Note** You can enter an IP address that ends with 0. For example, 192.168.0.0 and ignore any warning that appears.

---

- d Click **Save**.

- 7 If the Controller does not discover an IP subnet and its type, perform the following steps:

- a Click **Add Subnet**.
- b In **IP Subnet**, enter the CIDR of the network that provides the virtual IP addresses.

For example, 10.202.35.0/22

- c Select **Add Static IP Address Pool**.
- d Enter one or more IP addresses or IP address ranges.

The range must be a subset of the network CIDR in **IP Subnet**. For example, 10.202.35.1-10.202.35.254.

---

**Note** You can enter an IP address that ends with 0. For example, 192.168.0.0 and ignore any warning that appears.

---

- e Click **Save**.

The **Network Settings** page lists the IP Subnet with type **Configured** and an IP address pool.

- 8 Click **Save**.

## Results

The **Network** page lists the configured networks.

## Example

The `MGMT-VLAN1009` network displays the discovered network as 10.202.32.0/22 and configured subnets as 10.202.32.0/22 [254/254]. This indicates that 254 virtual IP addresses come from 10.202.32.0/22. Note that the summary view does not list the IP range 10.202.35.1-10.202.35.254.

## Configure Static Routes

Configure static routes to create layer 3 connectivity between the virtual IP network and the Workload network, if you require to create Tanzu Kubernetes clusters in dedicated Workload networks.

### Procedure

- 1 In the Avi Controller dashboard, click the menu in the upper-left hand corner and select **Infrastructure**.
- 2 Click **Routing**.
- 3 In the **Static Route** section, click **Create**.
- 4 In **Gateway Subnet** enter the subnet for the Workload network.  
For example, 192.168.2.0/24.
- 5 In **Next Hop**, enter the gateway IP address for the Data network.  
For example, 192.168.0.1.
- 6 Click **Save**.

## Configure IPAM

Configure IPAM for the Controller and assign it to the Default-Cloud configuration. Currently, only the Default-Cloud configuration is supported.

IPAM is required to allocate virtual IP addresses when virtual services get created.

### Procedure

- 1 In the Avi Controller dashboard, go to **Templates > Profile > IPAM/DNS Profiles**.
- 2 Select **Create IPAM Profile**
- 3 Configure the **IPAM Profile** as follows and click **Save** when you are done.

Option	Description
<b>Name</b>	User-defined string, such as <code>ipam-profile</code>
<b>Type</b>	Select <b>AVI Vantage IPAM</b>
<b>Allocate IP in VRF</b>	Checked
<b>Cloud for Usable Network</b>	<b>Default-Cloud</b>
<b>Usable Network</b>	Select the Virtual IP network that you configured.

The `ipam-profile` listed in the **IPAM/DNS Profiles** page.

- 4 Assign the IPAM to the **Default-Cloud** configuration.
  - a Go to **Infrastructure > Cloud**.
  - b Edit the **Default-Cloud** configuration:  
**IPAM Profile: ipam-profile**
  - c Leave all the other values as the default.
  - d Click **Save**.

## Test the NSX Advanced Load Balancer

After you have deployed and configured the NSX Advanced Load Balancer control plane, verify its functionality.

### Procedure

- 1 In the Avi Controller dashboard, go to **Infrastructure > Clouds**.
- 2 Verify that the status of the Controller for **Default-Cloud** is green.

To troubleshoot problems that you might encounter, see [Troubleshooting the NSX Advanced Load Balancer](#).

## Configuring vSphere Networking and HA Proxy Load Balancer for vSphere with Tanzu

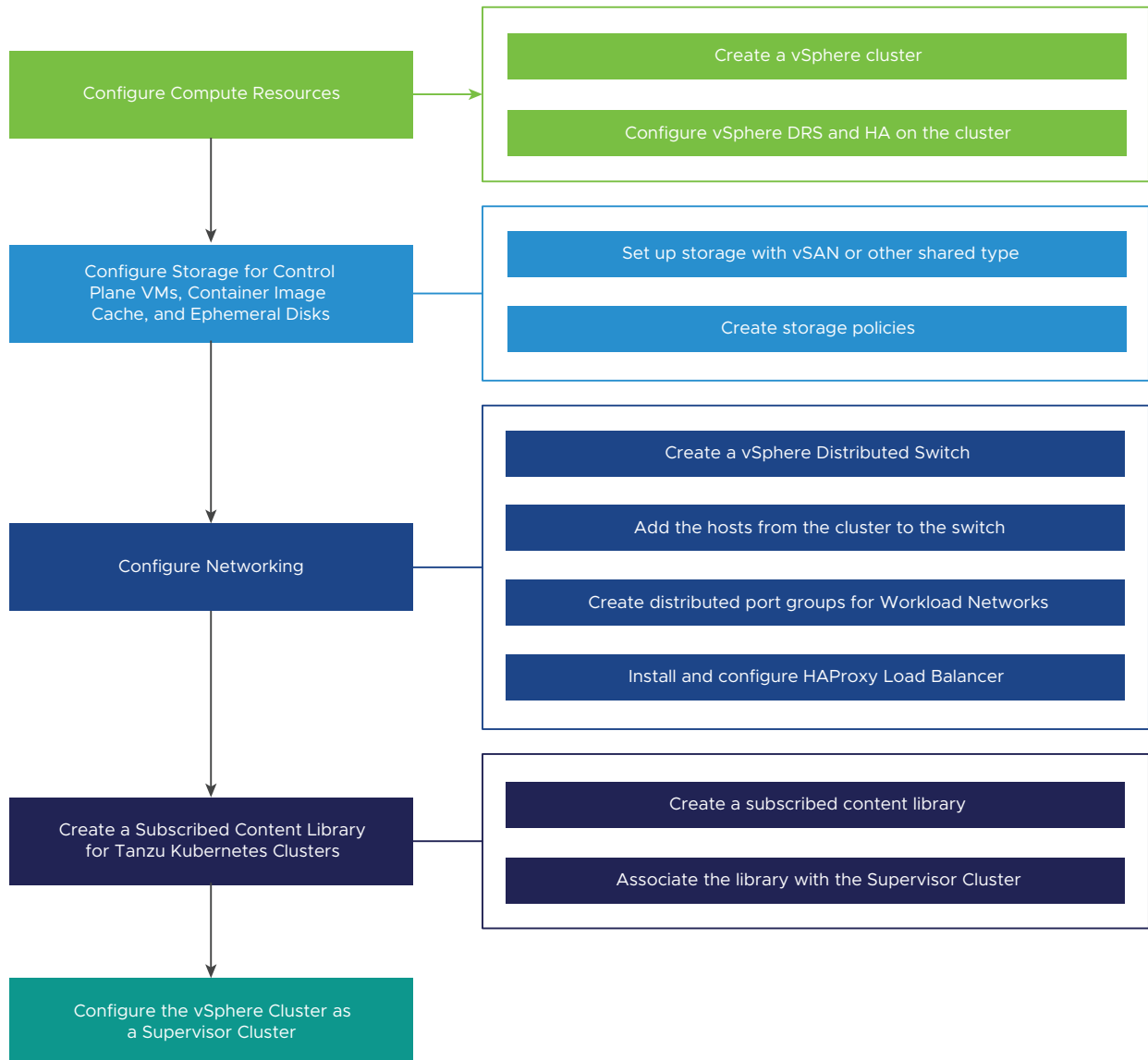
If you are using vSphere Distributed Switch networking for your vSphere with Tanzu environment, you can install and configure the open source HA Proxy load balancer. VMware provides an implementation of HA Proxy that you can deploy from an OVA file.

## Supervisor Cluster with vSphere Networking and HA Proxy Load Balancer Workflow

This diagram shows the workflow for configuring vSphere networking and HA Proxy load balancer for vSphere with Tanzu.



Figure 4-6. Configuring vDS networking with HA Proxy workflow



## System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and HA Proxy Load Balancer

Check out the system requirements for setting up a vSphere cluster as a Supervisor Cluster with the vSphere networking stack and HA Proxy Load Balancer.

### Minimum Compute Requirements

**Caution** Do not disable vSphere DRS after you configure the Supervisor Cluster. Having DRS enabled at all times is a mandatory prerequisite for running workloads on the Supervisor Cluster. Disabling DRS leads to breaking your Tanzu Kubernetes clusters.

System	Minimum Deployment Size	CPU	Memory	Storage
vCenter Server 7.0	Small	2	16 GB	290 GB
ESXi hosts 7.0	<p>Without vSAN: 3 ESXi hosts with 1 static IP per host.</p> <p>With vSAN: 4 ESXi hosts with at least 2 physical NICs.</p> <p>The hosts must be joined in a cluster with vSphere DRS and HA enabled. vSphere DRS must be in Fully Automate or Partially Automate mode.</p> <p><b>Note</b> Make sure that the names of the hosts that join the cluster use lower case letters. Otherwise, the enablement of the cluster for Workload Management might fail.</p>	8	64 GB per host	Not applicable
Kubernetes control plane VMs	3	4	16 GB	16 GB

## Minimum Network Requirements

Component	Minimum Quantity	Required Configuration
Static IPs for Kubernetes control plane VMs	Block of 5	A block of 5 consecutive static IP addresses to be assigned to the Kubernetes control plane VMs in the Supervisor Cluster.
Management traffic network	1	A Management Network that is routable to the ESXi hosts, vCenter Server, the Supervisor Cluster and load balancer. The network must be able to access an image registry and have Internet connectivity if the image registry is on the external network. The image registry must be resolvable through DNS.
vSphere Distributed Switch	1	All hosts from the cluster must be connected to a vSphere Distributed Switch.

Component	Minimum Quantity	Required Configuration
HAProxy load balancer	1	<p>An instance of HAProxy load balancer configured with the vCenter Server instance.</p> <ul style="list-style-type: none"> <li>■ If the same the HAProxy instance is serving multiple Supervisor Clusters, it must be able to route traffic to and from all Workload Networks across all Supervisor Clusters. IP ranges across Workload Networks in all Supervisor Clusters that the HAProxy serves must not overlap.</li> <li>■ A dedicated IP range for virtual IPs. The HAProxy VM must be the only owner of this virtual IP range. The range must not overlap with any IP range assigned to any Workload Network owned by any Supervisor Cluster.</li> <li>■ The network that HAProxy uses to allocate Virtual IPs must be routable to the Workload Networks used across all Supervisor Clusters to which HAProxy is connected.</li> </ul>
Workload Networks	1	<p>At least one distributed port group must be created on the vSphere Distributed Switch that you configure as the Primary Workload Network. Depending on the topology of choice, you can use the same distributed port group as the Workload Network of namespaces or create more port groups and configure them as Workload Networks. Workload Networks must meet the following requirements:</p> <ul style="list-style-type: none"> <li>■ Workload Networks that are used for Tanzu Kubernetes cluster traffic must be routable between each other and the Supervisor Cluster Primary Workload Network.</li> <li>■ Routability between any Workload Network with the network that HAProxy uses for virtual IP allocation.</li> <li>■ No overlapping of IP address ranges across all Workload Networks within a Supervisor Cluster.</li> </ul>
NTP and DNS Server	1	<p>A DNS server and NTP server that can be used with vCenter Server.</p> <p><b>Note</b> Configure NTP on all ESXi hosts and vCenter Server .</p>

Component	Minimum Quantity	Required Configuration
DHCP Server	1	<p>Optional. Configure a DHCP server to automatically acquire IP addresses for the management and workload networks as well as floating IPs. The DHCP server must support Client Identifiers and provide compatible DNS servers, DNS search domains, and an NTP server.</p> <p>The DHCP configuration is used by the Supervisor Cluster. Load balancers may require static IP addresses for Management. DHCP Scopes should not overlap these static IP's. DHCP is not used for virtual IPs. (VIPs)</p>
Management Network Subnet	1	<p>The subnet used for management traffic between ESXi hosts and vCenter Server, and the Kubernetes control plane. The size of the subnet must be the following:</p> <ul style="list-style-type: none"> <li>■ One IP address per host VMkernel adapter.</li> <li>■ One IP address for the vCenter Server Appliance.</li> <li>■ 5 IP addresses for the Kubernetes control plane. 1 for each of the 3 nodes, 1 for virtual IP, 1 for rolling cluster upgrade.</li> </ul> <p><b>Note</b> The Management Network and the Workload Network must be on different subnets. Assigning the same subnet to the Management and the Workload networks is not supported and can lead to system errors and problems.</p>
Management Network VLAN	1	The VLAN ID of the Management Network subnet.
Physical Network MTU	1600	The MTU size must be 1600 or greater on any network that carries overlay traffic.
Kubernetes services CIDR range	/16 Private IP addresses	A private CIDR range to assign IP addresses to Kubernetes services. You must specify a unique Kubernetes services CIDR range for each Supervisor Cluster.

## Topologies for Deploying the HAProxy Load Balancer

When using vSphere with Tanzu with vDS networking, HAProxy provides load balancing for developers accessing the Tanzu Kubernetes control plane, and for Kubernetes Services of Type Load Balancer. Review the possible topologies that you can implement for the HAProxy load balancer.

### Workload Networks on the Supervisor Cluster

To configure a Supervisor Cluster with the vSphere networking stack, you must connect all hosts from the cluster to a vSphere Distributed Switch. Depending on the topology that you implement for the Supervisor Cluster Workload Networks, you create one or more distributed port groups. You designate the port groups as Workload Networks to vSphere Namespaces.

Before you add a host to a Supervisor Cluster, you must add it to all the vSphere Distributed Switches that are part of the cluster.

Workload Networks provide connectivity to the nodes of Tanzu Kubernetes clusters and to Supervisor Cluster control plane VMs. The Workload Network that provides connectivity to Kubernetes control plane VMs is called a Primary Workload Network. Each Supervisor Cluster must have one Primary Workload Network. You must designate one of the distributed port group as the Primary Workload Network to the Supervisor Cluster.

---

**Note** Workload Networks are only added when you enable the Supervisor Cluster and cannot be added later.

---

The Kubernetes control plane VMs on the Supervisor Cluster use three IP addresses from the IP address range that is assigned to the Primary Workload Network. Each node of a Tanzu Kubernetes cluster has a separate IP address assigned from the address range of the Workload Network that is configured with the namespace where the Tanzu Kubernetes cluster runs.

## Allocation of IP Ranges

When you plan for the networking topology of the Supervisor Cluster with HA Proxy load balancer, plan for having two types of IP ranges:

- A range for allocating virtual IPs for HAProxy. The IP range that you configure for the virtual servers of HAProxy are reserved by the load balancer appliance. For example, if the virtual IP range is 192.168.1.0/24, all hosts on that range are not accessible for traffic other than virtual IP traffic.

---

**Note** You must not configure a gateway within the HAProxy virtual IP range, because all routes to that gateway will fail.

---

- An IP range for the nodes of the Supervisor Cluster and Tanzu Kubernetes clusters. Each Kubernetes control plane VM in the Supervisor Cluster has an IP address assigned, which make three IP addresses in total. Each node of a Tanzu Kubernetes cluster also has a separate IP assigned. You must assign a unique IP range to each Workload Network on the Supervisor Cluster that you configure to a namespace.

An example configuration with one /24 network:

- Network: 192.168.120.0/24
- HAProxy VIPs: 192.168.120.128/25
- 1 IP address for the HAProxy workload interface: 192.168.120.5

Depending on the IPs that are free within the first 128 addresses, you can define IP ranges for Workload Networks on the Supervisor Cluster, for example:

- 192.168.120.31-192.168.120.40 for the Primary Workload Network

- 192.168.120.51-192.168.120.60 for another Workload Network

**Note** The ranges that you define for Workload Networks must not overlap with the HAProxy VIP range.

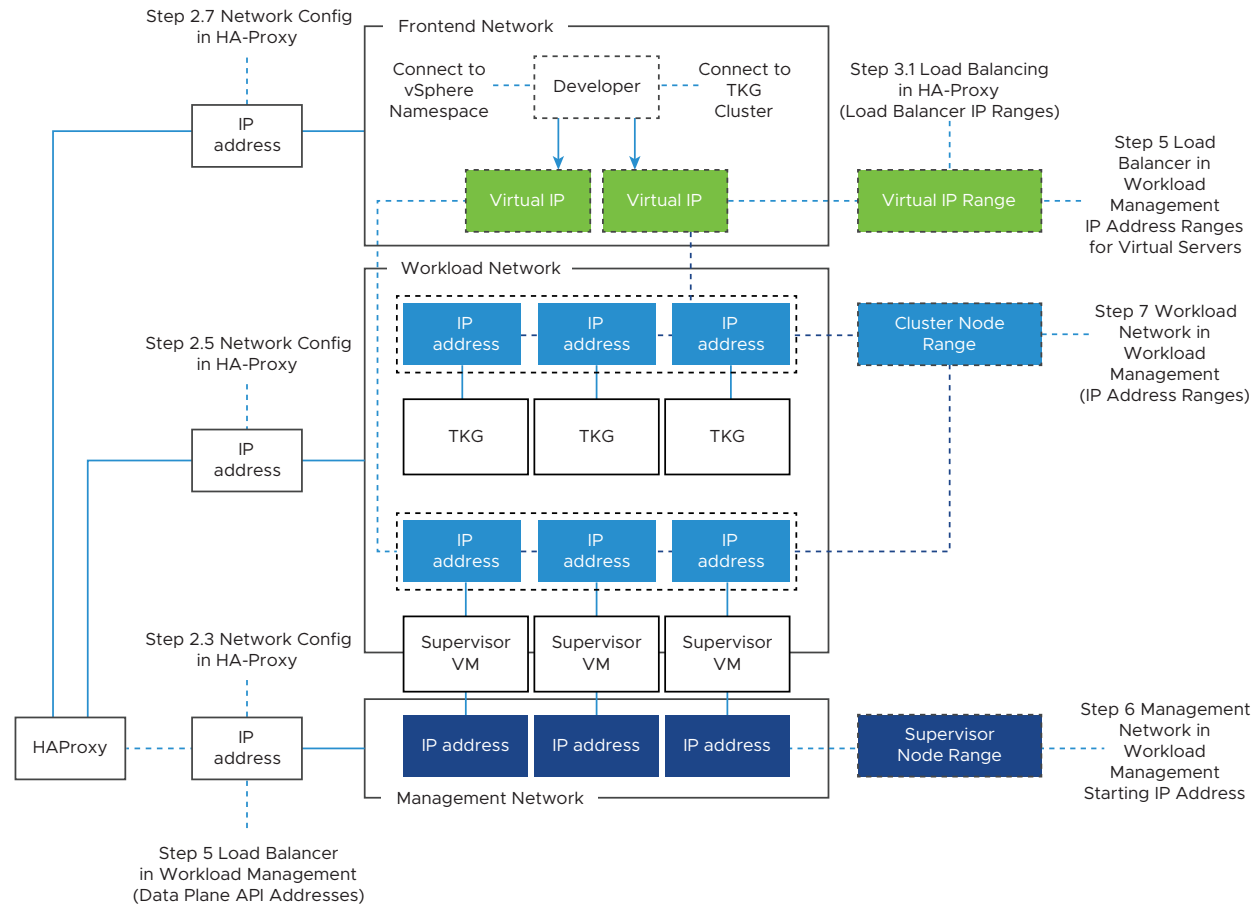
## HAProxy Network Topology

There are two network configuration options for deploying HAProxy: **Default** and **Frontend**. The default network has 2 NICs: one for the Management network and one for the Workload network. The Frontend network has 3 NICs: Management network, Workload network, and the Frontend network for clients. The table lists and describes characteristics of each network.

For production installations, it is recommended that you deploy the HAProxy load balancer using the **Frontend Network** configuration. If you deploy the HAProxy load balancer using the **Default** configuration, it is recommended that you assign a /24 IP address block size to the Workload network. For both configuration options, DHCP is not recommended.

Network	Characteristics
<b>Management</b>	<p>The Supervisor Cluster uses the Management network to connect to and program the HAProxy load balancer.</p> <ul style="list-style-type: none"> <li>■ The HAProxy Data Plane API endpoint is bound to the network interface connected to the Management network.</li> <li>■ The Management IP address assigned to the HAProxy control plane VM must be a static IP on the Management network so that the Supervisor Cluster can reliably connect to the load balancer API.</li> <li>■ The default gateway for the HAProxy VM should be on this network.</li> <li>■ DNS queries should occur on this network.</li> </ul>
<b>Workload</b>	<p>The HAProxy control plane VM uses the Workload network to access the services on the Supervisor Cluster and Tanzu Kubernetes cluster nodes.</p> <ul style="list-style-type: none"> <li>■ The HAProxy control plane VM forwards traffic to the Supervisor and Tanzu Kubernetes cluster nodes on this network.</li> <li>■ If the HAProxy control plane VM is deployed in Default mode (two NICs), the Workload network must provide the logical networks used to access the load balancer services.</li> <li>■ In the <b>Default</b> configuration, the load balancer virtual IPs and the Kubernetes cluster node IPs will come from this network. They will be defined as separate, non-overlapping ranges within the network.</li> </ul>
<b>Frontend</b> (optional)	<p>External clients (such as users or applications) accessing cluster workloads use the Frontend network to access backend load balanced services using virtual IP addresses.</p> <ul style="list-style-type: none"> <li>■ The Frontend network is only used when the HAProxy control plane VM is deployed with three NICs.</li> <li>■ Recommended for production installations.</li> <li>■ The Frontend network is where you expose the virtual IP address (VIP). HAProxy will balance and forward the traffic to the appropriate backend.</li> </ul>

The diagram below illustrates an HAProxy deployment using a **Frontend Network** topology. The diagram indicates where configuration fields are expected during the installation and configuration process.



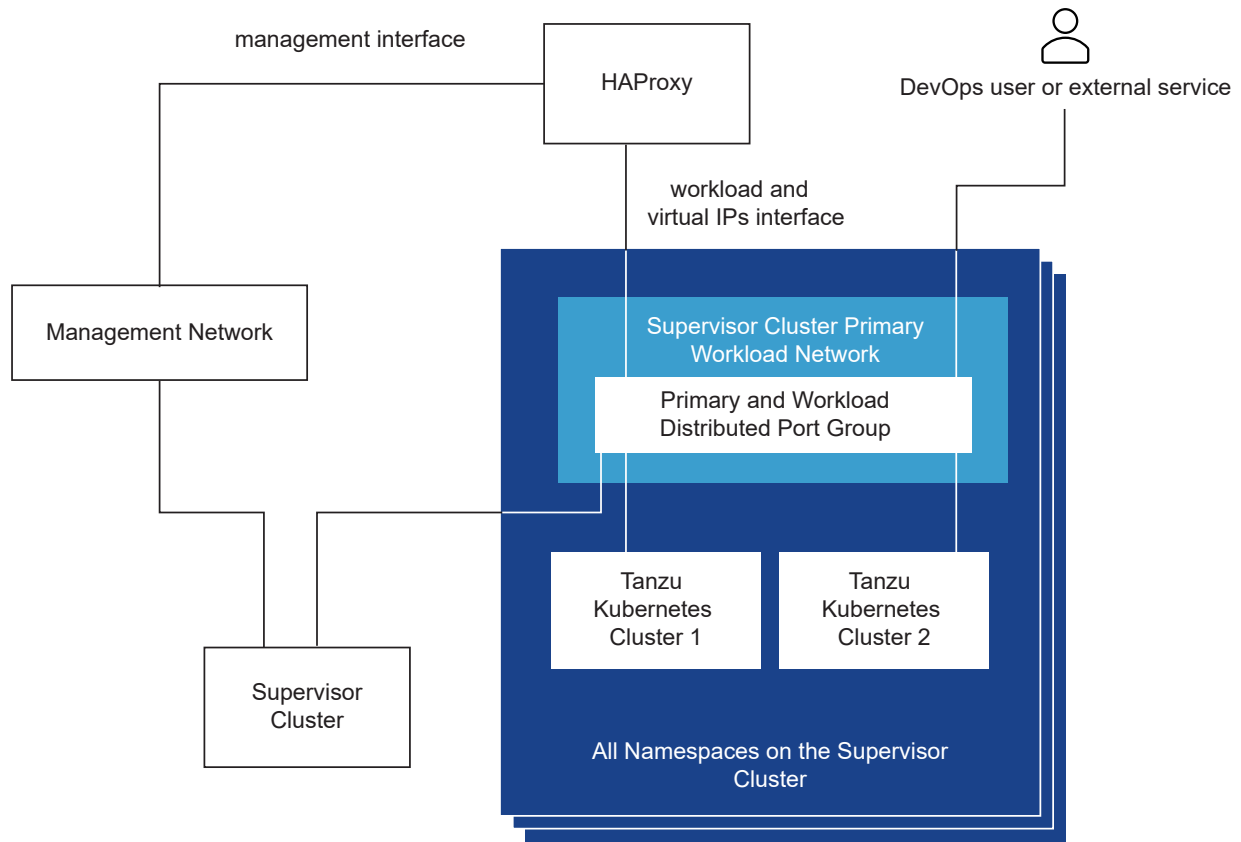
## Supervisor Cluster Topology with One Workload Network and HA Proxy with Two Virtual NICs

In this topology, you configure a Supervisor Cluster with one Workload Network for the following components:

- Kubernetes control plane VMs
- The nodes of Tanzu Kubernetes clusters.
- The HAProxy virtual IP range where external services and DevOps users connect. In this configuration, HAProxy is deployed with two virtual NICs (**Default** configuration), one connected to the management network, and a second one connected to the Primary Workload Network. You must plan for allocating Virtual IPs on a separate subnet from the Primary Workload Network.

You designate one port group as the Primary Workload Network to the Supervisor Cluster and then use the same port group as the Workload Network for vSphere Namespaces. Supervisor Cluster, Tanzu Kubernetes clusters, HAProxy, DevOps users, and external services all connect to the same distributed port group that is set as the Primary Workload Network.

Figure 4-7. Supervisor Cluster Backed by One Network



The traffic path for DevOps users or external applications is the following:

- 1 The DevOps user or external service sends traffic to a virtual IP on the Workload Network subnet of the distributed port group.
- 2 HAProxy load balances the virtual IP traffic to either Tanzu Kubernetes node IP or control plane VM IP. HAProxy claims the virtual IP address so that it can load balance the traffic coming on that IP.
- 3 The control plane VM or Tanzu Kubernetes cluster node delivers the traffic to the target pods running inside the Supervisor Cluster or Tanzu Kubernetes cluster respectively.

### Supervisor Cluster Topology with an Isolated Workload Network and HA Proxy with Two Virtual NICs

In this topology, you configure networks to the following components:

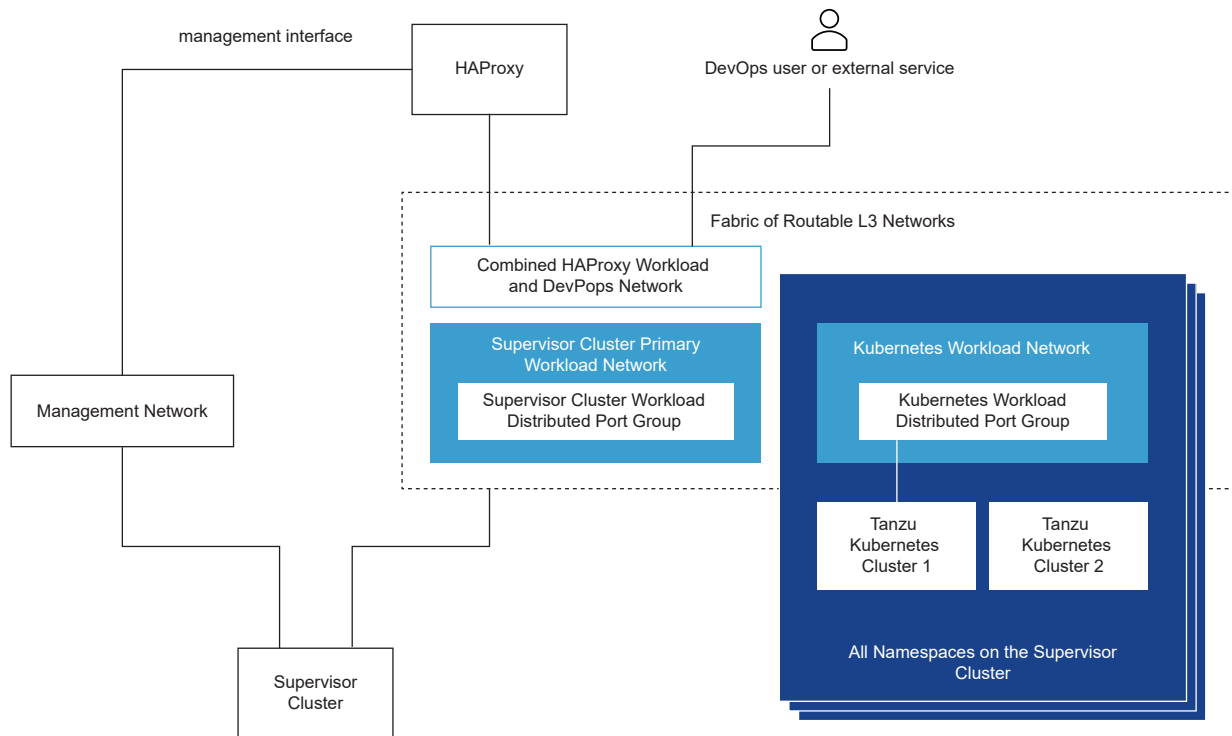
- Kubernetes control plane VMs. A Primary Workload Network to handle the traffic for Kubernetes control plane VMs.
- Tanzu Kubernetes cluster nodes. A Workload Network, that you assign to all namespaces on the Supervisor Cluster. This network connects the Tanzu Kubernetes cluster nodes.



- HAProxy virtual IPs. In this configuration, the HAProxy VM is deployed with two virtual NICs (**Default** configuration). You can either connect the HAProxy VM to the Primary Workload Network or the Workload Network that you use for namespaces. You can also connect HAProxy to a VM network that already exists in vSphere and is routable to the Primary and Workload networks.

The Supervisor Cluster is connected to the distributed port group backing the Primary Workload Network and Tanzu Kubernetes clusters are connected to a distributed port group backing the Workload Network. The two port groups must be layer 3 routable. You can implement layer 2 isolation through VLANs. Layer 3 traffic filtering is possible through IP firewalls and gateways.

**Figure 4-8. Supervisor Cluster with an Isolated Workload Network**



The traffic path for DevOps users or external service is the following:

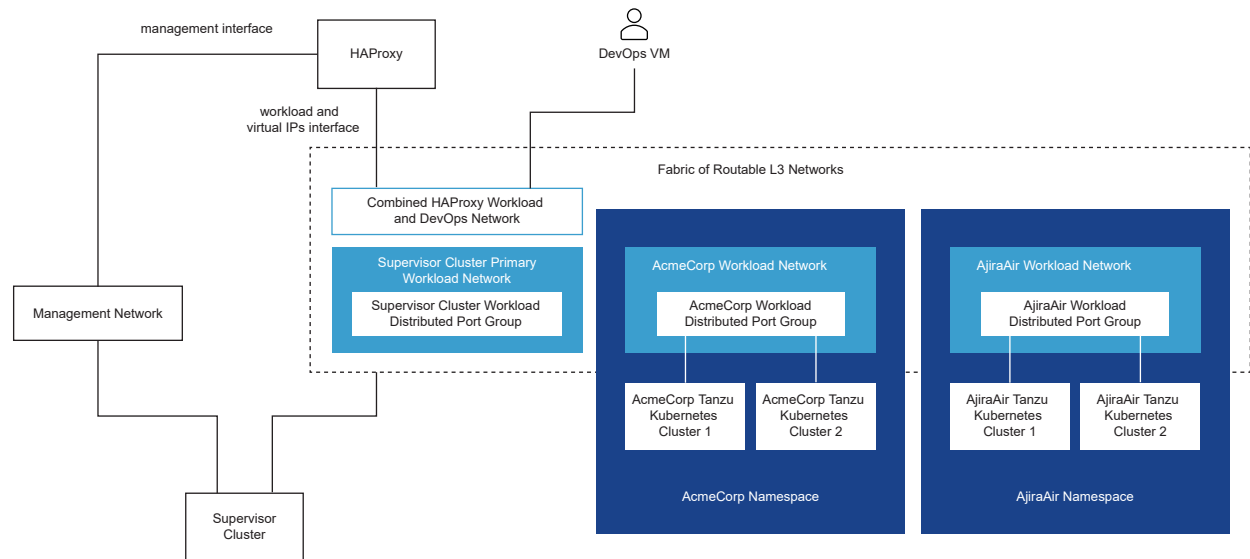
- 1 The DevOps user or external service sends traffic to a virtual IP. Traffic is routed to the network where HAProxy is connected.
- 2 HAProxy load balances the virtual IP traffic to either Tanzu Kubernetes node IP or control plane VM. HAProxy is claiming the virtual IP address so that it can load balance the traffic coming on that IP.
- 3 The control plane VM or Tanzu Kubernetes cluster node delivers the traffic to the target pods running inside the Tanzu Kubernetes cluster.

## Supervisor Cluster Topology with Multiple Workload Networks and HA Proxy with Two Virtual NICs

In this topology, you can configure one port group to act as the Primary Workload Network and a dedicated port group to serve as the Workload Network to each namespace. HAProxy is deployed with two virtual NICs (**Default** configuration), and you can either connect it to the Primary Workload Network or to any of the Workload Networks. You can also use an existing VM network that is routable to the Primary and Workload Networks.

The traffic path for the DevOps users and external services in this topology is the same as with the isolated Workload Network topology.

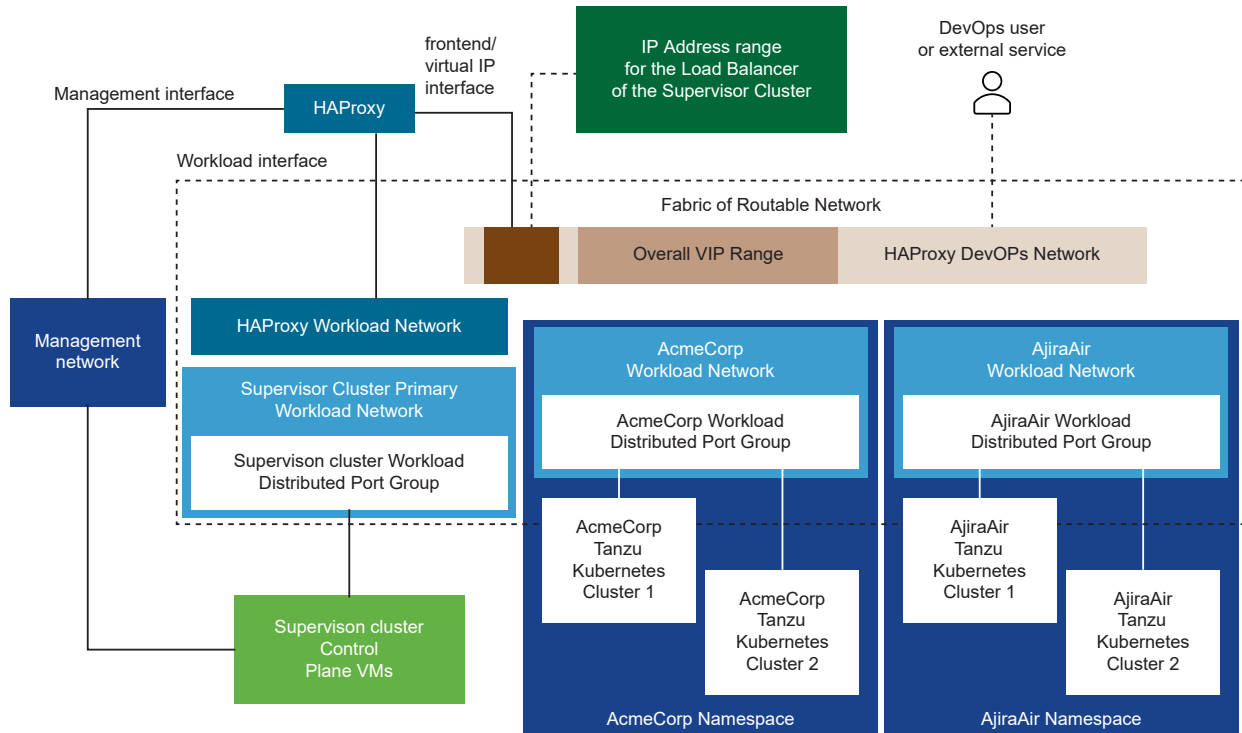
**Figure 4-9. Supervisor Cluster Backed by Multiple Isolated Workload Networks**



## Supervisor Cluster Topology with Multiple Workload Networks and HA Proxy with Three Virtual NICs

In this configuration, you deploy the HAProxy VM with three virtual NICs, thus connecting HAProxy to a Frontend network. DevOps users and external services can access HAProxy through virtual IPs on the Frontend network. Deploying HA Proxy with three virtual NICs is recommended for production environments.

Figure 4-10. HAProxy Deployed with Three Virtual NICs



## Selecting Between the Possible Topologies

Before you select between each of the possible topologies, assess the needs of your environment:

- 1 Do you need layer 2 isolation between Supervisor Cluster and Tanzu Kubernetes clusters?
  - a No: the simplest topology with one Workload Network serving all components.
  - b Yes: the isolated Workload Network topology with a separate Primary and Workload Networks.
- 2 Do you need further layer 2 isolation between your Tanzu Kubernetes clusters?
  - a No: isolated workload network topology with a separate Primary and Workload Networks.
  - b Yes: multiple workload networks topology with a separate Workload Network for each namespace and a dedicated Primary Workload Network.
- 3 Do you want to prevent your DevOps users and external services from directly routing to Kubernetes control plane VMs and Tanzu Kubernetes cluster nodes?
  - a No: two NIC HAProxy configuration.
  - b Yes: three NIC HAProxy configuration. This configuration is recommended for production environments

## Create a vSphere Distributed Switch for a Supervisor Cluster for Use with HAProxy Load Balancer

To configure a vSphere cluster as a Supervisor Cluster that uses the vSphere networking stack and the HA proxy load balancer, you must add the hosts to a vSphere Distributed Switch. You must create port groups on the distributed switch that you will configure as Workload Networks to the Supervisor Cluster.

You can select between different topologies for the Supervisor Cluster depending on the level of isolation that you want to provide to the Kubernetes workloads that will run on the cluster.

### Prerequisites

- Review the system requirements for using vSphere networking for the Supervisor Cluster with the HAProxy load balancer. See [System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and HA Proxy Load Balancer](#).
- Determine the topology for setting up Workload Networks with HA Proxy on the Supervisor Cluster. See [Topologies for Deploying the HAProxy Load Balancer](#).

### Procedure

- 1 In the vSphere Client, navigate to a data center.
- 2 Right click the data center and select **Distributed Switch > New Distributed Switch**.
- 3 Enter a name for the switch, for example **Workload Distributed Switch** and click **Next**.
- 4 Select version 7.0 for the switch and click **Next**.
- 5 In **Port group name**, enter **Primary Workload Network**, click **Next**, and click **Finish**.

A new distributed switch with one port group is created on the data center. You can use this port group as the Primary Workload Network for the Supervisor Cluster that you will create. The Primary Workload Network handles the traffic for Kubernetes control plane VMs.

- 6 Create distributed port groups for Workload Networks.

The number of port groups that you create depends on the topology that you want to implement for the Supervisor Cluster. For a topology with one isolated Workload Network, create one distributed port group that you will use as a network for all namespaces on the Supervisor Cluster. For a topology with isolated networks for each namespace, create the same number of port groups as the number of namespaces that you will create.

- a Navigate to the newly-created distributed switch.
- b Right-click the switch and select **Distributed Port Groups > New Distributed Port Group**.
- c Enter a name for the port group, for example **Workload Network** and click **Next**.
- d Leave the defaults, click **Next** and click **Finish**.

- 7 Add hosts from the vSphere clusters that you will configure as Supervisor Cluster to the distributed switch.
  - a Right-click the distributed switch and select **Add and Manage Hosts**.
  - b Select **Add Hosts**.
  - c Click **New Hosts**, select the hosts from the vSphere cluster that you will configure as a Supervisor Cluster, and click **Next**.
  - d Select a physical NIC from each host and assign it an uplink on the distributed switch.
  - e Click **Next** through the remaining screens of the wizard and click **Finish**.

### Results

The hosts are added to the distributed switch. You can now use the port groups that you created on the switch as Workload Networks of the Supervisor Cluster.

## Install and Configure the HAProxy Load Balancer

VMware provides an implementation of the open source HAProxy load balancer that you can use in your vSphere with Tanzu environment. If you are using vSphere Distributed Switch (vDS) networking for **Workload Management**, you can install and configure the HAProxy load balancer.

### Deploy the HAProxy Load Balancer Control Plane VM

If you want to use the vSphere networking stack for Kubernetes workloads, install the HAProxy control plane VM to provide load balancing services to Tanzu Kubernetes clusters.

#### Prerequisites

- Verify that your environment meets the compute and networking requirements for deploying HA Proxy. See [System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and HA Proxy Load Balancer](#).
- Verify that you have a Management network on a vSphere standard or distributed switch where to deploy the HAProxy load balancer. The Supervisor Cluster communicates with the HAProxy load balancer on that Management network.
- Create a vSphere Distributed Switch and port groups for Workload Networks. The HAProxy load balancer communicates with Supervisor Cluster and Tanzu Kubernetes cluster nodes over the Workload Networks. See [Create a vSphere Distributed Switch for a Supervisor Cluster for Use with HAProxy Load Balancer](#). For information on Workload Networks, see [Workload Networks on the Supervisor Cluster](#).
- Download the latest version of the VMware HAProxy OVA file from the [VMware-HAProxy site](#).
- Select a topology for deploying the HAProxy load balancer and Workload Networks on the Supervisor Cluster. See [Topologies for Deploying the HAProxy Load Balancer](#).

It may be helpful to view a demonstration of how to use vSphere with Tanzu with vDS networking and HAProxy. Check out the video [Getting Started Using vSphere with Tanzu](#).

### Procedure

- 1 Log in to the vCenter Server using the vSphere Client.
- 2 Create a new VM from the HAProxy OVA file.

Option	Description
<b>Content Library</b>	<p>If you imported the OVA to a Local Content Library:</p> <ul style="list-style-type: none"> <li>■ Go to <b>Menu &gt; Content Library</b>.</li> <li>■ Select the library where you imported the OVA.</li> <li>■ Select the <code>vmware-haproxy-vX.X.X</code> template.</li> <li>■ Right-click and choose <b>New VM from This Template</b>.</li> </ul>
<b>Local file</b>	<p>If you downloaded the OVA file to your local host:</p> <ul style="list-style-type: none"> <li>■ Select the vCenter cluster where you will enable <b>Workload Management</b>.</li> <li>■ Right-click and select <b>Deploy OVF Template</b>.</li> <li>■ Select <b>Local File</b> and click <b>Upload Files</b>.</li> <li>■ Browse to and select the <code>vmware-haproxy-vX.X.X.ova</code> file.</li> </ul>

- 3 Enter a **Virtual machine name**, such as `haproxy`.
- 4 Select the **Datacenter** where you are deploying HAProxy and click **Next**.
- 5 Select the vCenter Cluster where you will enable **Workload Management** and click **Next**.
- 6 Review and confirm the deployment details and click **Next**.
- 7 Accept the License agreements and click **Next**.
- 8 Select a deployment configuration. See [HAProxy Network Topology](#) for details.

Configuration	Description
<b>Default</b>	Select this option to deploy the appliance with 2 NICs: a Management network and a single Workload network.
<b>Frontend Network</b>	Select this option to deploy the appliance with 3 NICs. The frontend subnet is used to isolate cluster nodes from the network used by developers to access the cluster control plane.

- 9 Select the storage policy to use for the VM and click **Next**.

- 10 Select the network interfaces to use for the load balancer and click **Next**.

Source Network	Destination Network
<b>Management</b>	Select the Management network, such as <b>VM Network</b> .
<b>Workload</b>	Select the vDS portgroup configured for <b>Workload Management</b> .
<b>Frontend</b>	Select the vDS portgroup configured for the Frontend subnet. If you did not select Frontend configuration, this setting is ignored during installation, so you can leave the default.

- 11 Customize the application configuration settings. See [Appliance Configuration Settings](#)
- 12 Provide the network configuration details. See [Network Configuration](#).
- 13 Configure load balancing. See [Load Balancing Settings](#).
- 14 Click **Next** to complete the configuration of the OVA.
- 15 Review the deployment configuration details and click **Finish** to deploy the OVA.
- 16 Monitor the deployment of the VM using the **Tasks** panel.
- 17 When the VM deployment completes, power it on.

#### What to do next

Once the HAProxy load balancer is successfully deployed and powered on, proceed with enabling **Workload Management**. See [Chapter 5 Configuring and Managing a Supervisor Cluster](#).

## Customize the HAProxy Load Balancer

Customize the HAProxy control plane VM, including configuration settings, network settings, and load balancing settings.

### Appliance Configuration Settings

The table lists and describes the parameters for HAProxy appliance configuration.

Parameter	Description	Remark or Example
Root Password	Initial password for the root user (6-128 characters).	Subsequent changes of password must be performed in operating system.
Permit Root Login	Option to allow the root user to login to the VM remotely over SSH.	Root login might be needed for troubleshooting, but keep in mind the security implications of allowing it.

Parameter	Description	Remark or Example
TLS Certificate Authority (ca.crt)	To use the self-signed CA certificate, leave this field empty. To use your own CA certificate (ca.crt), paste its contents into this field. You might need to Base64-encode the contents. <a href="https://www.base64encode.org/">https://www.base64encode.org/</a>	If you are using the self-signed CA certificate, the public and private keys will be generated from the certificate.
Key (ca.key)	If you are using the self-signed certificate, leave this field empty. If you provided a CA certificate, paste the contents of the certificate private key in this field.	

## Network Configuration

The table lists and describes the parameters for HAProxy network configuration.

Parameter	Description	Remark or Example
Host Name	The host name (or FQDN) to assign to the HAProxy control plane VM	Default value: <code>haproxy.local</code>
DNS	A comma-separated list of DNS server IP addresses.	Default values: <code>1.1.1.1, 1.0.0.1</code> Example value: <code>10.8.8.8</code>
Management IP	The static IP address of the HAProxy control plane VM on the Management network.	A valid IPv4 address with the prefix length of the network, for example: <code>192.168.0.2/24</code> .
Management Gateway	The IP address of the gateway for the Management network.	For example: <code>192.168.0.1</code>
Workload IP	The static IP address of the HAProxy control plane VM on the Workload network. This IP address must be outside of the load balancer IP address range.	A valid IPv4 address with the prefix length of the network, for example: <code>192.168.10.2/24</code> .
Workload Gateway	The IP address of the gateway for the Workload network.	For example: <code>192.168.10.1</code> If you select Frontend configuration, you must enter a gateway. The deployment will not be successful if Frontend is selected and no gateway is specified.
Frontend IP	The static IP address of the HAProxy appliance on the Frontend network. This value is only used when the Frontend deployment model is selected.	A valid IPv4 address with the prefix length of the network, for example: <code>192.168.100.2/24</code>
Frontend Gateway	The IP address of the gateway for the Frontend network. This value is only used when the Frontend deployment model is selected.	For example: <code>192.168.100.1</code>



## Load Balancing Settings

The table lists and describes the parameters for HAProxy load balancer configuration.

Parameter	Description	Example or Remark
Load Balancer IP Range(s)	<p>In this field you specify a range of IPv4 addresses using CIDR format. The value must be a valid CIDR range or the installation will fail.</p> <p>HAProxy reserves the IP addresses for virtual IPs (VIPs). Once assigned each VIP address is allocated, HAProxy replies to requests on that address.</p> <p>The CIDR range you specify here must not overlap with the IPs you assign for the Virtual Servers when you enable <b>Workload Management</b> in the vCenter Server using the vSphere Client.</p>	<p>For example, the network CIDR 192.168.100.0/24 gives the load balancer 256 virtual IP addresses with range 192.168.100.0 - 192.168.100.255.</p> <p>For example, the network CIDR 192.168.100.0/25 gives the load balancer 128 virtual IP addresses with range 192.168.100.0 - 192.168.100.127.</p>
Dataplane API Management Port	The port on the HAProxy VM on which the load balancer's API service listens.	A valid port. Port 22 is reserved for SSH. The default value is 5556.
HAProxy User ID	Load balancer API user name	<p>The username clients use to authenticate to the load balancer's API service.</p> <p><b>Note</b> You need this username when you enable the Supervisor Cluster.</p>
HAProxy Password	Load balancer API password	<p>The password clients use to authenticate to the load balancer's API service.</p> <p><b>Note</b> You need this password when you enable the Supervisor Cluster.</p>

# Configuring and Managing a Supervisor Cluster

# 5

As a vSphere Administrator, you enable a vSphere cluster for Workload Management by creating a Supervisor Cluster. You can select between creating the Supervisor Cluster with the vSphere networking stack or with NSX-T Data Center as the networking solution. A cluster configured with NSX-T Data center supports running a vSphere Pod and a Tanzu Kubernetes cluster created through the VMware Tanzu™ Kubernetes Grid™ Service. A Supervisor Cluster that is configured with the vSphere networking stack only supports Tanzu Kubernetes clusters.

After you enable the Supervisor Cluster, you can use the vSphere Client to manage and monitor the cluster.

This chapter includes the following topics:

- [Prerequisites for Configuring vSphere with Tanzu on a Cluster](#)
- [Enable Workload Management with vSphere Networking](#)
- [Enable Workload Management with NSX-T Data Center Networking](#)
- [Assign the Tanzu Edition License to a Supervisor Cluster](#)
- [Replace the VIP Certificate to Securely Connect to the Supervisor Cluster API Endpoint](#)
- [Integrate the Tanzu Kubernetes Grid Service on the Supervisor Cluster with Tanzu Mission Control](#)
- [Set the Default CNI for Tanzu Kubernetes Clusters](#)
- [Add Workload Networks to a Supervisor Cluster Configured with VDS Networking](#)
- [Change the Control Plane Size of a Supervisor Cluster](#)
- [Change the Management Network Settings on a Supervisor Cluster](#)
- [Change the Workload Network Settings on a Supervisor Cluster Configured with VDS Networking](#)
- [Change Workload Network Settings on a Supervisor Cluster Configured with NSX-T Data Center](#)
- [Resolving Errors Health Statuses on Supervisor Cluster During Initial Configuration Or Upgrade](#)

## Prerequisites for Configuring vSphere with Tanzu on a Cluster

Check out the prerequisites for enabling vSphere with Tanzu in your vSphere environment. To run container-based workloads natively on vSphere, as a vSphere administrator you enable **Workload Management** on a vSphere cluster. The result is a Kubernetes management cluster known as a Supervisor Cluster where you run vSphere Pods, provision Tanzu Kubernetes clusters, and VMs.

### Create and Configure a vSphere Cluster

A vSphere cluster is a collection of ESXi hosts managed by a vCenter Server system. The Supervisor Cluster runs on a vSphere cluster. Create a vSphere cluster that meets the following requirements so that you can enable **Workload Management** on it:

- Create and configure a vSphere cluster with at least three host. If you are using vSAN you need a minimum of four ESXi hosts. See [Creating and Configuring Clusters](#).
- Configure the cluster with shared storage such as vSAN. Shared storage is required for vSphere HA, DRS, and for storing persistent container volumes. See [Creating a vSAN Cluster](#).
- If you plan to use persistent volumes in ReadWriteMany mode, enable File Services on the vSAN cluster. See [Creating ReadWriteMany Persistent Volumes in vSphere with Tanzu](#).
- Enable the cluster with vSphere HA. See [Creating and Using vSphere HA Clusters](#).
- Enable the cluster with vSphere DRS in fully-automated mode. See [Creating a DRS Cluster](#).
- Verify that your user account has the **Modify cluster-wide configuration** on the vSphere cluster so that you can enable the **Workload Management** functionality.

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**Caution** Do not disable vSphere DRS after you configure the Supervisor Cluster. Having DRS enabled at all times is a mandatory prerequisite for running workloads on the Supervisor Cluster. Disabling DRS leads to breaking your Tanzu Kubernetes clusters.

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### Choose and Configure the Networking Stack

To enable **Workload Management** on a vSphere cluster, you must configure the networking stack to be used for the Supervisor Cluster. You have two options: NSX-T Data Center or vSphere Distributed Switch (vDS) networking with a load balancer. You can configure the NSX Advanced Load Balancer or the HAProxy load balancer.

The table lists the high-level differences between the two supported networking stacks. For more information about the architectural differences, see [Supervisor Cluster Configured with the vSphere Networking Stack](#).

Functionality	NSX-T Networking	vDS Networking
vSphere Pods	Yes	No
Tanzu Kubernetes clusters	Yes	Yes

Functionality	NSX-T Networking	vDS Networking
Embedded Harbor Registry	Yes	No
Load Balancing	Yes	Yes, by installing and configuring the NSX Advanced Load Balancer or the HAProxy load balancer.

To use NSX-T Data Center networking for the Supervisor Cluster:

- Review the system requirements and topologies for NSX-T networking. See [System Requirements for Setting Up vSphere with Tanzu with NSX-T Data Center](#).
- Install and configure NSX-T Data Center for vSphere with Tanzu. See [Install and Configure NSX-T Data Center for vSphere with Tanzu](#).

To use vSphere vDS networking with the NSX Advanced Load Balancer for the Supervisor Cluster:

- Review the NSX Advanced Load Balancer requirements. See [System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and NSX Advanced Load Balancer](#).
- Create a vSphere Distributed Switch (vDS) and add all ESXi hosts from the cluster to the vDS and create port groups for Workload Networks. See [Create a vSphere Distributed Switch for a Supervisor Cluster for Use with NSX Advanced Load Balancer](#).
- Deploy and configure the NSX Advanced Load Balancer. See [Deploy the Controller](#).

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**Note** vSphere with Tanzu supports the NSX Advanced Load Balancer with vSphere 7 U2 and later.

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To use vSphere vDS networking with HAProxy load balancing for the Supervisor Cluster:

- Review the system requirements and network topologies for vSphere networking with an external load balancer. See [System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and HA Proxy Load Balancer](#) and [Topologies for Deploying the HAProxy Load Balancer](#).
- Create a vSphere Distributed Switch (vDS) and add all ESXi hosts from the cluster to the vDS and create port groups for Workload Networks. See [Create a vSphere Distributed Switch for a Supervisor Cluster for Use with HAProxy Load Balancer](#).
- Install and configure HA Proxy load balancer instance that is routable to the vSphere Distributed Switch that is connected to the hosts from the vSphere cluster. The HAProxy load balancer supports the network connectivity to workloads from client networks and to load balance traffic between Tanzu Kubernetes clusters. See [Install and Configure the HAProxy Load Balancer](#).

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**Note** vSphere with Tanzu supports the HAProxy load balancer with vSphere 7 U1 and later.

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## Create Storage Policy

You must create storage policies that will determine the datastore placement of the Kubernetes control plane VMs, containers, and images. You can create storage policies associated with different storage classes.

Before enabling **Workload Management** on a vSphere cluster, create a storage policy for the placement of Kubernetes control plane VMs. See [Create Storage Policies for vSphere with Tanzu](#).

## Create a Content Library

To provision Tanzu Kubernetes clusters and VMs, you need a **Content Library** created in the vCenter Server that manages the vSphere cluster where the Supervisor Cluster runs.

The **Content Library** provides the system with the distributions of Tanzu Kubernetes releases in the form of OVA templates. When you provision a Tanzu Kubernetes cluster, the OVA template for the selected version is used to create the Kubernetes cluster nodes.

You can create a **Subscribed Content Library** to automatically pull the latest released images, or you can create a **Local Content Library** and manually upload the images, which may be required for air-gapped provisioning of Tanzu Kubernetes clusters.

See [Creating and Managing Content Libraries for Tanzu Kubernetes releases](#).

## Watch vSphere with Tanzu Demos

Although not a hard requirement, before you embark it may be helpful to watch some demonstrations of vSphere with Tanzu, including setting up the vSphere environment in preparation for deploying the Supervisor Cluster, enabling **Workload Management**, and provisioning Tanzu Kubernetes clusters. If this sounds useful, check out the series of [vSphere with Tanzu Deep Dive](#) videos on the VMware vSphere channel. You can also check the [vSphere Tanzu Quick Bytes](#) series of short videos for configuring **Workload Management** with vDS networking and HA Proxy Load Balancer.

## Enable Workload Management with vSphere Networking

As a vSphere administrator, you can enable the **Workload Management** platform on a vSphere cluster by configuring the vSphere networking stack to provide connectivity to workloads. A Supervisor Cluster that is configured with vSphere networking supports the deployment of Tanzu Kubernetes clusters created by using the Tanzu Kubernetes Grid Service. It does not support running vSphere Pod or using the embedded Harbor Registry.

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**Caution** Do not disable vSphere DRS after you configure the Supervisor Cluster. Having DRS enabled at all times is a mandatory prerequisite for running workloads on the Supervisor Cluster. Disabling DRS leads to breaking your Tanzu Kubernetes clusters.

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## Prerequisites

- Complete the prerequisites for configuring a vSphere cluster as a Supervisor Cluster. See [Prerequisites for Configuring vSphere with Tanzu on a Cluster](#).

## Procedure

- 1 From the home menu, select **Workload Management**.
- 2 Select a licensing option for the Supervisor Cluster.
  - If you have a valid Tanzu Edition license, click **Add License** to add the license key to the license inventory of vSphere.
  - If you do not have a Tanzu edition license yet, enter the contact details so that you can receive communication from VMware and click **Get Started**.

The evaluation period of a Supervisor Cluster lasts for 60 days. Within that period, you must assign a valid Tanzu Edition license to the cluster. If you added a Tanzu Edition license key, you can assign that key within the 60 day evaluation period once you complete the Supervisor Cluster setup.

- 3 On the **Workload Management** screen, click **Get Started** again.
- 4 Select a vCenter Server system, select **vCenter Server Network**, and click **Next**.
- 5 Select a cluster from the list of compatible clusters.
- 6 From the **Control Plane Size** page, select the size for the Kubernetes control plane VMs that will be created on each host from the cluster.

The amount of resources that you allocate to control plane VMs determines the number of Kubernetes workloads that the Supervisor Cluster can manage.

- 7 On the **Load Balancer** screen, select the load balancer you want to use. You can select NSX Advanced Load Balancer or HAProxy.
  - Enter the following settings for NSX Advanced Load Balancer:

Option	Description
Name	Enter a name for the NSX Advanced Load Balancer.
Avi Controller IP	The IP address of the NSX Advanced Load Balancer Controller. The default port is 443.
User name	The user name that is configured with the NSX Advanced Load Balancer. You use this username to access the Controller.

Option	Description
Password	The password for the user name.
Server Certificate Authority	The certificate used by the Controller. You can provide the certificate that you assigned during the configuration. For more information, see <a href="#">Assign a Certificate to the Controller</a> .

- Enter the following settings for HAProxy:

Option	Description
Name	A user-friendly name for the load balancer.
Data plane API Address(es)	The IP address and port of the HAProxy Data Plane API. This component controls the HAProxy server and runs inside the HAProxy VM.
User name	The user name that is configured with the HAProxy OVA file. You use this name to authenticate with the HAProxy Data Plane API.
Password	The password for the user name.

Option	Description
IP Address Ranges for Virtual Servers	<p>Range of IP addresses that is used in the Workload Network by Tanzu Kubernetes clusters. This IP range comes from the list of IPs that were defined in the CIDR you configured during the HAProxy appliance deployment. Typically this will be the entire range specified in the HAProxy deployment, but it can also be a subset of that CIDR because you may create multiple Supervisor Clusters and use IPs from that CIDR range. This range must not overlap with the IP range defined for the Workload Network in this wizard. The range must also not overlap with any DHCP scope on this Workload Network.</p>
Server Certificate Authority	<p>The certificate in PEM format that is signed or is a trusted root of the server certificate that the Data Plane API presents.</p> <ul style="list-style-type: none"> <li>■ Option 1: If root access is enabled, SSH to the HAProxy VM as root and copy <code>/etc/haproxy/ca.crt</code> to the <b>Server Certificate Authority</b>. Do not use escape lines in the <code>\n</code> format.</li> <li>■ Option 2: Right-click the HAProxy VM and select <b>Edit Settings</b>. Copy the CA cert from the appropriate field and convert it from Base64 using a conversion tool such as <a href="https://www.base64decode.org/">https://www.base64decode.org/</a>.</li> <li>■ Option 3: Run the following PowerCLI script. Replace the variables <code>\$vc</code>, <code>\$vc_user</code>, and <code>\$vc_password</code> with appropriate values.</li> </ul> <pre> \$vc = "10.21.32.43" \$vc_user = "administrator@vsphere.local" \$vc_password = "PASSWORD" Connect-VIServer -User \$vc_user -Password \$vc_password -Server \$vc \$VMname = "haproxy-demo" \$AdvancedSettingName = "guestinfo.dataplaneapi.cacert" \$Base64cert = get-vm \$VMname  Get- AdvancedSetting -Name \$AdvancedSettingName while ([string]::IsNullOrEmpty(\$Base64cert.V alue)) {     Write-Host "Waiting for CA Cert Generation... This may take a under 5-10 minutes as the VM needs to boot and generate the CA Cert (if you haven't provided one already)."     \$Base64cert = get-vm \$VMname   Get-AdvancedSetting -Name \$AdvancedSettingName     Start-sleep -seconds 2 } </pre>



Option	Description
	<pre>Write-Host "CA Cert Found... Converting from BASE64" \$cert = [Text.Encoding]::Utf8.GetString([Conve rt]::FromBase64String(\$Base64cert.Valu e)) Write-Host \$cert</pre>

**8** On the **Management Network** screen, configure the parameters for the network that will be used for Kubernetes control plane VMs.

a Select a **Network Mode**.

- **DHCP Network.** In this mode, all the IP addresses for the management network, such as control plane VM IPs, a Floating IP, DNS servers, DNS, search domains, and NTP server are acquired automatically from a DHCP server. To obtain floating IPs, the DHCP server must be configured to support client identifiers. In DHCP mode, all control plane VMs use stable DHCP client identifiers to acquire IP addresses. These client identifiers can be used to setup static IP assignment for the IPs of control plane VMs on the DHCP server to ensure they do not change. Changing the IPs of control plane VMs as well as floating IPs is not supported.
- **Static.** Manually enter all networking settings for the management network.

b Configure the settings for the management network.

If you have selected the DHCP network mode, but you want to override the settings acquired from DHCP, click **Additional Settings** and enter new values. If you have selected the static network mode, fill in the values for the management network settings manually.

Option	Description
<b>Network</b>	Select a network that has a VMkernel adapter configured for the management traffic.
<b>Starting Control IP address</b>	Enter an IP address that determines the starting point for reserving five consecutive IP addresses for the Kubernetes control plane VMs as follows: <ul style="list-style-type: none"> <li>■ An IP address for each of the Kubernetes control plane VMs.</li> <li>■ A floating IP address for one of the Kubernetes control plane VMs to serve as an interface to the management network. The control plane VM that has the floating IP address assigned acts as a leading VM for all three Kubernetes control plane VMs. The floating IP moves to the control plane node that is the etcd leader in the Kubernetes cluster. This improves availability in the case of a network partition event.</li> <li>■ An IP address to serve as a buffer in case a Kubernetes control plane VM fails and a new control plane VM is being brought up to replace it.</li> </ul>
<b>Subnet Mask</b>	Only applicable for static IP configuration. Enter the subnet mask for the management network. For example, 255.255.255.0
<b>DNS Servers</b>	Enter the addresses of the DNS servers that you use in your environment. If the vCenter Server system is registered with an FQDN, you must enter the IP addresses of the DNS servers that you use with the vSphere environment so that the FQDN is resolvable in the Supervisor Cluster.

Option	Description
<b>DNS Search Domains</b>	Enter domain names that DNS searches inside the Kubernetes control plane nodes, such as <code>corp.local</code> , so that the DNS server can resolve them.
<b>NTP</b>	Enter the addresses of the NTP servers that you use in your environment, if any.

- 9 In the **Workload Network** page, enter the settings for the network that will handle the networking traffic for Kubernetes workloads running on the Supervisor Cluster.

**Note** If you select using a DHCP server to provide the networking settings for Workload Networks, you will not be able to create any new Workload Networks once you complete the Supervisor Cluster configuration.

- a Select a network mode.
  - **DHCP Network.** In this network mode, all networking settings for Workload Networks are acquired through DHCP.
  - **Static.** Manually configure Workload Network settings.
- b Select the port group that will serve as the Primary Workload Network to the Supervisor Cluster

The primary network handles the traffic for the Kubernetes control plane VMs and Kubernetes workload traffic.

Depending on your networking topology, you can later assign a different port group to serve as the network to each namespace. This way, you can provide layer 2 isolation between the namespaces in the Supervisor Cluster. Namespaces that do not have a different port group assigned as their network use the primary network. Tanzu Kubernetes clusters use only the network that is assigned to the namespace where they are deployed or they use the primary network if there is no explicit network assigned to that namespace

- c Configure the settings for workload networks.

If you have selected the DHCP network mode, all the values under the **Additional Settings** section are automatically filled in from the DHCP server. If You want to override these values, click **Additional Settings** and enter new values. If you have selected the **Static** network mode, fill in all the settings manually.

Option	Description
<b>Internal Network for Kubernetes Services</b>	Enter a CIDR notation that determines the range of IP addresses for Tanzu Kubernetes clusters and services that run inside the clusters.
<b>Network Name</b>	Enter the network name.

Option	Description
<b>DNS Server</b>	<p>Enter the IP addresses of the DNS servers that you use with your environment, if any.</p> <p>For example, <b>10.142.7.1</b>.</p> <p>When you enter IP address of the DNS server, a static route is added on each control plane VM. This indicates that the traffic to the DNS servers goes through the workload network.</p> <p>If the DNS servers that you specify are shared between the management network and workload network, the DNS lookups on the control plane VMs are routed through the workload network after initial setup.</p>
<b>Gateway</b>	Enter the gateway for the primary network.
<b>Subnet Mask IP</b>	Enter the subnet mask IP address.
<b>IP Address Ranges</b>	<p>Enter an IP range for allocating IP address of Kubernetes control plane VMs and workloads.</p> <p>This address range connects the Supervisor Cluster nodes and, in the case of a single Workload Network, also connects the Tanzu Kubernetes cluster nodes. This IP range must not overlap with the load balancer VIP range when using the <b>Default</b> configuration for HAProxy.</p>

**10** On the **Storage** page, configure storage and file volume support.

- a Select storage policies for the Supervisor Cluster.

The storage policy you select for each of the following objects ensures that the object is placed on the datastore referenced in the storage policy. You can use the same or different storage policies for the objects.

Option	Description
<b>Control Plane Node</b>	Select the storage policy for placement of the control plane VMs.
<b>Pod Ephemeral Disks</b>	Select the storage policy for placement of the vSphere Pods.
<b>Container Image Cache</b>	Select the storage policy for placement of the cache of container images.

- b (Optional) Activate file volume support.

**11** On the **Tanzu Kubernetes Grid** page, click **Add** and select the subscribed content library that contains the VM images for deploying the nodes of Tanzu Kubernetes clusters.

**12** Review your settings and click **Finish**.

## Results

A task runs on vCenter Server that creates the Supervisor Cluster. Once the task completes, three Kubernetes control plane VMs are created on the hosts that are part of the vSphere cluster.

## What to do next

Create and configure your first namespaces on the Supervisor Cluster.

# Enable Workload Management with NSX-T Data Center Networking

As a vSphere administrator, you can configure a vSphere cluster as a Supervisor Cluster that uses the NSX-T Data Center networking stack to provide connectivity to Kubernetes workloads.

## Prerequisites

- Verify that your environment meets the prerequisites for configuring a vSphere cluster as a Supervisor Cluster. For information about requirements, see [Prerequisites for Configuring vSphere with Tanzu on a Cluster](#).

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**Caution** Do not disable vSphere DRS after you configure the Supervisor Cluster. Having DRS enabled at all times is a mandatory prerequisite for running workloads on the Supervisor Cluster. Disabling DRS leads to breaking your Tanzu Kubernetes clusters.

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## Procedure

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Click **Get Started**.
- 3 Select the vCenter Server system that you want to configure.
- 4 Select the **NSX** networking stack.
- 5 Click **Next**.
- 6 Select **Select a Cluster > Datacenter**.
- 7 Select a cluster from the list of compatible clusters and click **Next**.
- 8 From the **Control Plane Size** page, select the sizing for the control plane VMs.  
The size of the control plane VMs determines the amount of workloads that you can run on the Supervisor Cluster.  
Refer to the [VMware Configuration Maximums](#) site for guidance.
- 9 Click **Next**.

**10** On the **Management Network** screen, configure the parameters for the network that will be used for Kubernetes control plane VMs.

a Select a **Network Mode**.

- **DHCP Network.** In this mode, all the IP addresses for the management network, such as control plane VM IPs, DNS servers, DNS, search domains, and NTP server are acquired automatically from a DHCP.
- **Static.** Manually enter all networking settings for the management network.

b Configure the settings for the management network.

If you have selected the DHCP network mode, but you want to override the settings acquired from DHCP, click **Additional Settings** and enter new values. If you have selected the static network mode, fill in the values for the management network settings manually.

Option	Description
<b>Network</b>	Select a network that has a VMkernel adapter configured for the management traffic.
<b>Starting Control IP address</b>	<p>Enter an IP address that determines the starting point for reserving five consecutive IP addresses for the Kubernetes control plane VMs as follows:</p> <ul style="list-style-type: none"> <li>■ An IP address for each of the Kubernetes control plane VMs.</li> <li>■ A floating IP address for one of the Kubernetes control plane VMs to serve as an interface to the management network. The control plane VM that has the floating IP address assigned acts as a leading VM for all three Kubernetes control plane VMs. The floating IP moves to the control plane node that is the ectd leader in this Kubernetes cluster, which is the Supervisor Cluster. This improves availability in the case of a network partition event.</li> <li>■ An IP address to serve as a buffer in case a Kubernetes control plane VM fails and a new control plane VM is being brought up to replace it.</li> </ul>
<b>Subnet Mask</b>	<p>Only applicable for static IP configuration. Enter the subnet mask for the management network.</p> <p>For example, 255.255.255.0</p>
<b>DNS Servers</b>	Enter the addresses of the DNS servers that you use in your environment. If the vCenter Server system is registered with an FQDN, you must enter the IP addresses of the DNS servers that you use with the vSphere environment so that the FQDN is resolvable in the Supervisor Cluster.
<b>DNS Search Domains</b>	Enter domain names that DNS searches inside the Kubernetes control plane nodes, such as <code>corp.local</code> , so that the DNS server can resolve them.
<b>NTP</b>	Enter the addresses of the NTP servers that you use in your environment, if any.

## 11 In the **Workload Network** pane, configure settings for the networks for namespaces.

The namespace network settings provide connectivity to vSphere Pods and namespaces running in the Supervisor Cluster. By default, the namespace will use cluster level network configurations and allocate IP addresses from the

Option	Description
<b>vSphere Distributed Switch</b>	Select the vSphere Distributed Switch that handles overlay networking for the Supervisor Cluster. For example, select <code>DSwitch</code> .
<b>DNS Server</b>	Enter the IP addresses of the DNS servers that you use with your environment, if any. For example, <code>10.142.7.1</code> .
<b>API Server Endpoint FQDN</b>	Optionally, enter the FQDN of the API server endpoint.
<b>Edge Cluster</b>	Select the NSX Edge cluster that has the tier-0 gateway that you want to use for namespace networking. For example, select <code>EDGE-CLUSTER</code> .
<b>Tier-0 Gateway</b>	Select the tier-0 gateway to associate with the cluster tier-1 gateway.
<b>NAT Mode</b>	The NAT mode is selected by default. If you deselect the option, all the workloads such as the vSphere Pods, VMs, and Tanzu Kubernetes clusters Node IP addresses are directly accessible from outside the tier-0 gateway and you do not have to configure the egress CIDRs. <b>Note</b> If you deselect NAT mode, File Volume storage is not supported.
<b>Namespace Network</b>	Enter one or more IP CIDRs to create subnets/segments and assign IP addresses to workloads.
<b>Namespace Subnet Prefix</b>	Enter the subnet prefix that specifies the size of the subnet reserved for namespaces segments. Default is 28.
<b>Pod CIDRs</b>	Enter a CIDR annotation to determine the IP range for vSphere Native Pods. You can use the default value.
<b>Services CIDRs</b>	Enter a CIDR annotation to determine the IP range for Kubernetes services. You can use the default value.
<b>Ingress CIDRs</b>	Enter a CIDR annotation that determines the ingress IP range for the Kubernetes services. This range is used for services of type load balancer and ingress.
<b>Egress CIDRs</b>	Enter a CIDR annotation that determines the egress IP for Kubernetes services. Only one egress IP address is assigned for each namespace in the Supervisor Cluster. The egress IP is the IP address that the vSphere Pods in the particular namespace use to communicate outside of NSX-T Data Center.

## 12 Click **Next**.

**13** On the **Storage** page, configure storage and file volume support.

- a Select storage policies for the Supervisor Cluster.

The storage policy you select for each of the following objects ensures that the object is placed on the datastore referenced in the storage policy. You can use the same or different storage policies for the objects.

Option	Description
<b>Control Plane Node</b>	Select the storage policy for placement of the control plane VMs.
<b>Pod Ephemeral Disks</b>	Select the storage policy for placement of the vSphere Pods.
<b>Container Image Cache</b>	Select the storage policy for placement of the cache of container images.

- b (Optional) Activate file volume support.

**14** In the **Ready to Complete** section, review the settings and **Finish**.

The cluster is enabled with vSphere with Tanzu and you can create vSphere Namespaces to provide to DevOps engineers. Kubernetes control plane nodes are created on the hosts that are part of the cluster and the Spherelet process.

#### What to do next

Create and configure a vSphere Namespace on the Supervisor Cluster. See [Create and Configure a vSphere Namespace](#)

## Assign the Tanzu Edition License to a Supervisor Cluster

If you are using a Supervisor Cluster in evaluation mode, you must assign the cluster a Tanzu edition license before the 60 day evaluation period expires.

Check out [Licensing for vSphere with Tanzu](#) for information about how the Tanzu license works.

#### Procedure

- 1 In the vSphere Client, navigate to the Supervisor Cluster.
- 2 Select **Configure** and under **Licensing** select **Supervisor Cluster**.
- 3 Select **Assign License**.
- 4 In the **Assign License** dialog, click **New License**.
- 5 Enter a valid license key and click **OK**.

## Replace the VIP Certificate to Securely Connect to the Supervisor Cluster API Endpoint

As a vSphere administrator, you can replace the certificate for the virtual IP address (VIP) to securely connect to the Supervisor Cluster API endpoint with a certificate signed by a CA that



your hosts already trust. The certificate authenticates the Kubernetes control plane to DevOps engineers, both during login and subsequent interactions with the Supervisor Cluster.

### Prerequisites

Verify that you have access to a CA that can sign CSRs. For DevOps engineers, the CA must be installed on their system as a trusted root.

### Procedure

- 1 In the vSphere Client, navigate to the Supervisor Cluster.
- 2 Click **Configure** then under **Namespaces** select **Certificates**.
- 3 In the **Workload platform MTG** pane, select **Actions > Generate CSR**.
- 4 Provide the details for the certificate.
- 5 Once the CSR is generated, click **Copy**.
- 6 Sign the certificate with a CA.
- 7 From the **Workload platform MTG** pane, select **Actions > Replace Certificate**.
- 8 Upload the signed certificate file and click **Replace Certificate**.
- 9 Validate the certificate on the IP address of the Kubernetes control plane.

For example, you can open the Kubernetes CLI Tools for vSphere download page and confirm that the certificate is replaced successfully by using the browser. On a Linux or Unix system you can also use `echo | openssl s_client -connect https://ip:6443`.

## Integrate the Tanzu Kubernetes Grid Service on the Supervisor Cluster with Tanzu Mission Control

You can integrate Tanzu Kubernetes Grid Service that runs on the Supervisor Cluster with Tanzu Mission Control. Doing so allows you to provision and manage Tanzu Kubernetes clusters using Tanzu Mission Control.

For more information on Tanzu Mission Control, see [Managing the Lifecycle of Tanzu Kubernetes Clusters](#). To watch a demonstration, check out the video [Tanzu Mission Control Integrated with Tanzu Kubernetes Grid Service](#).

### View the Tanzu Mission Control Namespace on the Supervisor Cluster

vSphere with Tanzu v7.0.1 U1 and later ships with a vSphere Namespace for Tanzu Mission Control. This namespace exists on the Supervisor Cluster where you install the Tanzu Mission Control agent. Once the agent is installed, you can provision and manage Tanzu Kubernetes clusters using the Tanzu Mission Control web interface.

- 1 Using the vSphere Plugin for kubectl, authenticate with the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

- 2 Switch context to the Supervisor Cluster, for example:

```
kubectl config use-context 10.199.95.59
```

- 3 Run the following command to list the namespaces.

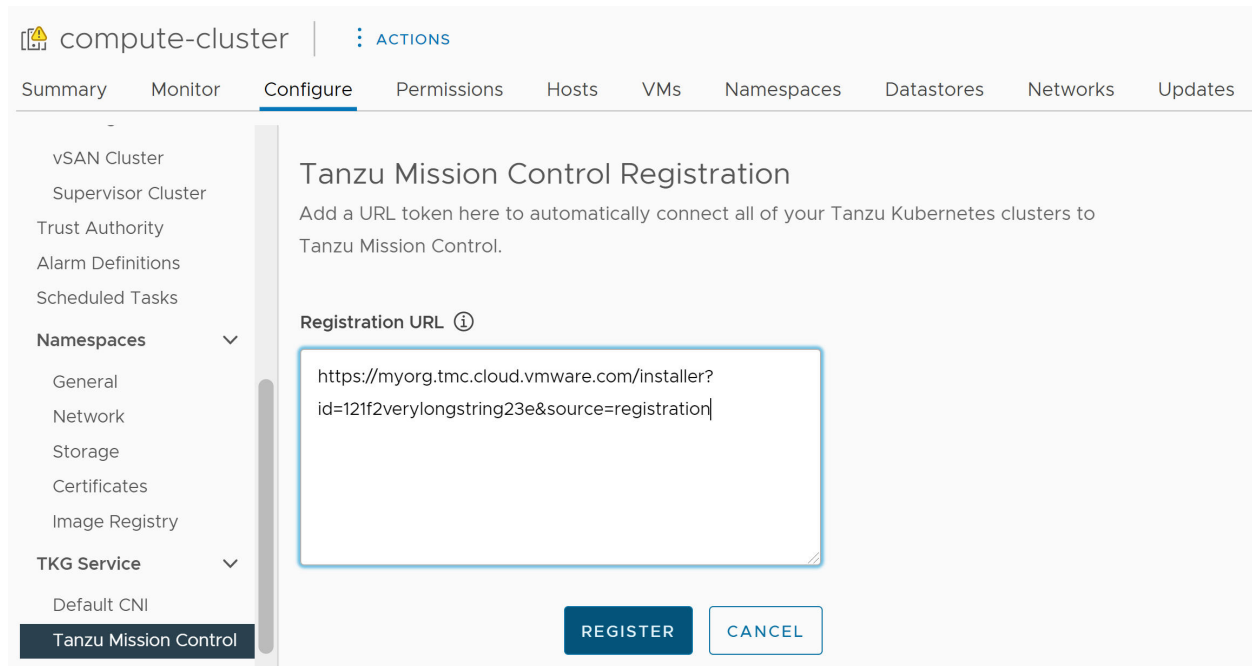
```
kubectl get ns
```

- 4 The vSphere Namespace provided for Tanzu Mission Control is identified as `svc-tmc-cXX` (where XX is a number).
- 5 Install the Tanzu Mission Control agent in this namespace. See [Install the Tanzu Mission Control Agent on the Supervisor Cluster](#).

## Install the Tanzu Mission Control Agent on the Supervisor Cluster

To integrate the Tanzu Kubernetes Grid Service with Tanzu Mission Control, install the agent on the Supervisor Cluster.

- 1 Register the Supervisor Cluster with Tanzu Mission Control and obtain the Registration URL. See [Register a Management Cluster with Tanzu Mission Control](#).
- 2 Open a firewall port in your vSphere with Tanzu environment for the port required by Tanzu Mission Control (typically 443). See [Outbound Connections Made by the Cluster Agent Extensions](#).
- 3 Log in to your vSphere with Tanzu environment using the vSphere Client.
- 4 Select the vCenter cluster where **Workload Management** is enabled.
- 5 Select the **Configure** tab.
- 6 Select **TKG Service > Tanzu Mission Control**.
- 7 Provide registration URL in the **Registration URL** field.
- 8 Click **Register**.



## Uninstall the Tanzu Mission Control Agent

To uninstall the Tanzu Mission Control agent from the Supervisor Cluster, see [Manually Remove the Cluster Agent from a Supervisor Cluster in vSphere with Tanzu](#).

## Set the Default CNI for Tanzu Kubernetes Clusters

As a vSphere administrator, you can set the default container network interface (CNI) for Tanzu Kubernetes clusters.

### Default CNI

The Tanzu Kubernetes Grid Service supports two CNI options for Tanzu Kubernetes clusters: [Antrea](#) and [Calico](#).

The system-defined default CNI is Antrea. For more information on the default CNI setting, see [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#).

You can change the default CNI using the vSphere Client. To set the default CNI, complete the following procedure.

---

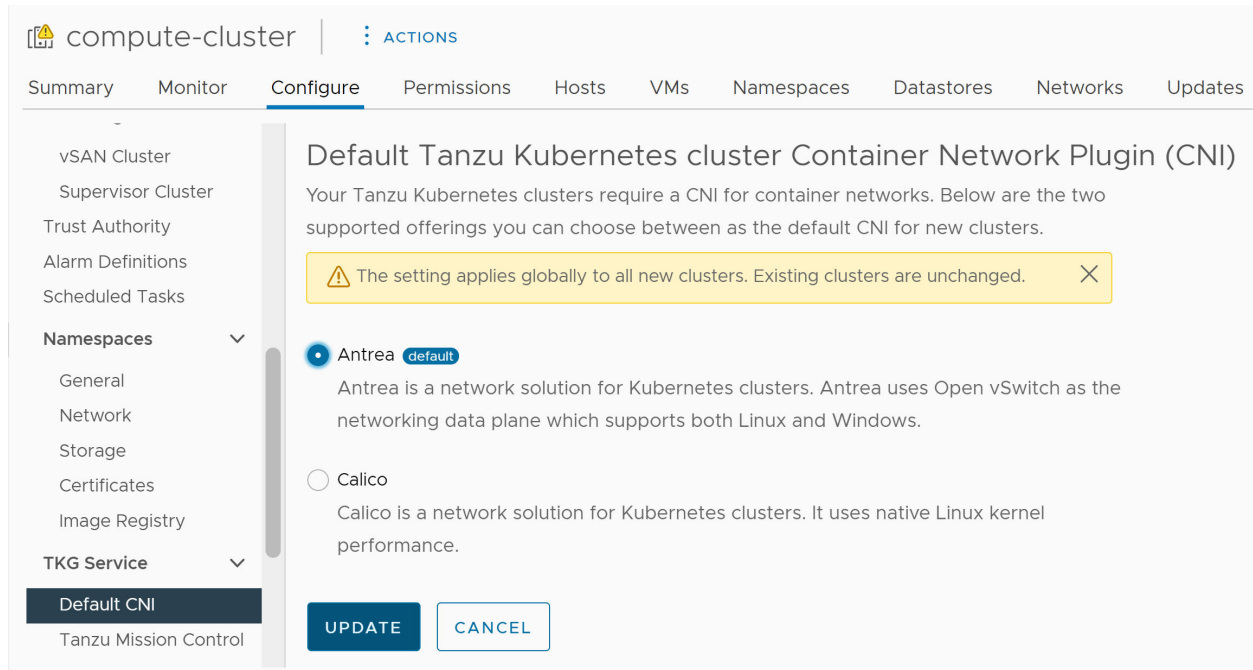
**Caution** Changing the default CNI is a global operation. The newly set default applies to all new clusters created by the service. Existing clusters are unchanged.

---

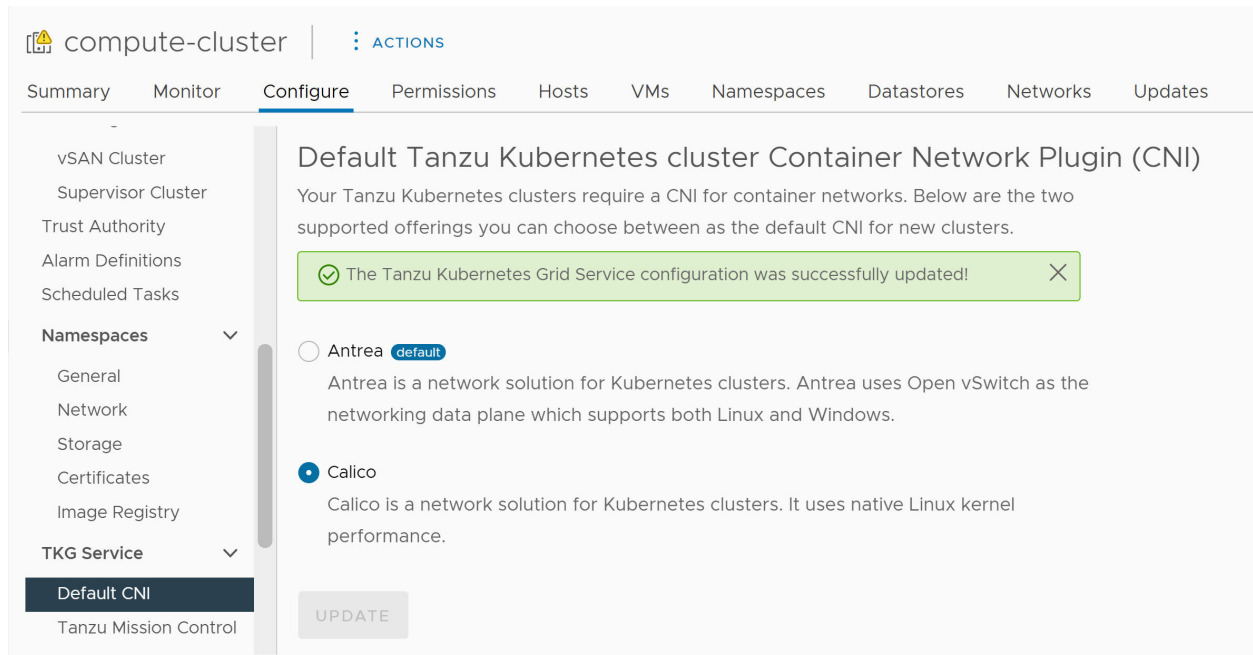
- 1 Log in to your vSphere with Tanzu environment using the vSphere Client.
- 2 Select the vCenter cluster where Workload Management is enabled.
- 3 Select the **Configure** tab.
- 4 Select **TKG Service > Default CNI**.

- 5 Choose the default CNI for new clusters.
- 6 Click **Update**.

The following image shows the default CNI selection.



The following image shows changing the CNI selection from Antrea to Calico.



# Add Workload Networks to a Supervisor Cluster Configured with VDS Networking

For a Supervisor Cluster that is configured with the vSphere networking stack, you can provide Layer 2 isolation for your Kubernetes workloads by creating Workload Networks and assigning them to namespaces. Workload Networks provide connectivity to Tanzu Kubernetes clusters in the namespace and are backed by distributed port groups on the switch that is connected to the hosts in the Supervisor Cluster.

For more information on the topologies that you can implement for the Supervisor Cluster, see [Topology for Supervisor Cluster with vSphere Networking and NSX Advanced Load Balancer](#) or [Topologies for Deploying the HAProxy Load Balancer](#).

---

**Note** If you have configured the Supervisor Cluster with a DHCP server providing networking settings for Workload Networks, you cannot create new Workload Networks post Supervisor Cluster configuration.

---

## Prerequisites

- Create a distributed port group that will back the Workload Network.
- Verify that the IP range that you will assign to the Workload Network is unique within all Supervisor Clusters available in your environment.

## Procedure

- 1 In the vSphere Client, navigate to the Supervisor Cluster.
- 2 Select **Configure**.
- 3 Under **Supervisor Cluster**, select **Network**.
- 4 Select **Workload Network** and click **Add**.

Option	Description
<b>Port Group</b>	Select the distributed port group to be associated with this Workload Network. The vSphere Distributed Switch (VDS) that is configured for the <b>Supervisor Cluster</b> networking contains the port groups from which you can select.
<b>Network Name</b>	The network name that identifies the Workload Network when assigned to namespaces. This value is automatically populated from the name of the port group that you select, but you can change it as appropriate.
<b>IP Address Ranges</b>	Enter an IP range for allocating IP addresses of Tanzu Kubernetes cluster nodes. . The IP range must be in the subnet indicated by the subnet mask.  <b>Note</b> You must use a unique IP address ranges for each Workload Network. Do not configure the same IP address ranges for multiple networks.

---

Option	Description
<b>Subnet Mask</b>	Enter the IP address of the subnet mask for the network on the port group.
<b>Gateway</b>	Enter the default gateway for the network on the port group. The gateway must be in the subnet indicated by the subnet mask.  <b>Note</b> Do not use the gateway that is assigned to the HAProxy loadbalancer.

5 Click **Add**.

#### What to do next

Assign the newly-created Workload Network to vSphere Namespaces.

## Change the Control Plane Size of a Supervisor Cluster

Checkout how to change the size of the Kubernetes control plane VMs of a Supervisor Cluster in your vSphere with Tanzu environment.

#### Prerequisites

- Verify that you have the **Modify cluster-wide configuration** privilege on the cluster.

#### Procedure

- 1 In the vSphere Client, navigate to the Supervisor Cluster.
- 2 Select **Configure** and click **General**.
- 3 Expand **Control Plane Size**, click **Edit** and select new control plane size from the drop-down menu.
- 4 Click **Save**.

You can only scale up the control plane size.

## Change the Management Network Settings on a Supervisor Cluster

Learn how to update the DNS and NTP settings on the Supervisor Cluster management network on your vSphere with Tanzu environment.

#### Prerequisites

- Verify that you have the **Modify cluster-wide configuration** privilege on the cluster.

#### Procedure

- 1 In the vSphere Client, navigate to the Supervisor Cluster.
- 2 Select **Configure**.

- 3 Under **Supervisor Cluster**, select **Network**.
- 4 Click **Management Network** .
- 5 Edit the DNS and NTP settings.

Option	Description
<b>DNS Server(s)</b>	Enter the addresses of the DNS servers that you use in your environment. If the vCenter Server system is registered with an FQDN, you must enter the IP addresses of the DNS servers that you use with the vSphere environment so that the FQDN is resolvable in the Supervisor Cluster.
<b>DNS Search Domain(s)</b>	Enter domain names that DNS searches inside the Kubernetes control plane nodes, such as <code>corp.local</code> , so that the DNS server can resolve them.
<b>NTP Server(s)</b>	Enter the addresses of the NTP servers that you use in your environment, if any.

## Change the Workload Network Settings on a Supervisor Cluster Configured with VDS Networking

Checkout how to change the NTP and DNS server settings for the Workload Networks of a Supervisor Cluster configured with the VDS networking stack. The DNS servers that you configure for Workload Networks are external DNS servers exposed to Kubernetes workloads and they resolve default domain names that are hosted outside of the Supervisor Cluster.

### Prerequisites

- Verify that you have the **Modify cluster-wide configuration** privilege on the cluster.

### Procedure

- 1 In the vSphere Client, navigate to the Supervisor Cluster.
- 2 Select **Configure**.
- 3 Under **Supervisor Cluster**, select **Network**.
- 4 Select **Workload Network**.
- 5 Edit the DNS server settings.

Enter the addresses of DNS Servers that can resolve the domain names of the vSphere management components, such as vCenter Server .

For example, `10.142.7.1`.

When you enter the IP address of the DNS server, a static route is added on each control plane VM. This indicates that the traffic to the DNS servers goes through the workload network.

If the DNS servers that you specify are shared between the management network and workload network, the DNS lookups on the control plane VMs are routed through the Workload Network after initial setup.

- 6 Edit the NTP settings as needed.

## Change Workload Network Settings on a Supervisor Cluster Configured with NSX-T Data Center

Learn how to change the networking settings for DNS server, namespace networks, ingress and egress of a Supervisor Cluster configured for NSX-T Data Center as the networking stack.

### Prerequisites

- Verify that you have the **Modify cluster-wide configuration** privilege on the cluster.

### Procedure

- 1 In the vSphere Client, navigate to the Supervisor Cluster.
- 2 Select **Configure**.
- 3 Under **Supervisor Cluster**, select **Network**.
- 4 Select **Workload Network**.
- 5 Change networking settings as needed.

Option	Description
<b>DNS Server(s)</b>	<p>Enter the addresses of DNS Servers that can resolve the domain names of the vSphere management components, such as vCenter Server .</p> <p>For example, 10.142.7.1.</p> <p>When you enter IP address of the DNS server, a static route is added on each control plane VM. This indicates that the traffic to the DNS servers go through the workload network.</p> <p>If the DNS servers that you specify are shared between the management network and workload network, the DNS lookups on the control plane VMs are routed through the workload network after initial setup.</p>
<b>Namespace Network</b>	<p>Enter a CIDR annotation to change the IP range for Kubernetes workloads that are attached to the namespace segments of the Supervisor Cluster. If NAT Mode is not configured, then this IP CIDR range must be a routable IP Address.</p>
<b>Ingress</b>	<p>Enter a CIDR annotation to change the ingress IP range for the Kubernetes services. This range is used for services of type load balancer and ingress. For Tanzu Kubernetes clusters, publishing services through ServiceType loadbalancer will also get the IP addresses from this IP CIDR block.</p>
<b>Egress</b>	<p>Enter a CIDR annotation for allocating IP addresses for SNAT (Source Network Address Translation) for traffic exiting the Supervisor Cluster to access external services. Only one egress IP address is assigned for each namespace in the Supervisor Cluster. The egress IP is the IP address that the vSphere Pods in the particular namespace use to communicate outside of NSX-T Data Center.</p>



## Resolving Errors Health Statuses on Supervisor Cluster During Initial Configuration Or Upgrade

After you initially configure a vSphere cluster as a Supervisor Cluster or you upgrade or edit the settings of an existing Supervisor Cluster, all the settings that you have specified are validated and applied to the cluster until the configuration completes. Health checks are performed on the entered parameters that might detect errors in the configuration resulting in an error health status of the Supervisor Cluster. You must resolve these error health statuses so that the configuration or upgrade of the Supervisor Cluster can resume.

You view the health status of the Supervisor Cluster in the vSphere Client, under **Workload Management > Supervisor Clusters**. The status of the cluster configuration is displayed in the **Config Status** column.

Table 5-1. vCenter Server Connection Errors

Error Message	Cause	Solution
Unable to resolve the vCenter Primary Network Identifier <FQDN> with the configured management DNS server(s) on control plane VM <VM name>. Validate that the management DNS servers <server name> can resolve <network name>.	<ul style="list-style-type: none"> <li>■ At least one management DNS server is reachable.</li> <li>■ At least one management DNS is statically supplied.</li> <li>■ The management DNS servers do not have any host name lookup for the vCenter Server PNID.</li> <li>■ The vCenter Server PNID is a domain name, not a static IP address.</li> </ul>	<ul style="list-style-type: none"> <li>■ Add a host entry for the vCenter Server PNID to the management DNS servers.</li> <li>■ Verify the configured DNS servers are correct.</li> </ul>
Unable to resolve the vCenter Primary Network Identifier <network name> with the DNS server(s) acquired via DHCP on the management network of the control plane VM <VM name>. Validate that the management DNS servers can resolve <network name>.	<ul style="list-style-type: none"> <li>■ The management DNS servers supplied by the DHCP server (at least one) are reachable.</li> <li>■ The management DNS servers are statically supplied.</li> <li>■ The management DNS servers do not have any host name lookup for the vCenter Server PNID.</li> <li>■ The management DNS servers do not have any host name lookup for the vCenter Server PNID.</li> <li>■ The vCenter Server PNID is a domain name, not a static IP address.</li> </ul>	<ul style="list-style-type: none"> <li>■ Add a host entry for the vCenter Server PNID to the management DNS servers supplied by the configured DHCP server.</li> <li>■ Verify the DNS servers supplied by the DHCP server are correct.</li> </ul>
Unable to resolve the host <host name> on control plane VM <VM name>, as there are no configured management DNS servers.	<ul style="list-style-type: none"> <li>■ The vCenter Server PNID is a domain name, not a static IP address.</li> <li>■ There are no DNS servers configured.</li> </ul>	Configure a management DNS server.

Table 5-1. vCenter Server Connection Errors (continued)

Error Message	Cause	Solution
Unable to resolve the host <host name> on control plane VM <VM name>. The hostname ends with the '.local' top level domain, which requires 'local' to be included in the management DNS search domains.	The vCenter Server PNID contains <code>.local</code> as a top-level domain (TLD), but the configured search domains do not include <code>local</code> .	Add <code>local</code> to the management DNS search domains.
Unable to connect to the management DNS servers <server name> from control plane VM <VM name>. The connection was attempted over the workload network.	<ul style="list-style-type: none"> <li>■ The management DNS servers are unable to be connected to vCenter Server.</li> <li>■ The provided <code>worker_dns</code> values wholly contain the provided management DNS values. This means that traffic is routed via the workload network, as the Supervisor Cluster must pick one network interface to direct static traffic to these IPs.</li> </ul>	<ul style="list-style-type: none"> <li>■ Check the Workload Network to verify that it can route to the configured management DNS servers.</li> <li>■ Verify there are no conflicting IP addresses that might trigger alternate routing between the DNS servers and some other servers on the Workload Network.</li> <li>■ Verify the configured DNS server is, in fact, a DNS server, and is hosting its DNS port on port 53.</li> <li>■ Verify the workload DNS servers are configured to allow connections from the IPs of the control plane VMs (the Workload Network provided IPs).</li> <li>■ Verify that there are no typos in the management DNS servers' addresses.</li> <li>■ Verify search domains don't include an unnecessary '-' that could be resolving the host name incorrectly.</li> </ul>

Table 5-1. vCenter Server Connection Errors (continued)

Error Message	Cause	Solution
Unable to connect to the management DNS servers <server name> from the control plane VM <VM name>.	Unable to connect to the DNS servers.	<ul style="list-style-type: none"> <li>■ Check the management network to verify that routes to the management DNS servers exist.</li> <li>■ Verify there are no conflicting IP addresses that may trigger alternate routing between the DNS servers and other servers.</li> <li>■ Verify the configured DNS server is, in fact, a DNS server, and is hosting its DNS port on port 53.</li> <li>■ Verify the management DNS servers are configured to allow connections from the IPs of the control plane VMs.</li> <li>■ Verify that there are no typos in the management DNS servers' addresses.</li> <li>■ Verify that search domains do not include an unnecessary '-' that could be resolving the host name incorrectly.</li> </ul>
Unable to connect to <component name> <component address> from control plane VM <vm name>. Error: <i>error message text</i>	<ul style="list-style-type: none"> <li>■ A generic network failure occurred.</li> <li>■ Error occurred while connecting to actual connecting to vCenter Server.</li> </ul>	<ul style="list-style-type: none"> <li>■ Validate that the host name or IP address of the configured components, such as vCenter Server, HAProxy, NSX Manager, or NSX Advanced Load Balancer are correct.</li> <li>■ Validate any external network settings such as conflicting IPs, firewall rules, and others, on the management network.</li> </ul>
The control plane VM <VM name> was unable to validate the vCenter <vCenter Server name> certificate. The vCenter server certificate is invalid.	The certificate provided by vCenter Server is in invalid format, and therefore is untrusted.	<ul style="list-style-type: none"> <li>■ Restart <code>wcpsvc</code> to verify that the Trusted Roots bundle in the control plane VMs are up-to-date with the latest vCenter Server root certificates.</li> <li>■ Verify that the vCenter Server certificate is actually a valid certificate.</li> </ul>
The control plane VM <VM name> does not trust the vCenter <vCenter Server name> certificate.	<ul style="list-style-type: none"> <li>■ The <code>vmca.pem</code> certificate presented by vCenter Server is different from what is configured to the control plane VMs.</li> <li>■ The trusted root certificates were replaced in the vCenter Server appliance, but <code>wcpsvc</code> wasn't restarted.</li> </ul>	<ul style="list-style-type: none"> <li>■ Restart <code>wcpsvc</code> to verify that the Trusted Roots bundle in the control plane VMs are up-to-date with the latest vCenter Server certificate roots.</li> </ul>

Table 5-2. NSX Manager Connection Errors

The control plane VM <VM name> was unable to validate the NSX Server<NSX server name> certificate. The thumbprint returned by the server <NSX-T address> doesn't match the expected client certificate thumbprint registered in vCenter <vCenter Server name>	The SSL thumbprints registered to the Supervisor Cluster don't match the SHA-1 hash of the certificate presented by the NSX manager.	<ul style="list-style-type: none"> <li>■ Re-enable trust on the NSX manager between NSX and thevCenter Server instance.</li> <li>■ Restart <code>wcp svc</code> on vCenter Server.</li> </ul>
Unable to connect to <component name> <component address> from control plane VM <vm name>. Error: <i>error message text</i>	A generic network failure occurred.	<ul style="list-style-type: none"> <li>■ Validate any external network settings, conflicting IPs, firewall rules, and others, on the management network for the NSX manager.</li> <li>■ Verify the NSX manager IP in the NSX extension is correct.</li> <li>■ Verify that the NSX manager is running.</li> </ul>

Table 5-3. Load Balancer Errors

The control plane VM <vm name> does not trust the load balancer's (<load balancer>- <load balancer endpoint>) certificate.	The certificate the load balancer presents is different from the certificater that is configured to the control plane VMs.	Verify that you have configured the correct Management TLS certificate to the load balancer.
The control plane VM <vm name> was unable to validate the load balancer's (<load balancer>- <load balancer endpoint>) certificate. The certificate is invalid.	The certificate the load balancer presents is in an invalid format, or expired.	Correct the server certificate of the configured load balancer.
The control plane VM <vm name> was unable to authenticate to the load balancer (<load balancer>- <load balancer endpoint>) with the username <user name> and the supplied password.	The user name or password of the load balancer are incorrect.	Verify the if the user name and password configured to the load balancer are correct.
An HTTP error occurred when attempting to connect to the load balancer (<load balancer>- <load balancer endpoint>) from the control plane VM <vm name>.	The control plane VMs can connect to the load balancer endpoint, but the endpoint does not return a successful (200) http response	Verify that the load balancer is healthy and accepting requests.
Unable to connect to <load balancer> (<load balancer endpoint>) from control plane VM <vm name>. Error: <error text>	<ul style="list-style-type: none"> <li>■ A generic network failure occurred.</li> <li>■ Typically, it means the load balancer is not working, or some firewall blocks the connection.</li> </ul>	<ul style="list-style-type: none"> <li>■ Validate that the load balancer endpoint is accessible</li> <li>■ Validate no firewalls are blocking the connection to the load balancer.</li> </ul>

# Creating and Managing Content Libraries in vSphere with Tanzu

# 6

vSphere with Tanzu objects, such as stand-alone VMs and Tanzu Kubernetes clusters, use content libraries as centralized repositories for templates, images, distributions, and other files related to their deployment.

This chapter includes the following topics:

- [Creating and Managing Content Libraries for Tanzu Kubernetes releases](#)
- [Creating and Managing Content Libraries for Stand-Alone VMs in vSphere with Tanzu](#)

## Creating and Managing Content Libraries for Tanzu Kubernetes releases

VMware Tanzu distributes Kubernetes software versions as Tanzu Kubernetes releases. To consume these releases, you configure a vSphere Content Library and synchronize the available releases. You can do so using a subscription-based model, or on-demand. If you want to provision Tanzu Kubernetes in an internet restricted environment, you can create a local library and manually import the releases.

### About Tanzu Kubernetes release Distributions

A Tanzu Kubernetes release provides the Kubernetes software distribution signed and supported by VMware for use with Tanzu Kubernetes clusters. You obtain and manage Tanzu Kubernetes releases using a vSphere Content Library.

Each Tanzu Kubernetes release is distributed as an OVA template. The Tanzu Kubernetes Grid Service uses the OVA template to construct the virtual machine nodes for Tanzu Kubernetes clusters.

For a list of Tanzu Kubernetes releases and compatibility with the Supervisor Cluster, refer to the [Tanzu Kubernetes releases Release Notes](#).

A Tanzu Kubernetes release is supported on Photon OS and Ubuntu. The disk size of the virtual machine built from the OVA template is fixed. You specify the CPU and RAM resources when you provision a Tanzu Kubernetes cluster. See [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).

The Tanzu Kubernetes Grid Service pulls the Tanzu Kubernetes release OVA templates from a [vSphere Content Library](#). You can use a subscribed content library for automating the process, or a local content library for internet-restricted environments. See [Create, Secure, and Synchronize a Subscribed Content Library for Tanzu Kubernetes releases](#) and [Create, Secure, and Synchronize a Local Content Library for Tanzu Kubernetes releases](#).

The size of the content library can grow over time as new Tanzu Kubernetes releases are distributed. If the underlying storage runs out of space, you can migrate to a new content library. See [Migrate Tanzu Kubernetes Clusters to a New Content Library](#).

After you have created the content library and synchronized it, configure each vSphere Namespace where you plan to provision Tanzu Kubernetes clusters. This includes associating the content library and virtual machine classes with the vSphere Namespace. At this point you can log in to the vSphere Namespace and verify that the Tanzu Kubernetes releases are available. See [Configure a vSphere Namespace for Tanzu Kubernetes releases](#).

## Create, Secure, and Synchronize a Subscribed Content Library for Tanzu Kubernetes releases

To store Tanzu Kubernetes release for use with Tanzu Kubernetes clusters, create a subscribed content library on the vCenter Server where vSphere with Tanzu is enabled.

A subscribed content library originates from a published content library. After the subscription is created, the system synchronizes it with the published library. You can choose the synchronization mode: immediate or on demand. For more information, see [Managing a Subscribed Library](#).

### Prerequisites

Review [About Tanzu Kubernetes release Distributions](#).

The following vSphere privileges are required to create a content library:

- **Content library.Create local library** or **Content library.Create subscribed library** on the vCenter Server instance where you want to create the library.
- **Datastore.Allocate space** on the destination datastore.

### Procedure

- 1 Log in to the vCenter Server using the vSphere Client.
- 2 Select **Menu > Content Libraries**.
- 3 Click **Create**.

The **New Content Library** wizard opens.

- 4 Specify the **Name and location** of the content library and click **Next** when you are done.

Field	Description
<b>Name</b>	Enter a descriptive name, such as <b>TanzuKubernetesRelease-subscriber</b> .
<b>Notes</b>	Include a description, such as <b>On-demand subscription library for Tanzu Kubernetes releases</b>
<b>vCenter Server</b>	Select the vCenter Server instance where vSphere with Tanzu is enabled.

- 5 Configure the content library subscription at the **Configure content library** page and click **Next** when you are done.

- a Select the **Subscribed content library** option.

---

**Note** To use a Local Content Library, see [Create, Secure, and Synchronize a Local Content Library for Tanzu Kubernetes releases](#).

---

- b Enter the **Subscription URL** address of the publisher:

<https://wp-content.vmware.com/v2/latest/lib.json>

- c For the **Download content** option, select one of the following:

Option	Description
<b>Immediately</b>	The subscription process synchronizes both the library metadata and images. If items are deleted from the published library, their contents remain in the subscribed library storage, and you have to manually delete them.
<b>When needed</b>	The subscription process synchronizes only the library metadata. The Tanzu Kubernetes Grid Service downloads the images when published. When you no longer need the item, you can delete the item contents to free storage space. To save storage this option is recommended.

- 6 When prompted, accept the SSL certificate thumbprint.

The SSL certificate thumbprint is stored on your system until you delete the subscribed content library from the inventory.

- 7 Configure the OVF security policy at the **Apply security policy** page and click **Next** when you are done.

- a Select **Apply Security Policy**

- b Select **OVF default policy**

When you select this option, the system verifies the OVF signing certificate during the synchronization process. An OVF template that does not pass certificate validation is marked with the **Verification Failed** tag. The the template metadata is kept, but the OVF files cannot be synchronized.

---

**Note** Currently the **OVF default policy** is the only supported security policy.

---

- 8 At the **Add storage** page, select a datastore as a storage location for the content library contents and click **Next**.
- 9 On the **Ready to complete** page, review the details and click **Finish**.
- 10 At the **Content Libraries** page, select the new content library you created.
- 11 Confirm or complete the synchronization of the library contents.

Synchronization Option	Description
<b>Immediately</b>	If you chose to download all content immediately, confirm that the library is synchronized. To view the synchronized library contents, select <b>Templates &gt; OVF &amp; OVA Templates</b> .
<b>When needed</b>	If you chose to synchronize the library on demand, you have two options: <ul style="list-style-type: none"> <li>■ Use <b>Actions &gt; Synchronize</b> to synchronize the entire library</li> <li>■ Right-click an item and select <b>Synchronize</b> to synchronize only it.</li> </ul> To view the synchronized library contents, select <b>Templates &gt; OVF &amp; OVA Templates</b> .

- 12 If you chose the **When needed** option, download the OVF templates you want to use.  
If you chose the **When needed** option, you see that the image files are not stored locally, only the metadata is stored. To download the template files, select the item, right-click and select **Synchronize item**.
- 13 To update the subscribed content library settings, choose **Actions > Edit Settings**.

Setting	Value
Subscription URL	<a href="https://wp-content.vmware.com/v2/latest/lib.json">https://wp-content.vmware.com/v2/latest/lib.json</a>
Authentication	Not enabled
Library content	Download when needed
Security policy	OVF default policy



## Edit Settings | tkgs-tkr



**Automatic synchronization**  Enable automatic synchronization with the external content library

**Subscription URL**

**Authentication**  Enable user authentication for access to this content library

**Library content**

Download all library content immediately

Download library content only when needed

Save storage space by storing only metadata for the items. To use a content library item, synchronize the item or the whole library.

---

Applying security policy enforces strict validation while importing. It will result in re-syncing of all OVF library items.

**Security policy**  Apply Security Policy

CANCEL

OK

### What to do next

Configure each vSphere Namespace where you will provision Tanzu Kubernetes clusters by associating the content library and virtual machine classes with the namespace. See [Configure a vSphere Namespace for Tanzu Kubernetes releases](#).

## Create, Secure, and Synchronize a Local Content Library for Tanzu Kubernetes releases

To provision a Tanzu Kubernetes cluster in an internet restricted ("air-gapped") environment, create a local content library and manually import each Tanzu Kubernetes release.

Creating a local content library involves configuring the library, downloading the OVA files, and importing them to the local content library.

### Prerequisites

Review [About Tanzu Kubernetes release Distributions](#).

The following privileges are required to create a subscribed content library:

- **Content library.Create local library** or **Content library.Create subscribed library** on the vCenter Server instance where you want to create the library.
- **Datastore.Allocate space** on the destination datastore.

### Procedure

- 1 Log in to the vCenter Server using the vSphere Client.

- 2 Click **Menu**.
- 3 Click **Content Library**.
- 4 Click **Create**.

The system displays the **New Content Library** wizard.

- 5 Specify the **Name and location** of the content library and click **Next** when you are done.

Field	Description
<b>Name</b>	Enter a descriptive name, such as <code>TanzuKubernetesRelease-local</code> .
<b>Notes</b>	Include a description, such as <code>Local library for Tanzu Kubernetes releases</code>
<b>vCenter Server</b>	Select the vCenter Server instance where vSphere with Tanzu is enabled.

- 6 At the **Configure content library** page, select the **Local content library** option and click **Next**.

As described below, for local content libraries you manually import the OVF templates you want to use.

---

**Note** To use a Subscribed Content Library, see [Create, Secure, and Synchronize a Subscribed Content Library for Tanzu Kubernetes releases](#).

---

- 7 Configure the OVF security policy at the **Apply security policy** page and click **Next** when you are done.
  - a Select **Apply Security Policy**
  - b Select **OVF default policy**

When you select this option, the system verifies the OVF signing certificate during the synchronization process. An OVF template that does not pass certificate validation is marked with the **Verification Failed** tag. The the template metadata is kept, but the OVF files cannot be synchronized.

---

**Note** Currently the **OVF default policy** is the only supported security policy.

---

- 8 At the **Add storage** page, select a datastore as a storage location for the content library contents and click **Next**.
- 9 On the **Ready to complete** page, review the details and click **Finish**.
- 10 At the **Content Libraries** page, select the new content library you created.

**11** Download the OVA files for each Tanzu Kubernetes release you want import to the local content library.

a Using a browser, navigate to the following URL:

<https://wp-content.vmware.com/v2/latest/>

b Click the directory for the image you want. Typically this directory is the latest or most recent version of the Kubernetes distribution.

For example:

```
ob-18186591-photon-3-k8s-v1.20.7---vmware.1-tkg.1.7fb9067
```

---

**Note** The distribution name is needed to import the files to the local content library, so you might want to copy it to a file or keep the browser open until you complete the procedure.

---

c For each of the following files, right-click and select **Save link as**.

- `photon-ova.ovf`

- `photon-ova-disk1.vmdk`

d Verify that each file successfully downloads to your local file system.

**12** Import the OVA files to the local content library.

a Select **Menu > Content Libraries >** .

b From the list of **Content Libraries**, click the link for the name of the local content library you created.

c Click **Actions**.

d Select **Import Item**.

e In the **Import Library Item** window, select **Local File**.

f Click **Upload Files**.

g Select both files `photon-ova.ovf` and `photon-ova-disk1.vmdk`.

You see the message `2 files ready to import`. Each file is listed with a green check mark beside its name.

- h Change the **Destination Item** name to be the Photon image version plus the Kubernetes version from the directory where you downloaded the files.

For example:

```
photon-3-k8s-v1.20.7---vmware.1-tkg.1.7fb9067
```

- i Click **Import**.

Import Library Item | tkgs-tkr-local
✕

ⓘ If the certificate or manifest file are not available at source during the import process, the imported library item will not be usable.

**Source**

Source file  URL Enter URL

Local file

Source file details

2 files ready to import

- ✓ photon-ova.ovf
- ✓ photon-ova-disk1.vmdk

**Destination**

Item name photon-3-k8s-v1.20.7---vmware.1-tkg.1.7fb9067

Notes

Content Library tkgs-tkr-local

- 13 Verify that the local content library is populated with the Tanzu Kubernetes release.
- Reveal the **Recent Tasks** pane at the bottom of the page.
  - Monitor the task **Fetch Content of a Library Item** and verify that it is successfully **Completed**.
  - In the local content library, select **Templates > OVF & OVA Templates**.
  - Verify that the Tanzu Kubernetes release metadata is listed and its content is stored locally.



Name	Guest OS	Stored Locally	Security Compliant	Size	Last Modified Date	Last Sync Date	Content Library	UUID	Content Version	Description
photon-3-k8s-v1.20.7---vmware.1-tkg.1.7fb9067		Yes	No	6.04 GB	08/27/2021, 11:08:24 AM		tkgs-tkr-local	urn:vsapi.com:vmware.c...	2	

## What to do next

Configure each vSphere Namespace where you will provision Tanzu Kubernetes clusters by associating the content library and virtual machine classes with the namespace. See [Configure a vSphere Namespace for Tanzu Kubernetes releases](#).

## Migrate Tanzu Kubernetes Clusters to a New Content Library

If the Subscribed Content Library reaches capacity, you can migrate a Tanzu Kubernetes cluster to use a new library with additional storage capacity.

When the vSphere administrator creates a Subscribed Content Library, the administrator specifies a datastore for storing library contents, in this case OVA files. Over time as more Kubernetes versions are distributed, the Subscribed Content Library will expand in size as OVA files are added for each update. While there is no explicit capacity on the Subscribed Content Library, it is limited by its datastore capacity.

If the Subscribed Content Library reaches capacity, you might see the message `Internal error occurred: get library items failed for`. In this case you can migrate the Tanzu Kubernetes cluster to a new Subscribed Content Library to increase storage capacity. The migration is done by a vSphere administrator using the vSphere Client.

### Procedure

- 1 Create a new Subscribed Content Library with sufficient capacity for the target cluster. See [Create, Secure, and Synchronize a Subscribed Content Library for Tanzu Kubernetes releases](#).
- 2 Log in to the vCenter Server using the vSphere Client.
- 3 Select **Menu > Hosts and Clusters**.
- 4 Select the vSphere Cluster object where the Supervisor Cluster containing the Tanzu Kubernetes cluster is provisioned.
- 5 Select the **Configure** tab.
- 6 Select the **Namespaces > General >** option in the navigation panel.
- 7 Click **Edit** beside the **Content Library** section in the main panel.
- 8 Select the new Content Library you created and click **OK**.

This action triggers the update to the cluster configuration.

---

**Note** After you modify the Content Library, it might take up to 10 minutes for the Tanzu Kubernetes cluster to pick up the change from the Content Source.

---

## Import the HAProxy OVA to a Local Content Library

If you are using vDS networking, as a convenience you can import the HAProxy OVA file to a Content Library. Importing the HAProxy OVA to a local Content Library can be used for air-gapped deployments.

## Prerequisites

Create a local Content Library. See [Create, Secure, and Synchronize a Local Content Library for Tanzu Kubernetes releases](#).

Download the latest version of the VMware HAProxy OVA file from the [VMware-HAProxy site](#).

## Procedure

- 1 Log in to the vCenter Server using the vSphere Client.
- 2 Select **Menu > Content Libraries >** .
- 3 From the list of **Content Libraries**, click the link for the name of the Local Content Library you created, such as **HAProxy**.
- 4 Click **Actions**.
- 5 Select **Import Item**.
- 6 In the **Import Library Item** window, select **Local File**.
- 7 Click **Upload Files**.
- 8 Select the file `vmware-haproxy-vX.X.X.ova`.  
  
You see the message `1 file ready to import`. The file is listed with a green check mark beside its name.
- 9 Click **Import**.
- 10 Reveal the **Recent Tasks** pane at the bottom of the page.
- 11 Monitor the task **Fetch Content of a Library Item** and verify that it is successfully **Completed**.

## What to do next

Deploy the HAProxy control plane VM. See [Deploy the HAProxy Load Balancer Control Plane VM](#).

# Creating and Managing Content Libraries for Stand-Alone VMs in vSphere with Tanzu

A stand-alone VM in the vSphere with Tanzu environment requires an access to VM images, or templates, that contain software configurations, including operating systems, applications, and

data. To provide an access to images, configure a VM content library and associate it with the namespace where the VMs are deployed.

## Procedure

### 1 Create a Content Library for Stand-Alone VMs in vSphere with Tanzu

To deploy virtual machines in the vSphere with Tanzu environment, DevOps users must have access to VM templates and images. As a vSphere administrator, create a content library to store and manage VM templates.

### 2 Populate a Content Library with VM Images for Stand-Alone VMs in vSphere with Tanzu

As a vSphere administrator, populate a content library with VM templates in OVA or OVF format. Your DevOps engineers can use the templates to provision new stand-alone virtual machines in the vSphere with Tanzu environment.

### 3 Associate a VM Content Library with a Namespace in vSphere with Tanzu

As a vSphere administrator, you must give your DevOps users access to a source of VM templates, so that the DevOps engineers can use the templates to provision new stand-alone VMs in the vSphere with Tanzu environment. To give the access, add a content library that contains VM templates to the namespace.

### 4 Manage VM Content Libraries on a Namespace in vSphere with Tanzu

As a vSphere administrator, you associate a content library that contains VM templates with a namespace, so that the DevOps engineers can use the templates to provision stand-alone VMs in the vSphere with Tanzu environment. After you associate the library with the namespace, you can remove the library to unpublish it from the Kubernetes namespace. You can also add more libraries.

## Create a Content Library for Stand-Alone VMs in vSphere with Tanzu

To deploy virtual machines in the vSphere with Tanzu environment, DevOps users must have access to VM templates and images. As a vSphere administrator, create a content library to store and manage VM templates.

You can create a local content library and populate it with templates and other types of files.

You can also create a subscribed library to use the contents of an already existing published local library.

Starting with vSphere 7.0 Update 3, you can protect the items of a content library by applying an OVF security policy. The OVF security policy enforces strict validation when you deploy or update a content library, import items to a content library, or synchronize templates. To make sure that the templates are signed by a trusted certificate, you can add the OVF signing certificate from a trusted CA to a content library.

For more information about content libraries and VM templates in vSphere, see [Using Content Libraries](#).

## Prerequisites

Required privileges:

- **Content library.Create local library** or **Content library.Create subscribed library** on the vCenter Server instance where you want to create the library.
- **Datastore.Allocate space** on the destination datastore.

## Procedure

- 1 Navigate to the **VM Service** page.
  - a From the vSphere Client home menu, select **Workload Management**.
  - b Click the **Services** tab and click **Manage** on the **VM Service** pane.
- 2 On the **VM Service** page, click **Content Libraries > Create a content library** .

This action takes you to the content library section in the vSphere Client.

- 3 Click **Create**.

The **New Content Library** wizard opens.

- 4 On the **Name and location** page, enter a name, select a vCenter Server instance for the content library and click **Next**.

Make sure to use an informative name for the content library, so that your DevOps team can easily find and access the library items.



- 5 On the **Configure content library** page, select the type of content library that you want to create and click **Next**.

Option	Description
<b>Local content library</b>	<p>A local content library is accessible only in the vCenter Server instance where you create it by default.</p> <ul style="list-style-type: none"> <li>a (Optional) To make the content of the library available to other vCenter Server instances, select <b>Enable publishing</b>.</li> <li>b (Optional) If you want to require a password for accessing the content library, select <b>Enable authentication</b> and set a password.</li> </ul>
<b>Subscribed content library</b>	<p>A subscribed content library originates from a published content library. Use this option to take advantage of existing content libraries.</p> <p>You can synchronize the subscribed library with the published library to see up-to-date content, but you cannot add or remove content from the subscribed library. Only an administrator of the published library can add, modify, and remove contents from the published library.</p> <p>Provide the following information to subscribe to a library:</p> <ul style="list-style-type: none"> <li>a In the <b>Subscription URL</b> text box, enter the URL address of the published library.</li> <li>b If authentication is enabled on the published library, select <b>Enable authentication</b> and enter the publisher password.</li> <li>c Select a download method for the contents of the subscribed library. <ul style="list-style-type: none"> <li>■ If you want to download a local copy of all the items in the published library immediately after subscribing to it, select <b>immediately</b>.</li> <li>■ If you want to save storage space, select <b>when needed</b>. You download only the metadata for the items in the published library.</li> </ul> <p>If you need to use an item, synchronize the item or the entire library to download its content.</p> </li> <li>d If prompted, accept the SSL certificate thumbprint.</li> </ul> <p>The SSL certificate thumbprint is stored on your system until you delete the subscribed content library from the inventory.</p>

- 6 (Optional) On the **Apply security policy** page, select **Apply Security Policy** and select **OVF default policy**.

For the subscribed library, this option appears only if the library supports security policies.

If you select this option, the system performs a strict OVF certificate verification when importing an OVF item to the library from the local host or synchronizing an item. The OVF items that do not pass the certificate validation cannot be imported.

If the item does not pass the validation during synchronization, it is marked with the **Verification Failed** tag. Only the item and metadata will be kept, but not the files in the item.

- 7 On the **Add storage** page, select datastore as a storage location for the content library contents and click **Next**.
- 8 On the **Ready to complete** page, review the details and click **Finish**.

## What to do next

After you create the content library, populate the library with VM templates, so that your DevOps engineers can use the templates to provision new virtual machines. See [Populate a Content Library with VM Images for Stand-Alone VMs in vSphere with Tanzu](#).

## Populate a Content Library with VM Images for Stand-Alone VMs in vSphere with Tanzu

As a vSphere administrator, populate a content library with VM templates in OVA or OVF format. Your DevOps engineers can use the templates to provision new stand-alone virtual machines in the vSphere with Tanzu environment.

After you create a content library, you can populate it with items in several ways. This topic describes how to add items to a local content library by importing files from your local machine or from a Web server. For other ways to populate the content library, see [Populating Libraries with Content](#).

### Prerequisites

- Create a content library for VM provisioning. [Create a Content Library for Stand-Alone VMs in vSphere with Tanzu](#).
- Use only compatible VM images that appear on VMware Cloud Marketplace as OVFs. To find compatible images, search for **VM Service image** on the [VMware Cloud Marketplace](#) web site. See an example of the VM Service image for CentOS at [VM Service Image for CentOS](#).
- If your library is protected by a security policy, make sure that all library items are compliant. If a protected library includes a mix of compliant and non-compliant items, the `kubectl get virtualmachineimages` fails to present VM images to the DevOps engineers.
- Required privilege: **Content library.Add library item** and **Content library.Update files** on the library.

### Procedure

- 1 From the vSphere Client home menu, select **Content Libraries**.
- 2 Right-click a local content library and select **Import Item**.

The **Import Library Item** dialog box opens.

- In the **Source** section, select the source of the item.

Option	Description
<b>URL</b>	Enter the path to the Web server where the item is.  <b>Note</b> You can import either an <code>.ovf</code> or <code>.ova</code> file. The resulting content library item is of the OVF Template type.
<b>Local File</b>	Click <b>Upload File</b> to navigate to the file that you want to import from your local system. You can use the drop-down menu to filter files in your local system.  <b>Note</b> You can import either an <code>.ovf</code> or <code>.ova</code> file. When you import an OVF template, first select the OVF descriptor file ( <code>.ovf</code> ). Next, you are prompted to select the other files in the OVF template, for example the <code>.vmdk</code> file. The resulting content library item is of the OVF Template type.

vCenter Server reads and validates the manifest and certificate files in the OVF package during importing. A warning is displayed in the **Import Library Item** wizard, if certificate issues exist, for example if vCenter Server detects an expired certificate.

**Note** vCenter Server does not read signed content, if the OVF package is imported from an `.ovf` file from your local machine.

- In the **Destination** section, enter a name and a description for the item.
- Click **Import**.

#### Results

The item appears on the **Templates** tab or on the **Other Types** tab.

#### What to do next

After you create the content library and populate it with VM templates, add the library to the namespace to give your DevOps users access to the content library. See [Associate a VM Content Library with a Namespace in vSphere with Tanzu](#).

## Associate a VM Content Library with a Namespace in vSphere with Tanzu

As a vSphere administrator, you must give your DevOps users access to a source of VM templates, so that the DevOps engineers can use the templates to provision new stand-alone VMs in the vSphere with Tanzu environment. To give the access, add a content library that contains VM templates to the namespace.

You can add multiple content libraries to a single namespace. You can add the same content library to different namespaces.

**Note** This procedure applies only to content libraries for VM Service. Tanzu Kubernetes Grid Service content libraries must be managed from the Tanzu Kubernetes Grid Service pane.

## Prerequisites

- Create a content library. See [Create a Content Library for Stand-Alone VMs in vSphere with Tanzu](#).
- Populate the library with VM templates. See [Populate a Content Library with VM Images for Stand-Alone VMs in vSphere with Tanzu](#).
- Required privileges:
  - **Namespaces.Modify cluster-wide configuration**
  - **Namespaces.Modify namespace configuration**

## Procedure

- 1 In the vSphere Client, go to the namespace.
  - a From the vSphere Client home menu, select **Workload Management**.
  - b Click the **Namespaces** tab and click the namespace.
- 2 Add a content library.
  - a On the **VM Service** pane, click **Add Content Library**.
  - b Select one or several content libraries and click **OK**.

## Results

Contents of the library you added become available in the Kubernetes namespace as VM images and can be used by DevOps to self-service VMs. See [Deploy a Virtual Machine in vSphere with Tanzu](#).

## What to do next

After you associate a content library with a namespace, you can add more content libraries or remove the library to unpublish it from the Kubernetes namespace. See [Manage VM Content Libraries on a Namespace in vSphere with Tanzu](#).

# Manage VM Content Libraries on a Namespace in vSphere with Tanzu

As a vSphere administrator, you associate a content library that contains VM templates with a namespace, so that the DevOps engineers can use the templates to provision stand-alone VMs in the vSphere with Tanzu environment. After you associate the library with the namespace, you can remove the library to unpublish it from the Kubernetes namespace. You can also add more libraries.

Removing a content library from a namespace does not affect VMs that were previously deployed with the library images.

---

**Note** This procedure applies only to content libraries for VM Service. Tanzu Kubernetes Grid Service content libraries must be managed from the Tanzu Kubernetes Grid Service pane.

---

## Prerequisites

- Add a content library to a namespace. [Associate a VM Content Library with a Namespace in vSphere with Tanzu.](#)
- Required privileges:
  - **Namespaces.Modify cluster-wide configuration**
  - **Namespaces.Modify namespace configuration**

## Procedure

- 1 In the vSphere Client, go to the namespace.
  - a From the vSphere Client home menu, select **Workload Management**.
  - b Click the **Namespaces** tab and click the namespace.
- 2 Add or remove a content library.
  - a On the **VM Service** pane, click **Manage Content Library**.
  - b Perform one of the following operations.

Option	Description
<b>Remove a content library</b>	Deselect the content library and click <b>OK</b> .
<b>Add a content library</b>	Select one or several content libraries and click <b>OK</b> .

## What to do next

Contents of the library become available in the Kubernetes namespace as VM images and can be used by DevOps to self-service VMs. See [Deploy a Virtual Machine in vSphere with Tanzu](#).

# Configuring and Managing vSphere Namespaces

# 7

vSphere with Tanzu workloads, including vSphere Pods, VMs, and Tanzu Kubernetes clusters, are deployed to a vSphere Namespace. You define a vSphere Namespace on a Supervisor Cluster and configure it with resource quota and user permissions. Depending on the DevOps needs and workloads they plan to run, you might also assign storage policies, VM classes, and content libraries for fetching the latest Tanzu Kubernetes releases and VM images.

This chapter includes the following topics:

- [Create and Configure a vSphere Namespace](#)
- [Set Default Memory and CPU Reservations and Limits for vSphere Pod Containers](#)
- [Configure Limitations on Kubernetes Objects in a vSphere Namespace](#)
- [Monitor and Manage Resources in a vSphere Namespace](#)
- [Configure a vSphere Namespace for Tanzu Kubernetes releases](#)
- [Provision a Self-Service Namespace Template](#)

## Create and Configure a vSphere Namespace

As a vSphere administrator, you create a vSphere Namespace on the Supervisor Cluster. You set resources limits to the namespace and permissions so that DevOps engineers can access it. You provide the URL of the Kubernetes control plane to DevOps engineers where they can run Kubernetes workloads on the namespaces for which they have permissions.

Namespaces on Supervisor Clusters configured with the vSphere networking stack and namespaces on clusters configured with NSX-T Data Center have different networking configuration and capabilities.

Namespaces that you create on Supervisor Clusters configured with NSX-T Data Center support the full set of capabilities of the Workload Management platform. They support vSphere Pods, VMs, and Tanzu Kubernetes clusters. The workload networking support for these namespaces is provided by NSX-T Data Center. For more information, see [System Requirements for Setting Up vSphere with Tanzu with NSX-T Data Center](#).

Namespaces that you create on a Supervisor Cluster configured with the vSphere networking stack only support Tanzu Kubernetes clusters and VMs, they do not support vSphere Pods and you cannot use the Harbor Registry with them. The workload networking support for these namespaces is provided by the vSphere Distributed Switch that is connected to the hosts part of the Supervisor Cluster. For more information, see [System Requirements for Setting Up vSphere with Tanzu with vSphere Networking and HA Proxy Load Balancer](#).

You can also set resources limits to the namespace, assign permissions, and provision or activate the namespace service on a cluster as a template. As a result, DevOps engineers can create a Supervisor Namespace in a self-service manner and deploy workloads within it. For more information, see [Provision a Self-Service Namespace Template](#).

### Prerequisites

- Configure a cluster with vSphere with Tanzu.
- Create users or groups for all DevOps engineers who will access the namespace.
- Create storage policies for persistent storage. Storage policies can define different types and classes of storage, for example, gold, silver, and bronze.
- Create VM classes and content libraries for stand-alone VMs.
- Create a content library for Tanzu Kubernetes releases for use with Tanzu Kubernetes clusters. See [Creating and Managing Content Libraries for Tanzu Kubernetes releases](#).
- Required privileges:
  - **Namespaces.Modify cluster-wide configuration**
  - **Namespaces.Modify namespace configuration**

### Procedure

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Click **Namespaces** and click **New Namespace**.
- 3 Select the Supervisor Cluster where you want to place the namespace.
- 4 Enter a name for the namespace.  
The name must be in a DNS-compliant format.
- 5 From the **Network** drop-down menu, select a Workload Network for the namespace.

---

**Note** This step is available only if you create the namespace on a cluster that is configured with the vSphere networking stack.

---

- 6 If you have configured the NSX-T Data Center networking stack for your cluster, you can select **Override cluster network settings** to override the cluster network settings and configure network settings for the namespace.

Configure the following network settings for the namespace:

Option	Description
<b>NAT Mode</b>	<p>The NAT mode is selected by default.</p> <p>If you deselect this option, all the workloads such as the vSphere Pods, VMs, and Tanzu Kubernetes clusters node IP addresses are directly accessible from outside the tier-0 gateway and you do not have to configure the egress CIDRs.</p> <hr/> <p><b>Note</b> Once you enable a namespace mode, you cannot change it.</p>
<b>Tier-0 Gateway</b>	<p>Select the tier-0 gateway to associate with the namespace tier-1 gateway.</p> <p>Selecting a tier-0 gateway overrides the tier-0 gateway you configured while enabling the cluster, so you must configure the CIDR ranges again.</p> <p>If you select a VRF gateway that is linked to the tier-0 gateway, the network and subnets are automatically configured.</p> <p>If you have selected the NAT mode, you must configure the subnet, ingress, and egress CIDRs.</p> <p>If you deselect the NAT mode, you must only configure the subnet and ingress CIDRs.</p> <hr/> <p><b>Note</b> Once you select a tier-0 gateway, you cannot change it.</p>
<b>Namespace Network CIDR</b>	<p>Enter one or more IP CIDRs to create subnets/segments and assign IP addresses for workloads connected to namespaces.</p> <hr/> <p><b>Note</b> Enter the CIDR range if you did not configure it for the cluster. You can configure additional CIDRs after you create the namespace, by editing the namespace network settings.</p>
<b>Namespace Subnet Prefix</b>	<p>Enter the subnet prefix that specifies the size of the subnet reserved for namespaces segments. Default is 28.</p> <hr/> <p><b>Note</b> Once you specify the subnet prefix, you cannot change it.</p>
<b>Ingress CIDR</b>	<p>Enter a CIDR annotation that determines the ingress IP range for the virtual IP addresses published by the load balancer service for vSphere Pods or Tanzu Kubernetes clusters.</p> <p>You can configure additional CIDRs after you create the namespace, by editing the namespace network settings.</p>
<b>Egress CIDR</b>	<p>Enter a CIDR annotation that determines the egress IP range for the SNAT IP addresses.</p> <p>You can configure additional CIDRs after you create the namespace, by editing the namespace network settings.</p>
<b>Load balancer Size</b>	<p>Select the size of the load balancer instance on the tier-1 gateway for the namespace.</p>

- 7 Enter a description, and click **Create**.

The namespace is created on the Supervisor Cluster.



8 Set permissions so that DevOps engineers can access the namespace.

- a From the **Permissions** pane, select **Add Permissions**.
- b Select an identity source, a user or a group, and a role, and click **OK**.

9 Set persistent storage to the namespace.

Storage policies that you assign to the namespace control how persistent volumes and Tanzu Kubernetes cluster nodes are placed within datastores in the vSphere storage environment. The persistent volume claims that correspond to persistent volumes can originate from a vSphere Pod, and VM, or from the Tanzu Kubernetes cluster. For more information, see [Chapter 10 Using Persistent Storage in vSphere with Tanzu](#).

- a From the **Storage** pane, select **Add Storage**.
- b Select a storage policy to control datastore placement of persistent volumes and click **OK**.

After you assign the storage policy, vSphere with Tanzu creates a matching Kubernetes storage class in the vSphere Namespace. If you use VMware Tanzu™ Kubernetes Grid™ Service, the storage class is automatically replicated from the namespace to the Kubernetes cluster. When you assign multiple storage policies to the namespace, a separate storage class is created for each storage policy.

10 From the Capacity and Usage pane, select **Edit Limits** and configure resource limitations to the namespace.

Option	Description
<b>CPU</b>	The amount of CPU resources to reserve for the namespace.
<b>Memory</b>	The amount of memory to reserve for the namespace.
<b>Storage</b>	The total amount of storage space to reserve for the namespace.
<b>Storage policies limits</b>	Set the amount of storage dedicated individually to each of the storage policies that you associated with the namespace.

A resource pool for the namespace is created on vCenter Server. The storage limitation determines the overall amount of storage that is available to the namespace whereas storage policies determine the placement of persistent volumes for vSphere Pods on the associated storage classes.

11 Set up VM Service for stand-alone VMs.

For information, see [Chapter 12 Deploying and Managing Virtual Machines in vSphere with Tanzu](#).

12 Configure the namespace for Tanzu Kubernetes clusters, including the following:

- Associate the Tanzu Kubernetes release content library with the namespace.
- Add the default VM classes to the namespace.

For more information, see [Configure a vSphere Namespace for Tanzu Kubernetes releases](#).

## What to do next

Share the Kubernetes Control Plane URL with DevOps engineers as well as the user name they can use to log in to the Supervisor Cluster through the Kubernetes CLI Tools for vSphere. You can grant access to more than one namespace to a DevOps engineer.

# Set Default Memory and CPU Reservations and Limits for vSphere Pod Containers

You can set the default memory and CPU reservations and limits for containers on a namespace through the vSphere Client. DevOps engineers can later override these values in the pod specifications they define. Container requests translate to resource reservations on vSphere Pods.

## Prerequisites

- Verify that you have the **Modify namespace configuration** privilege on the Supervisor Cluster.

## Procedure

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Select a namespace, select **Configure**, and click **Resource Limits**
- 3 Configure default memory and CPU reservations and limits for the containers in the namespace.

Option	Description
<b>CPU Request</b>	Set the default CPU reservation for containers in the namespace.
<b>CPU Limit</b>	Set the default limit for CPU usage for containers in the namespace.
<b>Memory Request</b>	Set the default memory reservation for containers in the namespace.
<b>Memory Limit</b>	Set the default limit for memory usage for containers in the namespace.

# Configure Limitations on Kubernetes Objects in a vSphere Namespace

You can configure limitations for pods running in the vSphere Namespace as well as limitations for various Kubernetes objects. The limitations that you configure for an object depend on the specifics of your applications and the way you want them to consume resources within a vSphere Namespace.

## Prerequisites

- Verify that you have the **Modify namespace configuration** privilege on the Supervisor Cluster.

**Procedure**

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Select the namespace to which you want to apply object or container restrictions.
- 3 To set container limitations, select **Resource Limits** and click **Edit**.

Option	Description
<b>CPU Requests</b>	Set the amount of CPU requests for containers.
<b>CPU Limit</b>	Set the amount of CPU that containers can use.
<b>Memory Requests</b>	Set the amount of memory requests for containers.
<b>Memory Limits</b>	Set the amount of memory containers can use.

- 4 To set limitations on Kubernetes objects that can exist in the namespace, select **Object Limits** and click **Edit**.

Option	Description
<b>Pods</b>	The number of vSphere Pod that can run in the namespace.
<b>Deployments</b>	The number of deployments that can run in the namespace.
<b>Jobs</b>	The number of jobs that can run in the namespace.
<b>DaemonSets</b>	The number of daemon sets that can run in the namespace.
<b>ReplicaSets</b>	The number of replica sets in the namespace.
<b>ReplicationControllers</b>	The number of replication controllers that can run in the namespace.
<b>StatefulSets</b>	The number of StatefulSets that can run in the namespace.
<b>ConfigMaps</b>	The number of ConfigMaps that can run in the namespace.
<b>Secrets</b>	The number of secrets that can run in the namespace.
<b>Persistent Volume Claims</b>	The persistent volume claims that can exist in the namespace.
<b>Services</b>	The services that can exist in the namespace.

## Monitor and Manage Resources in a vSphere Namespace

You can monitor and manage different aspects of a vSphere Namespace, such as resource consumption for the namespace as well as the number of different Kubernetes objects that exist in a namespace and their states.

**Prerequisites**

[Create and Configure a vSphere Namespace.](#)

**Procedure**

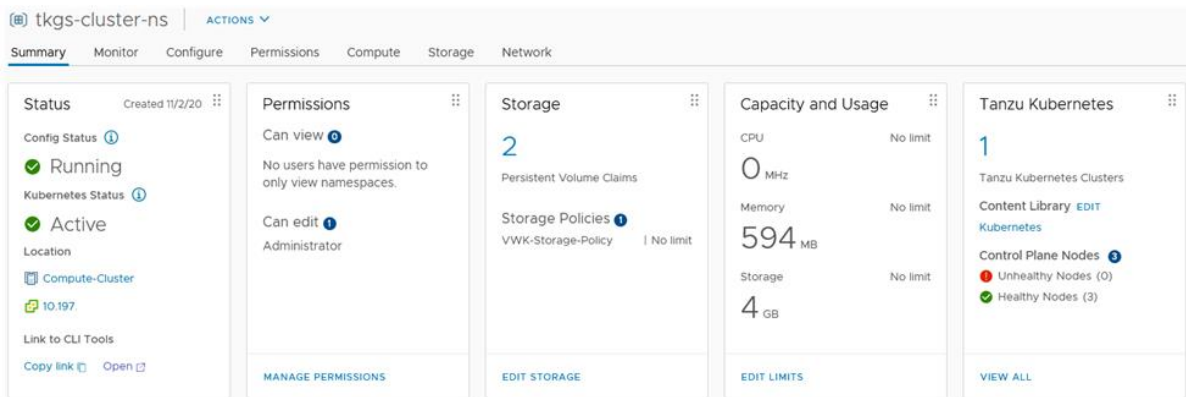
- 1 Log in to the vCenter Server using the vSphere Client.
- 2 Navigate to the **Menu > Hosts and Clusters** view.

- 3 Select the vCenter Cluster where you have enabled **Workload Management**.
- 4 Select the **Namespaces** resource pool and expand its contents.

The Supervisor Cluster control plane nodes are located in the Namespaces resource pool. In addition, each vSphere Namespace that is created for this Supervisor Cluster is located in the **Namespaces** resource pool.

- 5 Select the vSphere Namespace object, which is represented as a window icon.

In the **Summary** tab you see the various configuration sections for the vSphere Namespace, including **Status**, **Permissions**, **Storage**, **Capacity and Usage**, and **Tanzu Kubernetes**. From this screen you can manage any of these settings.



## Configure a vSphere Namespace for Tanzu Kubernetes releases

Configure the vSphere Namespace where you plan to provision Tanzu Kubernetes clusters by associating the namespace view with the content library for Tanzu Kubernetes releases and with the VM classes you want to use.

### Prerequisites

Create a vSphere Namespace. See [Create and Configure a vSphere Namespace](#).

Create a content library for hosting Tanzu Kubernetes releases. See [Create, Secure, and Synchronize a Subscribed Content Library for Tanzu Kubernetes releases](#) or [Create, Secure, and Synchronize a Local Content Library for Tanzu Kubernetes releases](#).

### Associate the Content Library with the vSphere Namespace

To associate the content library created for Tanzu Kubernetes releases with a vSphere Namespace, log in to the vCenter Server using the vSphere Client and complete either of the following procedures.

Associate Using the vSphere Inventory Path	Associate Using the Workload Management Path
<ol style="list-style-type: none"> <li>1 Select <b>Menu &gt; Hosts and Clusters</b>.</li> <li>2 Select the vSphere Cluster where <b>Workload Management</b> is enabled.</li> <li>3 Select the <b>Configure</b> tab.</li> <li>4 Select <b>Namespaces &gt; General</b>.</li> <li>5 Select <b>Tanzu Kubernetes Grid Service Configuration</b>.</li> <li>6 Click <b>Edit</b> beside the <b>Content Library</b> label.</li> <li>7 Select the content library for Tanzu Kubernetes releases.</li> <li>8 Click <b>OK</b>.</li> </ol>	<ol style="list-style-type: none"> <li>1 Select <b>Menu &gt; Workload Management</b>.</li> <li>2 Select the <b>Namespaces</b> tab.</li> <li>3 Select the target vSphere Namespace.</li> <li>4 Locate the <b>Tanzu Kubernetes Grid Service</b> tile.</li> <li>5 Click <b>Edit</b> beside the <b>Content Library</b> label.</li> <li>6 Select the content library for Tanzu Kubernetes releases.</li> <li>7 Click <b>OK</b>.</li> </ol>

**Note** After you associate the content library with the vSphere Namespace, it can take several minutes for the virtual machine templates to be available for provisioning Tanzu Kubernetes clusters. See [Verify the vSphere Namespace Configuration](#).

## Associate the VM Classes with the vSphere Namespace

vSphere with Tanzu provides several default virtual machine classes, and you can create your own. See [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).

To provision Tanzu Kubernetes clusters, you need to associate the virtual machine classes you want to use with each vSphere Namespace where you want to provision Tanzu Kubernetes clusters.

To associate the default VM classes with a vSphere Namespace, log in to the vCenter Server using the vSphere Client and complete the following procedure.

- 1 Select **Menu > Workload Management**.
- 2 Select the **Namespaces** tab.
- 3 Select the target vSphere Namespace where you plan to provision Tanzu Kubernetes clusters.
- 4 Locate the **VM Service** tile.
- 5 Click the **Add VM Class** link.
- 6 Select the VM classes to add.
  - a To add the default VM classes, select the checkbox in the table header on page 1 of the list, navigate to page 2 and select the checkbox in the table header on that page. Verify that all classes are selected.
  - b To create a custom class, click **Create New VM Class**. See [Create a VM Class in vSphere with Tanzu](#).
- 7 Click **OK** to complete the operation.

- 8 Confirm that the classes are added. The **VM Service** tile shows **Manage VM Classes**.

---

**Note** The content library referenced in the **VM Service** tile is for use with standalone VMs, not Tanzu Kubernetes releases. See [Creating and Managing Content Libraries for Stand-Alone VMs in vSphere with Tanzu](#).

---

## Verify the vSphere Namespace Configuration

Once you have associated the content library and virtual machine classes with the vSphere Namespace, log in to the Supervisor Cluster and verify that each synchronized Tanzu Kubernetes release is available and each selected VM class is available.

- 1 Install the Kubernetes CLI Tools for vSphere. See [Download and Install the Kubernetes CLI Tools for vSphere](#).
- 2 Log in to the Supervisor Cluster.

```
kubectl vsphere login --server IP-ADDRESS-SUPERVISOR-CLUSTER --vsphere-username VCENTER-SSO-USERNAME
```

- 3 Switch context to the target vSphere Namespace.

```
kubectl config use-context SUPERVISOR-NAMESPACE
```

- 4 List and describe the available Tanzu Kubernetes releases.

```
kubectl get tanzukubernetesreleases
```

```
kubectl describe tanzukubernetesreleases
```

- 5 List the available virtual machine classes.

```
kubectl get virtualmachineclassbindings
```

Once the namespace is configured, you can now provision Tanzu Kubernetes clusters. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#). If you are using a local content library, you will need to specify an OVA that you uploaded to the library. See [Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API](#).

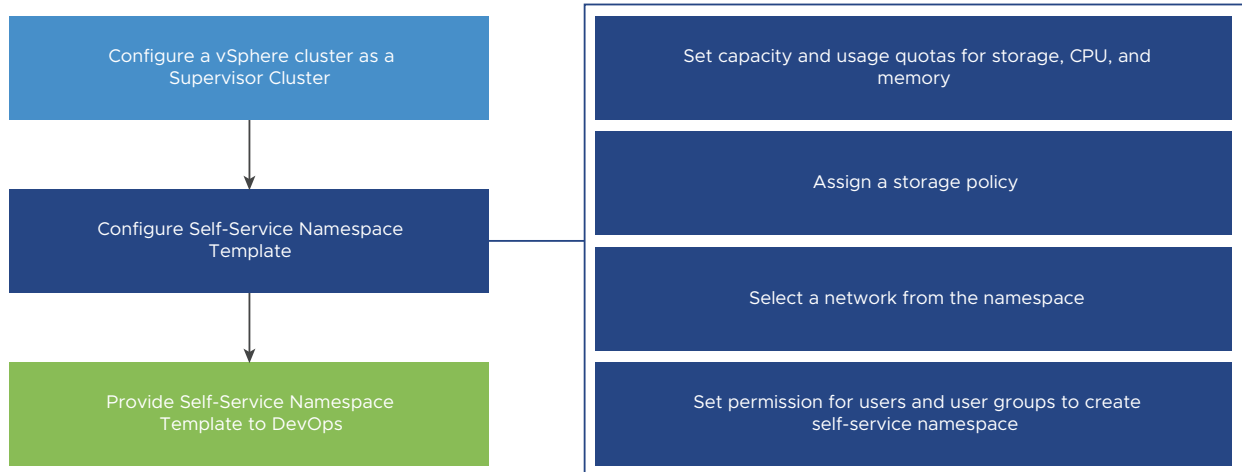
## Provision a Self-Service Namespace Template

As a vSphere administrator, you can create a Supervisor Namespace, set CPU, memory, and storage limits to the namespace, assign permissions, and activate the namespace service on a cluster as a template. As a result, DevOps engineers can create a Supervisor Namespace in a self-service manner and deploy workloads within it.

## Self-Service Namespace Creation and Configuration Workflow

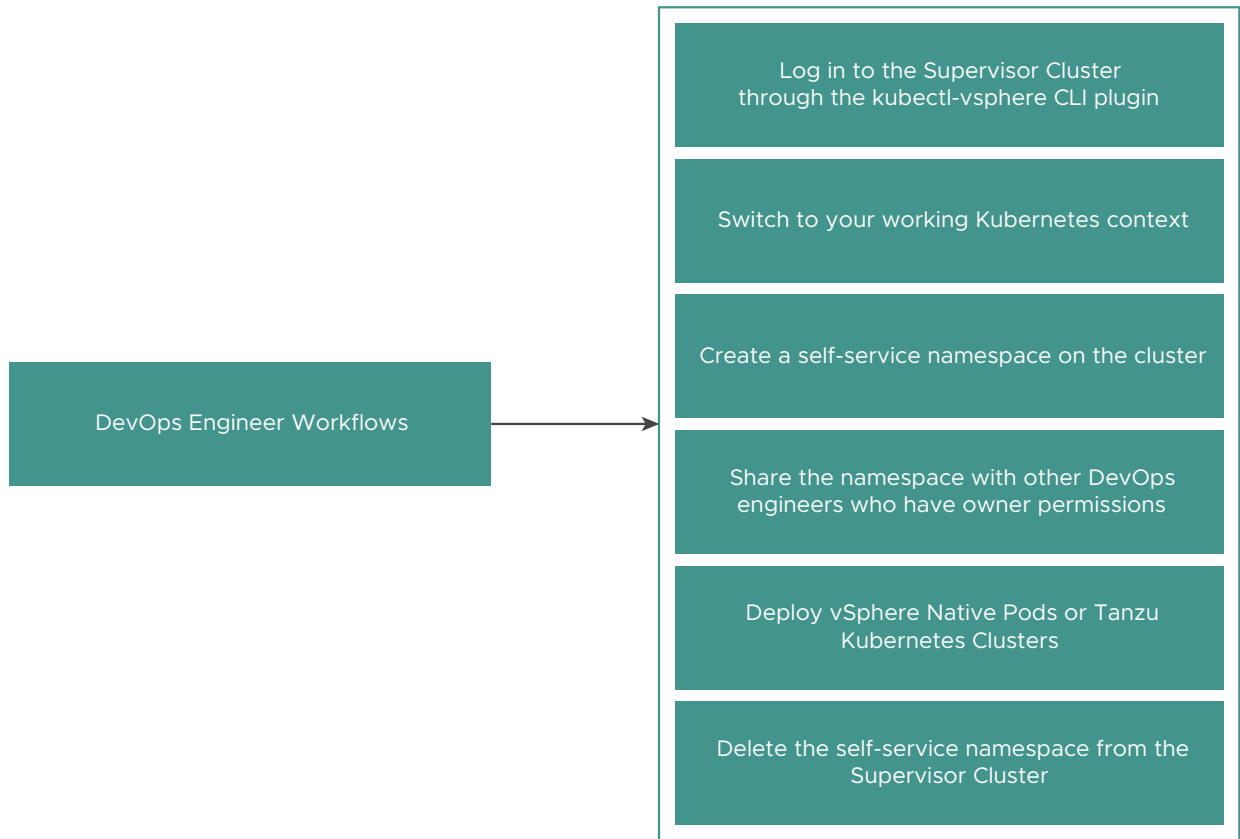
As a vSphere administrator, you can create a Supervisor Namespace, set CPU, memory, and storage limits to the namespace, assign permissions, and provision or activate the namespace service on a cluster as a template.

Figure 7-1. Self-service Namespace Template Provisioning Workflow



As a DevOps engineer, you can create a Supervisor Namespace in a self-service manner and deploy workloads within it. You can share it with other DevOps engineers or delete it when it is no longer required. To share the namespace with other DevOps engineers, contact the vSphere administrator.

Figure 7-2. Self-service Namespace Creation Workflow



## Create and Configure a Self-Service Namespace Template

As a vSphere administrator, you can create and configure a Supervisor Namespace as a self-service namespace template. DevOps engineers can then create and delete Supervisor Namespaces using the `kubectl` command line.

### Prerequisites

Configure a cluster with vSphere with Tanzu.

### Procedure

- 1 In the vSphere Client, select the vSphere cluster where the Supervisor Cluster is enabled.
- 2 In the **Configure** tab, select **Namespaces > General**.
- 3 Select **Namespace Service**.
- 4 Toggle the **Status** switch to enable the feature.

The **Create Namespace Template** page appears.



- 5 In the **Configuration** pane, configure resource limitations to the namespace.

Option	Description
CPU	The amount of CPU resources to reserve for the namespace.
Memory	The amount of memory to reserve for the namespace.
Storage	The total amount of storage space to reserve for the namespace.
Storage Policy	Set the amount of storage dedicated individually to each of the storage policies that you associated with the namespace.
Network	From the <b>Network</b> drop-down menu, select a network for the namespace.

- 6 Click **Next**.
- 7 In the **Permissions** pane, add DevOps engineers and groups to empower them to use the template to create namespaces.  
Select an identity source and a user or a group and click **Next**.
- 8 In the **Review and Confirm** pane, the properties you configure are displayed.  
Review the properties and click **Done**.

## Results

A namespace template is configured and is in Active state. As a vSphere administrator, you can edit the template. DevOps engineers can use the template to create namespaces.

## Deactivate a Self-Service Namespace

As a vSphere administrator, you can deactivate a self-service namespace on the cluster.

When you deactivate a self-service namespace template, DevOps engineers cannot use the template to create new namespaces on the cluster. They can delete the namespaces that they have already created.

### Procedure

- 1 In the vSphere Client, navigate to the Supervisor Cluster.
- 2 In the **Configure** tab, select **General** under **Namespaces**.
- 3 In the **Namespace Self-Service** pane, toggle the **Status** switch to deactivate the template.
- 4 To activate the template again, toggle the **Status** switch.

You can either create another self-service namespace or use the existing one.

## Create a Self-Service Namespace

As a DevOps Engineer, you can create a self-service namespace and run workloads within it. Once you create the namespace, you can share it with other DevOps Engineers or delete it when it is no longer required.

### Prerequisites

- Verify that a vSphere administrator has created and activated a self-service namespace template on the cluster. See [Create and Configure a Self-Service Namespace Template](#) .
- Verify that you are added to the permissions list in the self-service namespace template either individually or as a member of a group .
- Get the IP address of the Supervisor Cluster control plane.

### Procedure

- 1 Using the vSphere Plugin for kubectl, authenticate with the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

```
kubectl vsphere login --server=IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the Supervisor Cluster.

```
kubectl config use-context SUPERVISOR-CLUSTER-IP
```

- 3 Create a self-service namespace on the cluster.

```
kubectl create namespace NAMESPACE NAME
```

For example

```
kubectl create namespace test-ns
```

---

**Note** Owner permissions are available to DevOps Engineers after you enable vSphere with Tanzu and upgrade the cluster. If you have only upgraded vCenter Server and not the cluster, the DevOps Engineers will only have edit permissions on the namespaces.

---

The namespace that you create appears in the cluster. To share the namespace with other DevOps engineers, contact the vSphere administrator.

## Create a Self-Service Namespace with Annotations and Labels

DevOps engineers can create self-service namespaces with annotations and labels using the kubectl command line.

DevOps engineers can use a YAML manifest with user-defined annotations and labels.

**Procedure****1** Log in to the Supervisor Cluster.

```
kubectl vsphere login --server IP-ADDRESS-SUPERVISOR-CLUSTER --vsphere-username VCENTER-SSO-USERNAME
```

**2** Create a namespace YAML manifest file with annotations and labels.

```
kubectl create -f ns-create.yaml
```

For example, create the following `ns-create.yaml` file:

```
apiVersion: v1
kind: Namespace
metadata:
  name: test-ns-yaml
  labels:
    my-label: "my-label-val-yaml"
  annotations:
    my-ann-yaml: "my-ann-val-yaml"
```

**3** Apply the YAML manifest.

```
kubectl create -f ns-create.yaml
```

Or

```
kubectl apply -f ns-create.yaml
```

**4** Describe the namespace that you created to see the changes.

```
root@localhost [ /tmp ]# kubectl describe ns test-ns-yaml
Name:          test-ns-yaml
Labels:        my-label=my-label-val-yaml
               vSphereClusterID=domain-c50
Annotations:   my-ann-yaml: my-ann-val-yaml
               vmware-system-namespace-owner-count: 1
               vmware-system-resource-pool: resgroup-171
               vmware-system-resource-pool-cpu-limit: 0.4770
               vmware-system-resource-pool-memory-limit: 2000Mi
               vmware-system-self-service-namespace: true
               vmware-system-vm-folder: group-v172
Status:        Active

Resource Quotas
Name:          test-ns-yaml
Resource      Used  Hard
-----
requests.storage  0    5000Mi

Name:          test-ns-yaml-storagequota
Resource      Used  Hard
-----
```

```
namespace-service-storage-profile.storageclass.storage.k8s.io/requests.storage 0
9223372036854775807

No LimitRange resource.
```

## Update a Self-Service Namespace Using kubectl annotate and kubectl label

As a DevOps engineer you can update or delete self-service namespace annotations and labels using the `kubectl annotate` and `kubectl label` commands.

### Prerequisites

Verify that you have owner permissions on the namespace that you want to update.

### Procedure

#### 1 Log in to the Supervisor Cluster.

```
kubectl vsphere login --server IP-ADDRESS-SUPERVISOR-CLUSTER --vsphere-
username VCENTER-SSO-USERNAME
```

#### 2 Describe the namespace that you want to update.

```
root@localhost [ /tmp ]# kubectl describe ns testns
Name:          testns
Labels:        my-label=test-label-2
               vSphereClusterID=domain-c50
Annotations:   my-ann: test-ann-2
               vmware-system-namespace-owner-count: 2
               vmware-system-resource-pool: resgroup-153
               vmware-system-resource-pool-cpu-limit: 0.4770
               vmware-system-resource-pool-memory-limit: 2000Mi
               vmware-system-self-service-namespace: true
               vmware-system-vm-folder: group-v154
Status:        Active

Resource Quotas
Name:          testns
Resource      Used  Hard
-----
requests.storage 0    5000Mi

Name:          testns-
storagequota
Resource      Used  Hard
-----
namespace-service-storage-profile.storageclass.storage.k8s.io/requests.storage 0
9223372036854775807
```

**3** Update annotations using the `kubectl annotate` command.

For example, `kubectl annotate --overwrite ns testns my-ann="test-ann-3"`

To delete an annotation, run the command `kubectl annotate --overwrite ns testns my-ann-`

**4** Update labels using the `kubectl label` command.

For example, `kubectl label --overwrite ns testns my-label="test-label-3"`

To delete a label, run the command `kubectl label --overwrite ns testns my-label-`

**5** Describe the namespace to see the updates.

```

root@localhost [ /tmp ]# kubectl describe ns testns
Name:          testns
Labels:        my-label=test-label-3
               vSphereClusterID=domain-c50
Annotations:   my-ann: test-ann-3
               vmware-system-namespace-owner-count: 2
               vmware-system-resource-pool: resgroup-153
               vmware-system-resource-pool-cpu-limit: 0.4770
               vmware-system-resource-pool-memory-limit: 2000Mi
               vmware-system-self-service-namespace: true
               vmware-system-vm-folder: group-v154
Status:        Active

Resource Quotas
Name:          testns
Resource      Used  Hard
-----
requests.storage 0    5000Mi

Name:          testns-
storagequota
Resource      Used  Hard
-----
namespace-service-storage-profile.storage.k8s.io/requests.storage 0
9223372036854775807

No LimitRange resource.

```

## Update a Self-Service Namespace Using `kubectl edit`

As a DevOps engineer you can update self-service namespaces using the `kubectl edit` command.

### Prerequisites

Verify that you have owner permissions on the namespace that you want to update.

**Procedure****1** Log in to the Supervisor Cluster.

```
kubectl vsphere login --server IP-ADDRESS-SUPERVISOR-CLUSTER --vsphere-username VCENTER-SSO-USERNAME
```

**2** Describe the namespace that you want to update.

```
kubectl describe ns testns-1
Name:          testns
Labels:        vSphereClusterID=domain-c50
Annotations:   my-ann: test-ann-2
               vmware-system-namespace-owner-count: 2
               vmware-system-resource-pool: resgroup-153
               vmware-system-resource-pool-cpu-limit: 0.4770
               vmware-system-resource-pool-memory-limit: 2000Mi
               vmware-system-self-service-namespace: true
               vmware-system-vm-folder: group-v154
Status:        Active

Resource Quotas
Name:          testns-1
Resource      Used  Hard
-----
requests.storage 0    5000Mi

Name:          testns-1-
storagequota
Resource      Used  Hard
-----
namespace-service-storage-profile.storageclass.storage.k8s.io/requests.storage 0
9223372036854775807
```

**3** Edit the namespace using the `kubectl edit` command.

For example, `kubectl edit ns testns-1`

The `kubectl edit` command opens the namespace manifest in the text editor defined by your `KUBE_EDITOR` or the `EDITOR` environment variable.

**4** Update the labels.

For example, `my-label=test-label`

**5** Update the annotations.

For example, `my-ann: test-ann`

**6** Describe the namespace to see the updates.

```
root@localhost [ /tmp ]# kubectl describe ns testns-1
Name:          testns-1
Labels:        my-label=test-label
```

```

vSphereClusterID=domain-c50
Annotations:  my-ann: test-ann
              vmware-system-namespace-owner-count: 1
              vmware-system-resource-pool: resgroup-173
              vmware-system-resource-pool-cpu-limit: 0.4770
              vmware-system-resource-pool-memory-limit: 2000Mi
              vmware-system-self-service-namespace: true
              vmware-system-vm-folder: group-v174
Status:      Active

```

#### Resource Quotas

```

Name:        testns-1
Resource     Used  Hard
-----
requests.storage 0    5000Mi

```

```

Name:        testns-1-
storagequota
Resource     Used  Hard
-----
namespace-service-storage-profile.storageclass.storage.k8s.io/requests.storage 0
9223372036854775807

```

No LimitRange resource.

## Delete a Self-Service Namespace

As a DevOps Engineer, you can delete a self-service namespace that you create.

### Prerequisites

Verify that you have created a self-service namespace using the vSphere Plugin for kubectl.

### Procedure

- 1 Using the vSphere Plugin for kubectl, authenticate with the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).
- 2 Delete the self-service namespace from the cluster.

```
kubectl delete namespace NAMESPACE NAME
```

For example:

```
kubectl delete namespace test-ns
```

# Managing Supervisor Services with vSphere with Tanzu



Supervisor Services are vSphere certified Kubernetes operators that deliver Infrastructure-as-a-Service components and tightly-integrated Independent Software Vendor services to developers. You can install and manage Supervisor Services on the vSphere with Tanzu environment so that to make them available for use with Kubernetes workloads. When Supervisor Services are installed on Supervisor Clusters, DevOps engineers can use the service APIs to create instances on Supervisor Clusters in their user namespaces. These instances can then be consumed in vSphere Pods and Tanzu Kubernetes clusters.

Learn more about the supported Supervisor Services and how to download their service YAML files at <http://vmware.com/go/supervisor-service>.

You manage Supervisor Services in the vSphere Services platform from the vSphere Client. By using the platform, you can manage the life cycle of Supervisor Services, install them on Supervisor Clusters, as well as perform version control. A Supervisor Service can have multiple versions that you can install on Supervisor Clusters as only one version at a time can run on a Supervisor Cluster.

**Table 8-1. Supervisor Service States**

State	Service Version	Entire Service
Active	The service version is ready to be installed on Supervisor Clusters version.	At least one service version is in Active state.
Deactivated	The service version cannot be installed on Supervisor Clusters. It can continue running on any Supervisor Clusters where it is installed, but you cannot install a Deactivated version on new Supervisor Clusters.	When an entire Supervisor Service is Deactivated, all of its versions are also Deactivated and you cannot install any of them on Supervisor Clusters or add new service versions until you reactivate the service.



# Supervisor Services Life Cycle Management Operations

Managing the life cycle of a Supervisor Service includes the following operations:

- Adding a new Supervisor Service to vCenter Server. When you add a new service to vCenter Server, the service and all information about it is registered with vCenter Server. The service is not yet installed on any Supervisor Cluster. After the service is registered with vCenter Server, its state is Active, which means that you can install that service on Supervisor Clusters.
- Adding a new Supervisor Service version to vCenter Server. Once, you have added a Supervisor Service to vCenter Server, you can add new versions of that service. After the new service version is registered with vCenter Server it becomes in Active state and you can install the version on Supervisor Clusters.
- Installing a Supervisor Service on Supervisor Clusters. When you install a service on a Supervisor Cluster, the service YAML file is applied on the cluster, and all the pods and necessary resources are created for the service to operate. Each service you install on a Supervisor Cluster has a dedicated namespace where you can manage the service resources. Supervisor Services might also have a UI plug-in for vCenter Server, where you can manage the service configuration.
- Upgrading a Supervisor Service. You can upgrade a service that is installed on a Supervisor Cluster by first adding a new service version to vCenter Server and then installing the new version on the Supervisor Cluster. During the service upgrade, the YAML file of the new version is applied to the Supervisor Cluster. Any resources that are specified in the previous service version that are not required by the new version will be deleted. For example, if version 1 specifies pod A and version 2 specifies pod B, after the upgrade to version 2 a new pod B is created and pod A is deleted. No currently running workloads are impacted during the process.
- Uninstalling a Supervisor Service version. Uninstalling a service version from a Supervisor Cluster leads to all of the services resources being removed from the cluster including the service namespace. Application instances of the service in Kubernetes workloads will continue to run.
- Deleting a Supervisor Service version. To delete a service version, first you must Deactivate that version and uninstall it from the Supervisor Clusters where it runs. Then you can delete the service version from vCenter Server.
- Deleting an entire Supervisor Service. To delete a entire service, you must deactivate all of its versions, then uninstall these versions from Supervisor Clusters, and finally delete all the service versions.

This chapter includes the following topics:

- [Add a Supervisor Service to vCenter Server](#)
- [Install a Supervisor Service on Supervisor Clusters](#)
- [Access the Management Interface of a Supervisor Service on the Supervisor Cluster](#)

- [Add a New Version to a Supervisor Service](#)
- [View Supervisor Services Installed on a Supervisor Cluster](#)
- [Deactivate a Supervisor Service or a Version](#)
- [Activate a Supervisor Service Version on vCenter Server](#)
- [Uninstall a Supervisor Service from a Supervisor Cluster](#)
- [Delete a Supervisor Service Version](#)
- [Delete a Supervisor Service](#)

## Add a Supervisor Service to vCenter Server

You can add Supervisor Services to the vCenter Server system where your vSphere with Tanzu environment runs. After adding services to vCenter Server, you install Supervisor Services on Supervisor Clusters so that your DevOps engineers can use the services in Kubernetes workloads.

- Learn more about the supported Supervisor Services and how to download their service YAML files at <http://vmware.com/go/supervisor-service>.

### Prerequisites

- Verify that you have the **Manage Supervisor Services** privilege on the vCenter Server system where you add the service.

### Procedure

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Select **Services**.
- 3 Select a vCenter Server system from the drop-down menu at the top.

#### 4 Drag and drop the service YAML file in the **Add New Service** card.

The screenshot shows the 'Register Service' dialog. On the left, a sidebar lists '1 Register Service' (selected) and '2 EULA'. The main content area has a title 'Register Service' and a close button. It contains two notification boxes: a blue one stating 'YAML was uploaded successfully. Note: YAML content is not verified and could fail during installation into a Supervisor Cluster.' and a yellow one with a warning icon stating 'Running 3rd party services on user workloads has security risks. A 3rd party service has network access to user workloads, Pod VMs, and exposed APIs.' Below these is the instruction 'Upload service definition to support the service on vSphere.' and a link for 'YAML File details' with an 'Upload new' button. A file icon and name 'minio-supervisorservice-2.0.0.yaml' are shown. The 'Service Details' section lists: vCenter (sc2-10-185-226-93.eng.vmware.com), Service Name (MinIO), Service ID (minio), Service Description (MinIO is a high-performance, cloud-native object store. Compatible with the Amazon S3 API, it scales seamlessly to hundreds of PBs and is simple to deploy and manage.), and Version (2.0.0). At the bottom right are 'CANCEL' and 'NEXT' buttons.

5 Click **Next** and accept the EULA if any.

6 Click **Finish**.

#### Results

The Supervisor Service and all of its information is registered with the vCenter Server system. The service is in Active state.

## Workload Management

Namespaces   Supervisor Clusters   **Services**   Updates

vSphere Services | SC2-10-185-226-93.ENG.VMWARE.COM ▾

vSphere Services is a platform for managing core infrastructure components, such as virtual machines. Application teams are able to deploy instances of vSphere Services within their own Namespaces using industry standard tools and practices.


Sort By: Recently added ▾ ↕

Below are the services registered to the selected vCenter. Services with multiple versions can be managed from the same Service card.

✔ MinIO was registered successfully on vCenter sc2-10-185-226-93.eng.vmware.com. This service can now be [View Supervisor Clusters](#) ✕ installed on Supervisor Clusters.


Add New Service  
or drop a service bundle file

[ADD](#)

 VM Service

This service allows developers to self-service VMs and allows you to set policies for VM deployment.

[MANAGE](#)

 MinIO

Status: Active

[Active Versions 1](#) [Supervisors 0](#)

MinIO is a high-performance, cloud-native obje...

[ACTIONS ▾](#)

### What to do next

Install the Supervisor Service on Supervisor Clusters so that your DevOps engineers can use it in Kubernetes workloads. See [Install a Supervisor Service on Supervisor Clusters](#).

## Install a Supervisor Service on Supervisor Clusters

After adding a Supervisor Service to vCenter Server, you can install it on Supervisor Clusters in your vSphere with Tanzu environment. If you install a newer version of a Supervisor Service, it overrides any older service versions on that Supervisor Cluster. Only one Supervisor Clusters version can run on a Supervisor Cluster at a time.

- Learn more about the supported Supervisor Services and how to download their service YAML files at <http://vmware.com/go/supervisor-service>.

## Prerequisites

- Add a new Supervisor Service or a newer version of an existing service to vCenter Server. See [Add a Supervisor Service to vCenter Server](#) or [Add a New Version to a Supervisor Service](#).
- Verify that you have the **Manage Supervisor Services** privilege on the vCenter Server system that hosts the Supervisor Cluster where you install the service.
- If the Supervisor Service requires persistent storage, configure the vSAN Data Persistence platform. See [Using vSAN Data Persistence Platform with Modern Stateful Services](#).

## Procedure

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Select **Services**.
- 3 Select the Supervisor Service version that you want to install.

---

**Note** You cannot install Supervisor Service versions that are Deactivated.

---

- 4 Select the Supervisor Cluster where you want to install the service.
- 5 Fill in the registry endpoint, user name, and password if you have hosted the images in a private registry.

Other key-value pairs might exist in case the service requires them. Refer to the service documentation for more details.

## Results

The Supervisor Service is in Configuring state, which means that all the necessary resources are being created in the Supervisor Cluster and the service YAML is being applied to the cluster. Once the YAML is successfully applied to the Supervisor Cluster with all its resources and namespace created or updated, the service state changes to Configured. The service is available to all the namespaces in that cluster and DevOps engineers can use it with their Kubernetes workloads.

vSphere Services

**INSTALLED** AVAILABLE

Below are the service versions installed on this Supervisor Cluster. [View available services for installation](#)

EDIT UNINSTALL

	Service Version Name	Namespace	Status	Version	Desired version
<input type="radio"/>	Hyperstore	svc-hyperstore-domain-c9	✔ Configured	1.0.0	1.0.0

1 item

**Note** The Supervisor Cluster is not monitoring if the Supervisor Service is actually working. For example, if you have specified incorrect registry user name or password, the service might not be able to fetch any of the images that it needs to run. This way, the service might show as Configured but it's not actually working. To confirm if the Supervisor Service is working or not, check the service namespace and the running pods.

#### What to do next

Configure the Supervisor Service by using the interface. See where to find it at [Access the Management Interface of a Supervisor Service on the Supervisor Cluster](#)

## Access the Management Interface of a Supervisor Service on the Supervisor Cluster

Check out where to find the management UI of Supervisor Services once you install them on a Supervisor Cluster. Supervisor Services can provide their own UI plug-in for vCenter Server that adds the service interface to the Supervisor Cluster view in the vSphere Client. Depending on the Supervisor Service specifics, you can use its interface to configure and manage the service also to deploy service instances of that service.

#### Procedure

- 1 In the vSphere Client, navigate to the Supervisor Cluster.
- 2 Select **Configure** and scroll down to the service interface, which is usually named after the service, for example **MinIO**.

## Add a New Version to a Supervisor Service

Once you have added a Supervisor Service to vCenter Server where you have your vSphere with Tanzu environment, you can add new version to that service. You can install different service versions on Supervisor Clusters.

- Learn more about the supported Supervisor Services and how to download their service YAML files at <http://vmware.com/go/supervisor-service>.

### Prerequisites

- Add the service to vCenter Server. See [Add a Supervisor Service to vCenter Server](#).
- Verify that you have the **Manage Supervisor Services** privilege on the vCenter Server system where you add the new service version.

### Procedure

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Select **Services**.
- 3 In the card of the service to which you want to add a new version, select **Actions > Add New Version**.
- 4 Upload the YAML file of the new service version and click **Next**.
- 5 Accept the EULA if any and click **Finish**.

### Results

The new service version is added and it's in Active state.

### What to do next

Install the new service version on Supervisor Clusters. See [Install a Supervisor Service on Supervisor Clusters](#).

## View Supervisor Services Installed on a Supervisor Cluster

View the vSphere services installed on the Supervisor Clusters in your vSphere with Tanzu environment. Supervisor Services installed on a Supervisor Cluster are available to each namespace on the cluster.

### Prerequisites

- Add Supervisor Services to vCenter Server. See [Add a Supervisor Service to vCenter Server](#).
- Install Supervisor Services on Supervisor Clusters. See [Install a Supervisor Service on Supervisor Clusters](#).

### Procedure

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Select the **Supervisor Clusters** tab.

- On a Supervisor Cluster, in the **Services** column, click **View**.

vSphere Services

**INSTALLED** AVAILABLE

Below are the service versions installed on this Supervisor Cluster. [View available services for installation](#)

EDIT UNINSTALL

	Service Version Name	Namespace	Status	Version	Desired version
<input type="radio"/>	Hyperstore	svc-hyperstore-domain-c9	✔ Configured	1.0.0	1.0.0

1 item

- In the **Installed** tab, view the Supervisor Services that are currently installed in the Supervisor Cluster.
- In the **Available** tab, view the Supervisor Services that are available for installation.

### What to do next

You can manage the Supervisor Services on that Supervisor Cluster, uninstall services, or install new ones from the services in the **Available** tab.

## Deactivate a Supervisor Service or a Version

Deactivate a Supervisor Service version if you no longer want to use it with Kubernetes workloads in your vSphere with Tanzu environment. A Deactivated service version continues to run on the Supervisor Clusters where it is installed, but you cannot install a Deactivated service version on other Supervisor Clusters. When you deactivate an entire service, all of the service versions become Deactivated, you cannot add new service versions or install them on Supervisor Clusters, until you reactivate the service.

### Prerequisites

- Verify that you have the **Manage Supervisor Services** privilege on vCenter Server level.

### Procedure

- From the vSphere Client home menu, select **Workload Management**.
- Select **Services**.
- In the service card, select **Actions > Manage Versions**.
  - To deactivate a Supervisor Service version, select the version and click **Deactivate**.
  - To deactivate the entire service, click **Confirm** next to **Deactivate entire service**.



## Manage Versions: MinIO

Service ID: minio



Deactivating a version for this service will prevent its installation on supported Supervisor Clusters. Your running instances will not be impacted.



Below are details for all the versions available for MinIO.

- To delete a version, you must deactivate it and remove it on Supervisor Clusters before deleting.
- To delete a service, you must first deactivate the entire service and remove its versions on Supervisor Clusters.

You cannot create instances on Supervisor Clusters with deactivated versions and services.

[DEACTIVATE](#) [DELETE](#)

	Service Version Name	Version	Status	Supervisor Clusters
<input checked="" type="radio"/>	MinIO	3.0.0	Active	0
<input type="radio"/>	MinIO	2.0.0	Active	0

2 items

Deactivate entire service [CONFIRM](#)

You must deactivate a service before deleting it.

- All versions will also be deactivated.
- Versions cannot be added or changed.
- Versions cannot be installed on clusters.

[CLOSE](#)

### Results

The service version is deactivated and you cannot install on Supervisor Clusters.

## Activate a Supervisor Service Version on vCenter Server

Once a Supervisor Service version has been deactivated, you can activate it again in case your DevOps team wants to use that service version in their Kubernetes workloads running on vSphere with Tanzu.

- Verify that you have the **Manage Supervisor Services** privilege on the vCenter Server system where the service is registered.

### Procedure

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Select **Services**.
- 3 In the Supervisor Service card click **Active Versions**.
- 4 Select **Manage Versions**.
- 5 Select the Supervisor Service version that is in Deactivated status and click **Reactivate**.

## Uninstall a Supervisor Service from a Supervisor Cluster

Uninstall a Supervisor Service from a Supervisor Cluster if your DevOps team no longer needs that service for their Kubernetes workloads running in the vSphere with Tanzu environment.

### Prerequisites

- Verify that you have the **Manage Supervisor Services** privilege on the vCenter Server system that hosts the Supervisor Cluster where the service is installed.

### Procedure

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Select **Supervisor Clusters**.
- 3 On a Supervisor Cluster, in the **Services** column, click **View**.
- 4 Select the Supervisor Service that you want to uninstall and click **Uninstall**.

### Results

The Supervisor Service is uninstalled from the Supervisor Cluster. All the services resources and the service namespace are removed from the Supervisor Cluster. All the managed instances of services that use the vSAN Data Persistence Platform are removed from the Supervisor Cluster.

## Delete a Supervisor Service Version

Delete the version of a Supervisor Service from vCenter Server if this version is obsolete and your DevOps team no longer need it for their Kubernetes workload running in the vSphere with Tanzu environment.

### Prerequisites

- Verify that the Supervisor Service version that you want to delete is not installed on Supervisor Clusters. See [Uninstall a Supervisor Service from a Supervisor Cluster](#).
- Verify that you have the **Manage Supervisor Services** privilege on vCenter Server level.

### Procedure

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Select **Services**.
- 3 In the Supervisor Service card, select **Actions > Manage Versions**.
- 4 Select the version that you want to delete and click **Deactivate**.
- 5 Select the deactivated version and click **Delete**.

## Delete a Supervisor Service

Delete a Supervisor Service from the vSphere with Tanzu environment if your DevOps engineers no longer need it for their Kubernetes workloads.

### Prerequisites

- Verify that you have the **Manage Supervisor Services** privilege on the vCenter Server system where the service is registered.

### Procedure

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Select **Services**.
- 3 In the card of the Supervisor Service that you want to remove, select **Actions > Delete**.
- 4 Confirm deactivating all currently available service versions.
- 5 Confirm uninstalling the service from Supervisor Clusters.

Uninstalling a Supervisor Service from the Supervisor Clusters where it runs might take some time. You can close the dialog while the process completes and then reopen it to proceed with the next stage.

## Delete Hyperstore | Service ID: hyperstore



You cannot delete the service until all steps are complete.

Uninstalling Hyperstore versions from Supervisor Clusters. You can close this modal and come back.

Hyperstore deactivated.

Impact to services upon uninstallation is dependent on each operator. Running instances might be deleted.

**1. Service deactivated.**

- All versions will also be deactivated.
- Versions cannot be added or changed.
- Versions cannot be installed on clusters.

[REACTIVATE](#)**2. Uninstall all versions from Supervisor Clusters.**

All versions need to be uninstalled from Supervisor Clusters for the Service to be deleted.

Supervisor Cluster	Service Version Name	Version	Service Status
compute-cluster	Hyperstore	1.0.0	Removing
			1 item

**3. Delete all versions of the Service.**

All versions needs to be deleted before deleting the service.

**6** Confirm deleting all available versions of the service.**7** Click **Delete**.

# Connecting to vSphere with Tanzu Clusters

# 9

You connect to the Supervisor Cluster to provision Tanzu Kubernetes clusters. Once provisioned you can connect to Tanzu Kubernetes clusters using various methods and authenticate based on your role and objective.

This chapter includes the following topics:

- Download and Install the Kubernetes CLI Tools for vSphere
- Configure Secure Login for vSphere with Tanzu Clusters
- Connect to the Supervisor Cluster as a vCenter Single Sign-On User
- Authenticating with Tanzu Kubernetes Clusters
- Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User
- Connect to the Tanzu Kubernetes Cluster Control Plane as the Administrator
- SSH to Tanzu Kubernetes Cluster Nodes as the System User Using a Private Key
- SSH to Tanzu Kubernetes Cluster Nodes as the System User Using a Password
- Grant Developer Access to Tanzu Kubernetes Clusters

## Download and Install the Kubernetes CLI Tools for vSphere

You can use Kubernetes CLI Tools for vSphere to view and control vSphere with Tanzu namespaces and clusters.

The Kubernetes CLI Tools download package includes two executables: the standard open-source kubectl and the vSphere Plugin for kubectl. The kubectl CLI has a pluggable architecture. The vSphere Plugin for kubectl extends the commands available to kubectl so that you connect to the Supervisor Cluster and to Tanzu Kubernetes clusters using vCenter Single Sign-On credentials.

---

**Note** As a best practice, once you have performed a vSphere Namespace update and upgraded the Supervisor Cluster, update the vSphere Plugin for kubectl. See [Update the vSphere Plugin for kubectl](#).

---

### Prerequisites

- Get the link for the Kubernetes CLI Tools download page from your vSphere administrator.

- Alternatively, if you have access to the vCenter Server, get the link as follows:
  - Log in to the vCenter Server using the vSphere Client.
  - Navigate to **vSphere Cluster > Namespaces** and select the vSphere Namespace where you are working.
  - Select the **Summary** tab and locate the **Status** area on this page.
  - Select **Open** beneath the **Link to CLI Tools** heading to open the download page. Or, you can **Copy** the link.

#### Procedure

- 1 Using a browser, navigate to the **Kubernetes CLI Tools** download URL for your environment.
- 2 Select the operating system.
- 3 Download the `vsphere-plugin.zip` file.
- 4 Extract the contents of the ZIP file to a working directory.

The `vsphere-plugin.zip` package contains two executable files: `kubectl` and vSphere Plugin for `kubectl`. `kubectl` is the standard Kubernetes CLI. `kubectl-vsphere` is the vSphere Plugin for `kubectl` to help you authenticate with the Supervisor Cluster and Tanzu Kubernetes clusters using your vCenter Single Sign-On credentials.

- 5 Add the location of both executables to your system's PATH variable.
- 6 To verify the installation of the `kubectl` CLI, start a shell, terminal, or command prompt session and run the command `kubectl`.

You see the `kubectl` banner message, and the list of command-line options for the CLI.

- 7 To verify the installation of the vSphere Plugin for `kubectl`, run the command `kubectl vsphere`.

You see the vSphere Plugin for `kubectl` banner message, and the list of command-line options for the plugin.

#### What to do next

[Configure Secure Login for vSphere with Tanzu Clusters.](#)

## Configure Secure Login for vSphere with Tanzu Clusters

To log in securely to vSphere with Tanzu clusters, including the Supervisor Cluster and Tanzu Kubernetes clusters, configure the vSphere Plugin for `kubectl` with the appropriate TLS certificate and ensure that you are running the latest edition of the plugin.

## Supervisor Cluster CA Certificate

vSphere with Tanzu supports vCenter Single Sign-On for cluster access using the vSphere Plugin for kubectl command `kubectl vsphere login ...`. To install and use this utility, see [Download and Install the Kubernetes CLI Tools for vSphere](#).

The vSphere Plugin for kubectl defaults to secure login and requires a trusted certificate, the default being the certificate signed by the vCenter Server root CA. Although the plugin supports the `--insecure-skip-tls-verify` flag, for security reasons this is not recommended.

To securely log in to the Supervisor Cluster and Tanzu Kubernetes clusters using the vSphere Plugin for kubectl, you have two options:

Option	Instructions
Download and install the vCenter Server root CA certificate on each client machine.	Refer to the VMware knowledge base article <a href="#">How to download and install vCenter Server root certificates</a> .
Replace the VIP certificate used for the Supervisor Cluster with a certificate signed by a CA each client machine trusts.	See <a href="#">Replace the VIP Certificate to Securely Connect to the Supervisor Cluster API Endpoint</a>

**Note** For additional information on vSphere authentication, including vCenter Single Sign-On, managing and rotating vCenter Server certificates, and troubleshooting authentication, see the [vSphere Authentication](#) documentation.

## Tanzu Kubernetes Cluster CA Certificate

To connect securely with the Tanzu Kubernetes cluster API server using the `kubectl` CLI, you need to download the Tanzu Kubernetes cluster CA certificate.

If you are using the latest edition of the vSphere Plugin for kubectl, the first time you log in to the Tanzu Kubernetes cluster, the plugin registers the Tanzu Kubernetes cluster CA certificate in your kubeconfig file. This certificate is stored in the Kubernetes secret named `TANZU-KUBERNETES-CLUSTER-NAME-ca`. The plugin uses this certificate to populate the CA information in the corresponding cluster's certificate authority datastore.

If you are updating vSphere with Tanzu, make sure you update to the latest version of the plugin. See [Update the vSphere Plugin for kubectl](#).

## Connect to the Supervisor Cluster as a vCenter Single Sign-On User

To provision vSphere Pods, or Tanzu Kubernetes clusters by using the Tanzu Kubernetes Grid Service, you connect to the Supervisor Cluster by using the vSphere Plugin for kubectl and authenticate with your vCenter Single Sign-On credentials.

After you log in to the Supervisor Cluster, the vSphere Plugin for kubectl generates the context for the cluster. In Kubernetes, a configuration context contains a cluster, a namespace, and a user. You can view the cluster context in the file `.kube/config`. This file is commonly called the `kubeconfig` file.

---

**Note** If you have an existing `kubeconfig` file, it is appended with each cluster context. The vSphere Plugin for kubectl respects the `KUBECONFIG` environment variable that kubectl itself uses. Although not required, it can be useful to set this variable before running `kubectl vsphere login ...` so that the information is written to a new file, instead of being added to your current `kubeconfig` file.

---

### Prerequisites

- Get your vCenter Single Sign-On credentials.
- Get the IP address of the Supervisor Cluster control plane.
- Get the name of the vSphere Namespace.
- Get confirmation that you have **Edit** permissions on the vSphere Namespace.
- [Download and Install the Kubernetes CLI Tools for vSphere.](#)
- Verify that the certificate served by the Kubernetes control plane is trusted on your system, either by having the signing CA installed as a Trust Root or by adding the certificate as a Trust Root directly. See [Configure Secure Login for vSphere with Tanzu Clusters.](#)

### Procedure

- 1 To view the command syntax and options for logging in, run the following command.

```
kubectl vsphere login --help
```

- 2 To connect to the Supervisor Cluster, run the following command.

```
kubectl vsphere login --server=<KUBERNETES-CONTROL-PLANE-IP-ADDRESS> --vsphere-username  
<VCENTER-SSO-USER>
```

For example:

```
kubectl vsphere login --server=10.92.42.13 --vsphere-username administrator@example.com
```

This action creates a configuration file with the JSON Web Token (JWT) to authenticate to the Kubernetes API.



- 3 To authenticate, enter the password for the user.

After you connect to the Supervisor Cluster, you are presented with the configuration contexts can access. For example:

```
You have access to the following contexts:
tanzu-ns-1
tkg-cluster-1
tkg-cluster-2
```

- 4 To view details of the configuration contexts which you can access to, run the following `kubectl` command:

```
kubectl config get-contexts
```

The CLI displays the details for each available context.

- 5 To switch between contexts, use the following command:

```
kubectl config use-context <example-context-name>
```

#### What to do next

[Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User.](#)

## Authenticating with Tanzu Kubernetes Clusters

You can authenticate with the Tanzu Kubernetes cluster environment in various ways depending on your role and purpose.

DevOps engineers provision and operate Tanzu Kubernetes clusters. Developers deploy workloads to Tanzu Kubernetes clusters. Administrators might need to troubleshoot Tanzu Kubernetes clusters. vSphere with Tanzu provides authentication methods supporting each role or objective.

- DevOps engineers connect to the Supervisor Cluster to provision and update Tanzu Kubernetes clusters. Authentication is done using the vSphere Plugin for `kubectl` and vCenter Single Sign-On credentials. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).
- Cluster administrators connect to a provisioned Tanzu Kubernetes cluster to operate and manage it.
  - A user granted the **Edit** permission on the vSphere Namespace where the cluster is deployed is assigned to the `cluster-admin` role. Cluster administrators authenticate using the vSphere Plugin for `kubectl` and their vCenter Single Sign-On credentials. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).

- Alternatively, cluster administrators can connect to a Tanzu Kubernetes cluster as the `kubernetes-admin` user. This method might be appropriate if vCenter Single Sign-On authentication is not available. See [Connect to the Tanzu Kubernetes Cluster Control Plane as the Administrator](#).
- Cluster users or developers connect to a Tanzu Kubernetes cluster to deploy workloads, including pods, services, load balancers, and other resources.
  - A cluster administrator grants cluster access to developers by binding the user or group to default or custom pod security policy. For more information, see [Grant Developer Access to Tanzu Kubernetes Clusters](#).
  - Bound developers authenticate with Tanzu Kubernetes clusters using the vSphere Plugin for kubectl and their vCenter Single Sign-On credentials. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).
- For troubleshooting purposes, system administrators can connect to a Tanzu Kubernetes cluster as the `vmware-system-user` using SSH and a private key. See [SSH to Tanzu Kubernetes Cluster Nodes as the System User Using a Private Key](#).

## Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User

You can connect to a Tanzu Kubernetes cluster using the vSphere Plugin for kubectl and authenticate with your vCenter Single Sign-On credentials.

After you log in to the Tanzu Kubernetes cluster, the vSphere Plugin for kubectl generates the context for the cluster. In Kubernetes, a configuration context contains a cluster, a namespace, and a user. You can view the cluster context in the file `.kube/config`. This file is commonly called the `kubeconfig` file.

---

**Note** If you have an existing `kubeconfig` file, it is appended with each cluster context. The vSphere Plugin for kubectl respects the `KUBECONFIG` environment variable that kubectl itself uses. Although not required, it can be useful to set this variable before running `kubectl vsphere login ...` so that the information is written to a new file, instead of being added to your current `kubeconfig` file.

---

### Prerequisites

Obtain the following information from your vSphere administrator:

- Get your vCenter Single Sign-On credentials.
- Get the IP address of the Supervisor Cluster control plane.
- Get the name of the vSphere Namespace.
- [Download and Install the Kubernetes CLI Tools for vSphere](#).

**Procedure**

- 1 To view the command syntax and options for logging in, run the following command.

```
kubectl vsphere login --help
```

- 2 To connect to the Tanzu Kubernetes cluster, run the following command.

```
kubectl vsphere login --server=SUPERVISOR-CLUSTER-CONTROL-PLANE-IP
--tanzu-kubernetes-cluster-name TANZU-KUBERNETES-CLUSTER-NAME
--tanzu-kubernetes-cluster-namespace SUPERVISOR-NAMESPACE-WHERE-THE-CLUSTER-IS-DEPLOYED
--vsphere-username VCENTER-SSO-USER-NAME
```

For example:

```
kubectl vsphere login --server=10.92.42.137
--tanzu-kubernetes-cluster-name tanzu-kubernetes-cluster-01
--tanzu-kubernetes-cluster-namespace tanzu-ns-1
--vsphere-username administrator@example.com
```

This action creates a configuration file with the JSON Web Token (JWT) to authenticate to the Kubernetes API.

- 3 To authenticate, enter your vCenter Single Sign-On password.

If the operation is successful, you see the message `Logged in successfully`, and you can run `kubectl` commands against the cluster. If the command returns `Error from server (Forbidden)`, typically this error means you do not have the required permissions. For more information, see [Troubleshoot vCenter Single Sign-On Connection Errors](#).

- 4 To get a list of contexts available to you, run the following command:

```
kubectl config get-contexts
```

This command lists the configuration contexts you have access to. You see a configuration context for the target cluster, such as `tkg-cluster-01`.

- 5 To use the context for the target cluster, run the following command:

```
kubectl config use-context CLUSTER-NAME
```

- 6 To list cluster nodes, run the following command:

```
kubectl get nodes
```

You see the control plane and worker nodes in this cluster.

- 7 To list all the cluster pods, run the following command:

```
kubectl get pods -A
```

You see all the pods in this cluster across all Kubernetes namespaces that you have access to. If you have not deployed any workloads, you do not see any pods in the default namespace.

## Connect to the Tanzu Kubernetes Cluster Control Plane as the Administrator

You can connect to the Tanzu Kubernetes cluster control plane as the `kubernetes-admin` user to perform administrative tasks and troubleshoot cluster problems.

A valid `kubeconfig` file for a provisioned Tanzu Kubernetes cluster is available on the Supervisor Cluster as a secret object named `TKGS-CLUSTER-NAME-kubeconfig`. You can use this secret to connect to the cluster control plane as the `kubernetes-admin` user. For more information, see [Get Tanzu Kubernetes Cluster Secrets](#).

### Procedure

- 1 Connect to the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).
- 2 Switch context to the vSphere Namespace where the target Tanzu Kubernetes cluster is provisioned.

```
kubectl config use-context VSPHERE-NAMESPACE
```

- 3 View the secret objects in the namespace.

```
kubectl get secrets
```

The secret is named `TKGS-CLUSTER-NAME-kubeconfig`.

```
kubectl config use-context tkgs-cluster-ns
Switched to context "tkgs-cluster-ns".
ubuntu@ubuntu:~$ kubectl get secrets
NAME                                TYPE          DATA   AGE
...
tkgs-cluster-1-kubeconfig           Opaque        1       23h
...
```

- 4 Decode the secret by running the following command.

The secret is Base64 encoded. To decode it: on Linux use `base64 --decode` (or `base64 -d`); on MacOS, use `base64 --Decode` (or `base64 -D`); on Windows, use an [online tool](#).

```
kubectl get secret TKGS-CLUSTER-NAME-kubeconfig -o jsonpath='{.data.value}' | base64 -d >
tkgs-cluster-kubeconfig-admin
```

This command decodes the secret and writes it to a local file named `tkgs-cluster-kubeconfig-admin`. Use the `cat` command to verify the file contents.

- 5 Connect to the Tanzu Kubernetes cluster as the Kubernetes administrator using the decoded `tkgs-cluster-kubeconfig-admin` file.

There are two options to do this:

Option	Description
<code>--kubeconfig &lt;path\to\kubeconfig&gt;</code>	Use the <code>--kubeconfig</code> flag and the path to the local kubeconfig file. For example, assuming the kubeconfig file is in the same directory where you are running the command: <code>kubectl --kubeconfig tkgs-cluster-kubeconfig-admin get nodes</code>
<b>KUBECONFIG</b>	Set your KUBECONFIG environment variable to point to the decoded kubeconfig file and run kubectl, such as <code>kubectl get nodes</code> .

You should see the nodes in the cluster. For example:

```
kubectl --kubeconfig tkgs-cluster-kubeconfig-admin get nodes
NAME                                STATUS    ROLES    AGE   VERSION
tkgs-cluster-1-control-plane-4ncm4  Ready    master   23h   v1.18.5+vmware.1
tkgs-cluster-1-control-plane-jj9gq  Ready    master   23h   v1.18.5+vmware.1
tkgs-cluster-1-control-plane-r4hm6  Ready    master   23h   v1.18.5+vmware.1
tkgs-cluster-1-workers-6nj7-84dd7f48c6-nz2n8  Ready    <none>   23h   v1.18.5+vmware.1
tkgs-cluster-1-workers-6nj7-84dd7f48c6-rk9pk  Ready    <none>   23h   v1.18.5+vmware.1
tkgs-cluster-1-workers-6nj7-84dd7f48c6-zzngh  Ready    <none>   23h   v1.18.5+vmware.1
```

## SSH to Tanzu Kubernetes Cluster Nodes as the System User Using a Private Key

You can SSH to a Tanzu Kubernetes cluster node as the `vmware-system-user` using a private key.

You can connect through SSH to any Tanzu Kubernetes cluster node as the `vmware-system-user` user. The secret that contains the SSH private key is named `CLUSTER-NAME-ssh`. For more information, see [Get Tanzu Kubernetes Cluster Secrets](#).

To connect to a Tanzu Kubernetes cluster node over SSH using a private key, you create a jump box vSphere Pod on the Supervisor Cluster.

### Prerequisites

In this task you provision a vSphere Pod as a jump host for SSH connectivity. vSphere Pods require NSX-T networking for the Supervisor Cluster. If you are using vDS networking for the Supervisor Cluster, use the following approach instead: [SSH to Tanzu Kubernetes Cluster Nodes as the System User Using a Password](#).

### Procedure

- 1 Connect to the Supervisor Cluster.

See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

- 2 Create an environment variable named **NAMESPACE** whose value is the name of the vSphere Namespace where the target Tanzu Kubernetes cluster is provisioned.

```
export NAMESPACE=VSPHERE-NAMESPACE
```

- 3 Switch context to the vSphere Namespace where the Tanzu Kubernetes cluster is provisioned.

```
kubectl config use-context $NAMESPACE
```

- 4 View the `TKGS-CLUSTER-NAME-ssh` secret object.

```
kubectl get secrets
```

- 5 Create a vSphere Pod using the following `jumpbox.yaml`.

Replace the `namespace` value `YOUR-NAMESPACE` with the vSphere Namespace where the target cluster is provisioned. Replace the `secretName` value `YOUR-CLUSTER-NAME-ssh` with name of the target cluster.

```
apiVersion: v1
kind: Pod
metadata:
  name: jumpbox
  namespace: YOUR-NAMESPACE      #REPLACE
spec:
  containers:
  - image: "photon:3.0"
    name: jumpbox
    command: [ "/bin/bash", "-c", "--" ]
    args: [ "yum install -y openssh-server; mkdir /root/.ssh; cp /root/ssh/ssh-privatekey /
root/.ssh/id_rsa; chmod 600 /root/.ssh/id_rsa; while true; do sleep 30; done;" ]
    volumeMounts:
    - mountPath: "/root/ssh"
      name: ssh-key
      readOnly: true
  resources:
    requests:
      memory: 2Gi
  volumes:
  - name: ssh-key
    secret:
      secretName: YOUR-CLUSTER-NAME-ssh      #REPLACE
```

- 6 Deploy the pod by applying the `jumpbox.yaml` spec.

```
kubectl apply -f jumpbox.yaml
```

```
pod/jumpbox created
```

**7** Verify that the pod is running.

```
kubectl get pods
```

NAME	READY	STATUS	RESTARTS	AGE
jumpbox	1/1	Running	0	3h9m

**Note** You should also see the jumpbox pod in vCenter in the vSphere Namespace.

**8** Create an environment variable with the IP address of the target cluster node by running the following set of commands.

- a Get the name of the target virtual machine.

```
kubectl get virtualmachines
```

- b Create the environment variable `VMNAME` whose value is the name of the target node.

```
export VMNAME=NAME-OF-THE-VIRTUAL-MACHINE
```

- c Create the environment variable `VMIP` whose value is the IP address of the target node VM.

```
export VMIP=$(kubectl -n $NAMESPACE get virtualmachine/$VMNAME -o
jsonpath='{.status.vmIp}')
```

**9** SSH to the cluster node using the jump box pod by running the following command.

```
kubectl exec -it jumpbox /usr/bin/ssh vmware-system-user@$VMIP
```

**Important** It takes approximately 60 seconds to create the container and install the software. If you receive an "error executing command in container: container\_linux.go:370: starting container process caused: exec: "/usr/bin/ssh": stat /usr/bin/ssh: no such file or directory," try the command again in a few seconds.

**10** Confirm the authenticity of the host by entering **yes**.

```
The authenticity of host '10.249.0.999 (10.249.0.999)' can't be established.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '10.249.0.999' (ECDSA) to the list of known hosts.
Welcome to Photon 3.0
```

- 11 Confirm that you are logged into the target node as the `vmware-system-user`.

For example, the following output indicates that you are logged into a control plane node as the system user.

```
vmware-system-user@tkgs-cluster-1-control-plane-66tbr [ ~ ]$
```

- 12 Perform the desired operations on the node.

---

**Attention** You might need to use `sudo` or `sudo su` to perform certain operations on the node, such as restarting kubelet.

---

- 13 When done, type `exit` to log out of the SSH session on the vSphere Pod.

- 14 To delete the pod, run the command `kubectl delete pod jumpbox`.

---

**Caution** For security, consider deleting the jumpbox pod after you have done your work. If needed you can recreate it at a later time.

---

## SSH to Tanzu Kubernetes Cluster Nodes as the System User Using a Password

You can SSH to a Tanzu Kubernetes cluster node as the `vmware-system-user` using a password.

You can connect to a cluster node as the `vmware-system-user` user with a password. The password is stored as a secret named `CLUSTER-NAME-ssh-password`. The password is base64 encoded in `.data.ssh-passwordkey`. You can provide the password over an SSH session. For more information about this secret, see [Get Tanzu Kubernetes Cluster Secrets](#).

### Prerequisites

To route SSH connections to the appropriate workload network, deploy a Linux jump host VM in the vSphere environment where **Workload Management** is enabled. See [Create a Linux Jump Host VM](#).

---

**Note** This is a hard requirement if you want to connect to cluster nodes using SSH and you are using vDS networking, which does not support vSphere Pods. You can also use this approach with NSX-T networking if you prefer to use a password instead of a private key to connect over SSH.

---

### Procedure

- 1 Get the IP address of the jump host VM, the username, and the password. See [Create a Linux Jump Host VM](#).
- 2 Connect to the Supervisor Cluster.  
[Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).



- 3 Switch context to the vSphere Namespace where the target Tanzu Kubernetes cluster is provisioned.

```
kubectl config use-context VSPHERE-NAMESPACE
```

- 4 Get the IP address of the target cluster node.

List the nodes.

```
kubectl get virtualmachines
```

Describe the nodes to get the IP address of the target node.

```
kubectl describe virtualmachines
```

- 5 View the `TKGS-CLUSTER-NAME-ssh-password` secret.

```
kubectl get secrets
```

- 6 Get the ssh-passwordkey for the target cluster.

```
kubectl get secrets TKGS-CLUSTER-NAME-ssh-password -o yaml
```

The ssh-passwordkey is returned, for example.

```
apiVersion: v1
data:
  ssh-passwordkey: RU1pQ1l1LTC9TRjVFV0RBcCtmdlzwOTROeURYSWNGeXNReXJhaXRBU11Yaz0=
```

- 7 Decode the ssh-passwordkey.

The secret is Base64 encoded. To decode it: on Linux use `base64 --decode` (or `base64 -d`); on MacOS, use `base64 --Decode` (or `base64 -D`); on Windows, use an [online tool](#).

```
echo <ssh-passwordkey> | base64 --decode
```

- 8 SSH to the target cluster node as the `vmware-system-user`.

```
ssh vmware-system-user@TKGS-CLUSTER-NODE-IP-ADDRESS
```

- 9 Log in using the password you decoded.

## Create a Linux Jump Host VM

To SSH to Tanzu Kubernetes cluster nodes using a password, first create a jump box VM that connects to the workload network and the management or frontend network for SSH tunneling.

## Create a Linux Jump Host VM

Follow these steps to create a Linux jump box VM. There are many ways to do this. This is one approach. The instructions use PhotonOS which you can download here: <https://github.com/vmware/photon/wiki/Downloading-Photon-OS>.

- 1 Log into vCenter Server using the vSphere Client.
- 2 Create a new virtual machine.
- 3 Select the Linux guest OS, in this example, VMware Photon OS (64-bit).
- 4 Install the OS. To do this, download the ISO, attach it to the VM and boot it.
- 5 Configure the VM with an IP address on the Workload network.
- 6 Add a second virtual NIC to the VM and assign it to the Frontend network.
- 7 Complete the configuration of the OS and power on the VM after reboot.
- 8 Log into the vSphere console for the VM as the root user.
- 9 Create a network interface for the new NIC and give it an IP on the Frontend network.

```
ifconfig eth1 IP-ADDRESS netmask NETMASK up
```

---

**Note** This method is non-persistent on reboots.

---

- 10 Verify that you can ping the gateway and DNS server through that interface
- 11 In the vSphere console for the VM, set up an SSH user with certificates. Verify that it works by creating a nested shell.
- 12 SSH into the jumpbox from the Frontend network as the SSH user to verify that works.
- 13 Install `sshpas` onto the VM (so you can log in over SSH using a password). For PhotonOS, the command is as follows:

```
tdnf install -y sshpass
```

- 14 Add the client's public key to the `~/.ssh/authorized_keys` file and restart the `sshd` process so that ssh can work without a password.
  - Get your public key, for example: `cat ~/.ssh/id_rsa.pub`.
  - Access the jumphost VM.
  - Create the SSH directory (if it does not exist): `mkdir -p ~/.ssh`.
  - Append the public key to the `authorized_keys` file: `echo ssh-rsa AAAA... >> ~/.ssh/authorized_keys`. Replace `ssh-rsa AAAA...` with the entire public key string that was output from the `cat ~/.ssh/id_rsa.pub` command.
  - Ensure that the `~/.ssh` directory and `authorized_keys` file have the appropriate permissions set, for example: `chmod -R go= ~/.ssh`.

## Grant Developer Access to Tanzu Kubernetes Clusters

Developers are the target users of Kubernetes. Once a Tanzu Kubernetes cluster is provisioned, you can grant developer access using vCenter Single Sign-On authentication.

### Authentication for Developers

A cluster administrator can grant cluster access to other users, such as developers. Developers can deploy pods to clusters directly using their user accounts, or indirectly using service accounts. For more information, see [Using Pod Security Policies with Tanzu Kubernetes Clusters](#).

- For user account authentication, Tanzu Kubernetes clusters support vCenter Single Sign-On users and groups. The user or group can be local to the vCenter Server, or synchronized from a supported directory server.
- For service account authentication, you can use service tokens. For more information, see the Kubernetes documentation.

### Adding Developer Users to a Cluster

To grant cluster access to developers:

- 1 Define a Role or ClusterRole for the user or group and apply it to the cluster. For more information, see the Kubernetes documentation.
- 2 Create a RoleBinding or ClusterRoleBinding for the user or group and apply it to the cluster. See the following example.

### Example RoleBinding

To grant access to a vCenter Single Sign-On user or group, the subject in the RoleBinding must contain either of the following values for the `name` parameter.

**Table 9-1. Supported User and Group Fields**

Field	Description
<code>sso:USER-NAME@DOMAIN</code>	For example, a local user name, such as <code>sso:joe@vsphere.local</code> .
<code>sso:GROUP-NAME@DOMAIN</code>	For example, a group name from a directory server integrated with the vCenter Server, such as <code>sso:devs@ldap.example.com</code> .

The following example RoleBinding binds the vCenter Single Sign-On local user named Joe to the default ClusterRole named `edit`. This role permits read/write access to most objects in a namespace, in this case the `default` namespace.

```
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: rolebinding-cluster-user-joe
  namespace: default
```

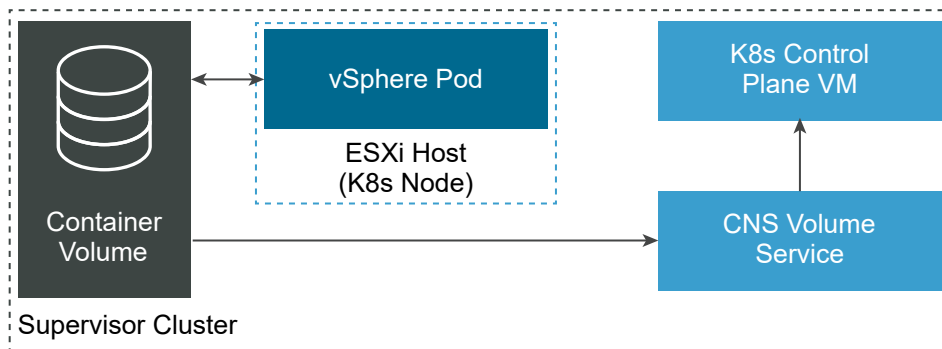
```
roleRef:
  kind: ClusterRole
  name: edit #Default ClusterRole
  apiGroup: rbac.authorization.k8s.io
subjects:
- kind: User
  name: sso:joe@vsphere.local #sso:<username>@<domain>
  apiGroup: rbac.authorization.k8s.io
```

# Using Persistent Storage in vSphere with Tanzu

# 10

Certain Kubernetes workloads require persistent storage to store data permanently. To provision persistent storage for Kubernetes workloads, vSphere with Tanzu integrates with Cloud Native Storage (CNS), a vCenter Server component that manages persistent volumes.

Persistent storage is used by vSphere Pods Tanzu Kubernetes clusters, and VMs. The following example illustrates how persistent storage is used by a vSphere Pod.



To understand how vSphere with Tanzu works with persistent storage, be familiar with the following essential concepts.

## Persistent Volume

To provide persistent storage, Kubernetes uses persistent volumes that can retain their state and data. If persistent volumes are mounted by a pod, they continue to exist even when the pod is deleted or reconfigured. In the vSphere with Tanzu environment, the persistent volume objects are backed by the First Class Disks on a datastore.

vSphere with Tanzu supports dynamic and static provisioning of volumes in ReadWriteOnce mode, where the volumes can be mounted by a single pod.

Starting with vSphere 7.0 Update 3 release, vSphere with Tanzu also supports ReadWriteMany mode for persistent volumes in Tanzu Kubernetes clusters. With the ReadWriteMany support, a single volume can be mounted simultaneously by multiple pods or applications running in a cluster. vSphere with Tanzu uses vSAN file shares for persistent volumes of the ReadWriteMany type. For more information, see [Creating ReadWriteMany Persistent Volumes in vSphere with Tanzu](#).

## Dynamic and Static Provisioning

With dynamic volume provisioning, storage does not need to be pre-provisioned and persistent volumes can be created on demand. DevOps engineers issue a persistent volume claim that references a storage class available in the namespace. vSphere with Tanzu automatically provisions the corresponding persistent volume and a backing virtual disk.

Both the Supervisor Cluster and Tanzu Kubernetes cluster support dynamic provisioning.

For an example of how to dynamically create a persistent volume, see [Provision a Dynamic Persistent Volume for a Stateful Application](#).

With static provisioning, you can use an existing storage object and make it available to a cluster.

Typically, a DevOps engineer must know the details of the existing storage object, its supported configurations, and mount options to be able to reuse it.

For an example of how to provision a static persistent volume, see [Provision a Static Persistent Volume in a Tanzu Kubernetes Cluster](#).

### First Class Disk

vSphere with Tanzu uses the First Class Disk (FCD) type of virtual disks to back persistent volumes. First Class Disk, also known as Improved Virtual Disk, is a named virtual disk not associated with a VM.

First Class Disks are identified by UUID. This UUID is globally unique and is the primary identifier for the FCD. The UUID remains valid even if its FCD is relocated or snapshotted.

### Persistent Volume Claim

DevOps engineers create persistent volume claims to request persistent storage resources. The request provisions a persistent volume object and a matching virtual disk. In the vSphere Client, the persistent volume claim manifests as an FCD virtual disk that can be monitored by vSphere administrators.

The claim is bound to the persistent volume. The workloads can use the claim to mount the persistent volumes and access storage.

When the DevOps engineers delete the claim, the corresponding persistent volume object and the provisioned virtual disk are also deleted.

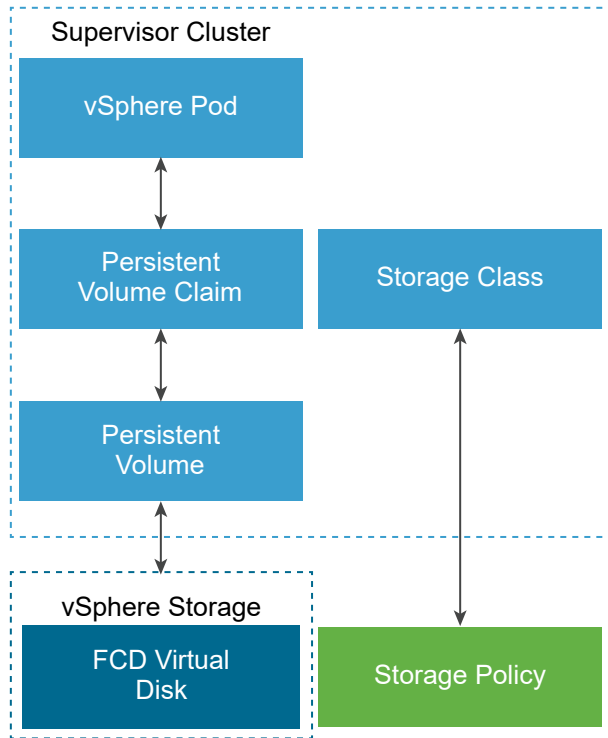
### Storage Class

Kubernetes uses storage classes to describe requirements for storage backing the persistent volumes. DevOps engineers can include a specific storage class in their persistent volume claim specification to request the type of storage the class describes.

## Persistent Storage Workflow

The workflow for provisioning persistent storage in vSphere with Tanzu generally includes the following sequential actions.

Step	Action	Description
1	vSphere administrators deliver persistent storage resources to the DevOps team.	vSphere administrators create VM storage policies that describe different storage requirements and classes of services. They can then assign the storage policies to a vSphere Namespace.
2	vSphere with Tanzu creates storage classes that match the storage policies assigned to the vSphere Namespace.	<p>The storage classes automatically appear in the Kubernetes environment, and can be used by the DevOps team. If a vSphere administrator assigns multiple storage policies to the vSphere Namespace, a separate storage class is created for each storage policy.</p> <p>If you use the Tanzu Kubernetes Grid Service to provision Tanzu Kubernetes clusters, each Tanzu Kubernetes cluster inherits storage classes from the vSphere Namespace in which the cluster is provisioned.</p>
3	DevOps engineers use the storage classes to request persistent storage resources for a workload.	The request comes in a form of a persistent volume claim that references a specific storage class.
4	vSphere with Tanzu creates a persistent volume object and a matching persistent virtual disk for a workload.	vSphere with Tanzu places the virtual disk into the datastore that meets the requirements specified in the original storage policy and its matching storage class. The virtual disk can be mounted by a workload.
5	vSphere administrators monitor persistent volumes in the vSphere with Tanzu environment.	Using the vSphere Client, vSphere administrators monitor the persistent volumes and their backing virtual disks. They can also monitor storage compliance and health statuses of the persistent volumes.



Watch this video to learn about the persistent storage in vSphere with Tanzu.



Persistent Storage in vSphere with Kubernetes

([http://link.brightcove.com/services/player/bcpid2296383276001?bctid=ref:video\\_persistent\\_storage\\_vs7\\_kubernetes](http://link.brightcove.com/services/player/bcpid2296383276001?bctid=ref:video_persistent_storage_vs7_kubernetes))

## Storage Management Tasks of a vSphere Administrator

Generally, the persistent storage management tasks in vSphere with Tanzu include the following. As a vSphere administrator, you use the vSphere Client to perform these tasks.

- Perform lifecycle operations for the VM storage policies.

Before enabling a Supervisor Cluster and configuring namespaces, create storage policies for persistent storage. The storage policies are based on the storage requirements communicated to you by the DevOps engineers. See [Create Storage Policies for vSphere with Tanzu](#).

---

**Note** Do not delete the storage policy from vCenter Server or a vSphere Namespace when a persistent volume claim with the corresponding storage class is running in the namespace. This recommendation also applies to Tanzu Kubernetes clusters.

---

- Provide storage resources to the DevOps engineers by assigning the storage policies to the namespace and by setting storage limits. For information about changing storage policy assignments, see [Change Storage Settings on a Namespace](#). For information on setting limits, see [Configure Limitations on Kubernetes Objects in a vSphere Namespace](#).



- Monitor Kubernetes objects and their storage policy compliance in the vSphere Client. See [Monitor Persistent Volumes in the vSphere Client](#).

## Storage Management Tasks of a DevOps Engineer

Typically, the DevOps engineer uses `kubectl` to perform the following storage tasks.

- Manage storage classes. See [Display Storage Classes in a vSphere Namespace or Tanzu Kubernetes Cluster](#).
- Deploy and manage stateful applications. See [Provision a Dynamic Persistent Volume for a Stateful Application](#).
- Perform lifecycle operations for persistent volumes. [Tanzu Kubernetes Persistent Volume Claim Examples](#).

This chapter includes the following topics:

- [How vSphere with Tanzu Integrates with vSphere Storage](#)
- [Functionality Supported by vSphere CNS-CSI and Paravirtual CSI in vSphere with Tanzu](#)
- [Storage Permissions in vSphere with Tanzu](#)
- [Create Storage Policies for vSphere with Tanzu](#)
- [Change Storage Settings on the Supervisor Cluster](#)
- [Change Storage Settings on a Namespace](#)
- [Display Storage Classes in a vSphere Namespace or Tanzu Kubernetes Cluster](#)
- [Provision a Dynamic Persistent Volume for a Stateful Application](#)
- [Provision a Static Persistent Volume in a Tanzu Kubernetes Cluster](#)
- [Creating ReadWriteMany Persistent Volumes in vSphere with Tanzu](#)
- [Volume Expansion in vSphere with Tanzu](#)
- [Monitor Persistent Volumes in the vSphere Client](#)
- [Monitor Volume Health in a vSphere Namespace or Tanzu Kubernetes Cluster](#)
- [Using vSAN Data Persistence Platform with Modern Stateful Services](#)

## How vSphere with Tanzu Integrates with vSphere Storage

vSphere with Tanzu uses several components to integrate with vSphere storage.

### Cloud Native Storage (CNS) on vCenter Server

The CNS component resides in vCenter Server. It is an extension of vCenter Server management that implements provisioning and lifecycle operations for persistent volumes.

When provisioning container volumes, the component interacts with the vSphere First Class Disk functionality to create virtual disks that back the volumes. In addition, the CNS server component communicates with the Storage Policy Based Management to guarantee a required level of service to the disks.

The CNS also performs query operations that allow vSphere administrators to manage and monitor persistent volumes and their backing storage objects through vCenter Server.

### First Class Disk (FCD)

Also called Improved Virtual Disk. It is a named virtual disk unassociated with a VM. These disks reside on a VMFS, NFS, or vSAN datastore and back ReadWriteOnce persistent volumes.

The FCD technology performs lifecycle operations related to persistent volumes outside of a lifecycle of a VM or pod.

When you use FCDs, keep in mind the following:

- FCDs do not support NFS 4.x protocols. Instead, use NFS 3.
- vCenter Server does not serialize operations on the same FCD. As a result, applications cannot simultaneously perform operations on the same FCD. Performing such operations as clone, relocate, delete, retrieve, and so on simultaneously from different threads causes unpredictable results. To avoid problems, applications must perform operations on the same FCD in a sequential order.
- FCD is not a managed object and does not support a global lock protecting multiple writes to a single FCD. As a result, FCD doesn't support multiple vCenter Server instances managing the same FCD. If you need to use multiple vCenter Server instances with FCDs, you have the following options:
  - Multiple vCenter Server instances can manage different datastores.
  - Multiple vCenter Server instances do not operate on the same FCD.

### Storage Policy Based Management

Storage Policy Based Management is a vCenter Server service that supports provisioning of persistent volumes and their backing virtual disks according to storage requirements described in a storage policy. After provisioning, the service monitors compliance of the volume with the storage policy characteristics. For more information about Storage Policy Based Management, see [Storage Policy Based Management](#).

### vSphere CNS-CSI

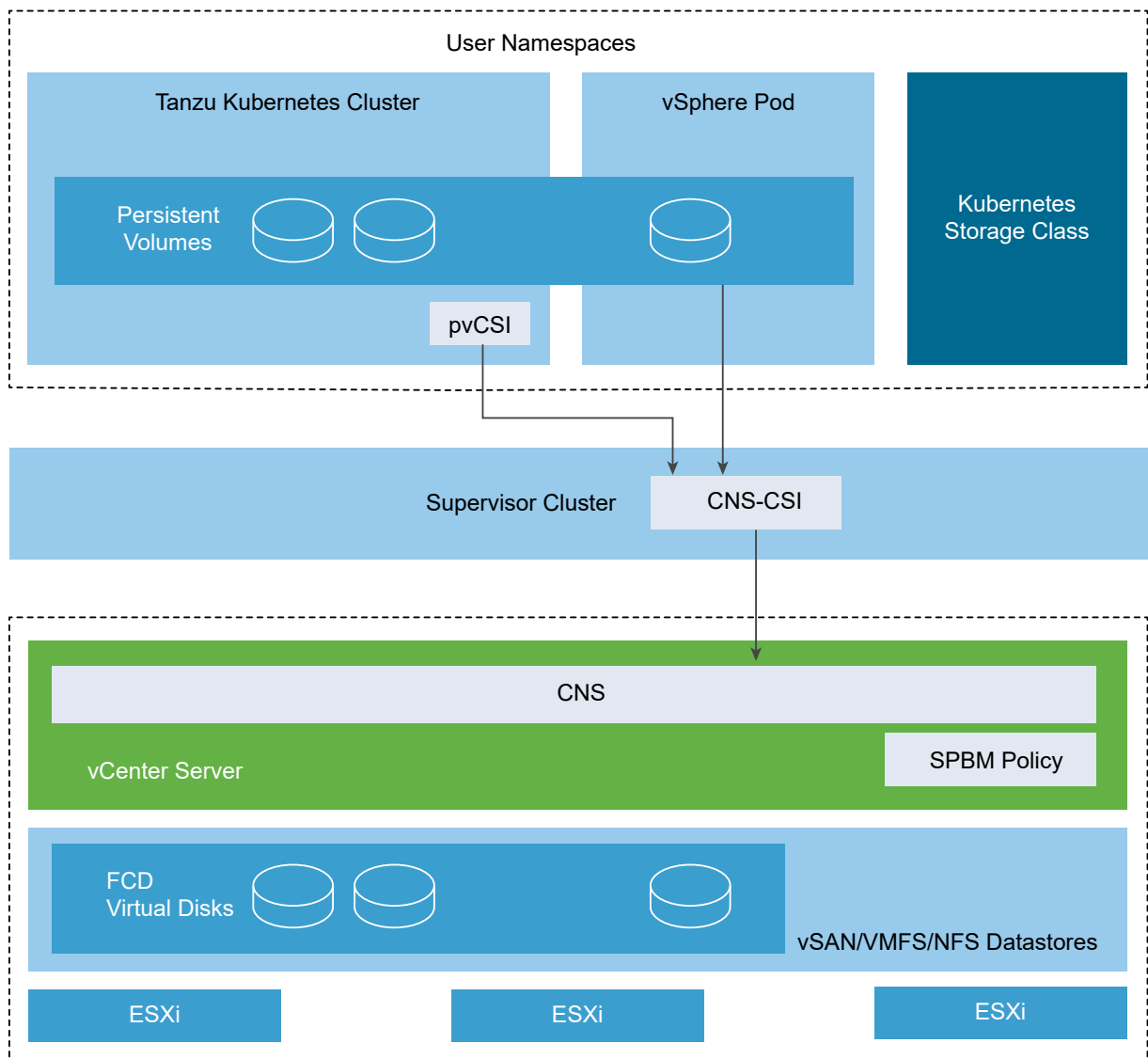
The vSphere CNS-CSI component conforms to Container Storage Interface (CSI) specification, an industry standard designed to provide an interface that container orchestrators like Kubernetes use to provision persistent storage. The CNS-CSI driver runs in the Supervisor Cluster and connects vSphere storage to Kubernetes environment on a vSphere Namespace. The vSphere CNS-CSI communicates directly with the CNS control plane for all storage

provisioning requests that come from vSphere Pods and pods that runs in a Tanzu Kubernetes cluster on the namespace.

### Paravirtual CSI (pvCSI)

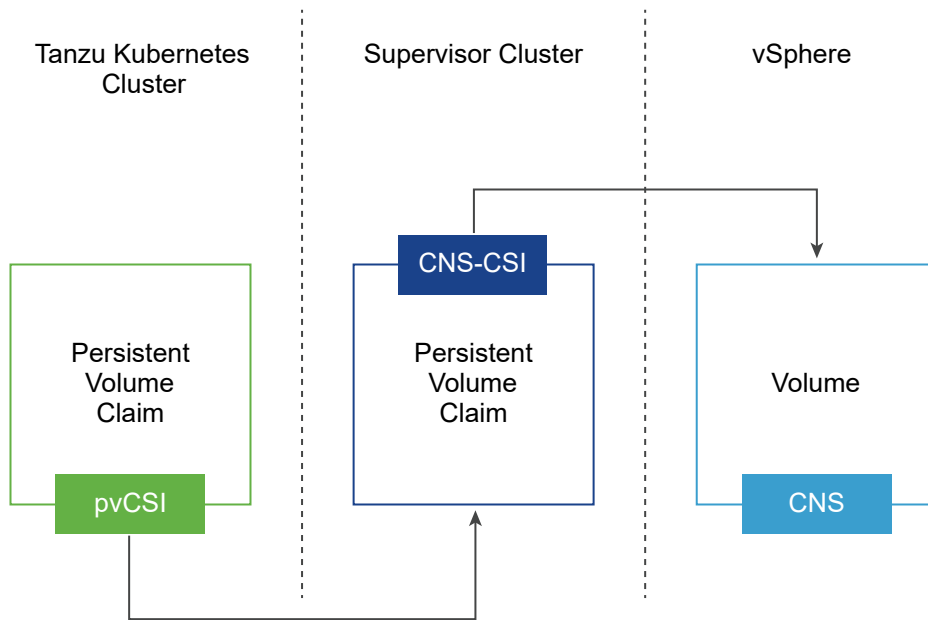
The pvCSI is the version of the vSphere CNS-CSI driver modified for Tanzu Kubernetes clusters. The pvCSI resides in the Tanzu Kubernetes cluster and is responsible for all storage related requests originating from the Tanzu Kubernetes cluster. The requests are delivered to the CNS-CSI, which then propagates them to CNS in vCenter Server. As a result, the pvCSI does not have direct communication with the CNS component, but instead relies on the CNS-CSI for any storage provisioning operations.

Unlike the CNS-CSI, the pvCSI does not require infrastructure credentials. It is configured with a service account in the vSphere Namespace.



The following illustrates how different components interact when a DevOps engineer performs a storage related operation within the Tanzu Kubernetes cluster, for example creates a persistent volume claim (PVC).

The DevOps engineer creates a PVC using the command line on the Tanzu Kubernetes cluster. This action generates a matching PVC on the supervisor cluster and triggers the CNS-CSI. The CNS-CSI invokes the CNS create volume API.



After successful creation of a volume, the operation propagates back through the supervisor cluster to the Tanzu Kubernetes cluster. As a result of this propagation, users can see the persistent volume and the persistent volume claim in the bound state in the supervisor cluster. And they also see the persistent volume and the persistent volume claim in the bound state in the Tanzu Kubernetes cluster.

## Functionality Supported by vSphere CNS-CSI and Paravirtual CSI in vSphere with Tanzu

The vSphere CNS-CSI driver that runs in the Supervisor Cluster and pvCSI driver, the CSI version modified for Tanzu Kubernetes clusters, support multiple vSphere and Kubernetes storage features. However, certain limitations apply.

Supported Functionality	vSphere CNS-CSI with Supervisor Cluster	pvCSI with Tanzu Kubernetes Cluster
CNS Support in the vSphere Client	Yes	Yes
Enhanced Object Health in the vSphere Client	Yes (vSAN only)	Yes (vSAN only)
Dynamic Block Persistent Volume (ReadWriteOnce Access Mode)	Yes	Yes

Supported Functionality	vSphere CNS-CSI with Supervisor Cluster	pvCSI with Tanzu Kubernetes Cluster
Dynamic File Persistent Volume (ReadWriteMany Access Mode)	No	Yes (with vSAN File Services)
vSphere Datastore	VMFS/NFS/vSAN/vVols	VMFS/NFS/vSAN/vVols
Static Persistent Volume	Yes	Yes
Encryption	No	No
Offline Volume Expansion	Yes	Yes
Online Volume Expansion	Yes	Yes
Volume Topology and Zones	No	No
Kubernetes Multiple Control Plane Instances	Yes	Yes
WaitForConsumerFirst	No	No
VolumeHealth	Yes	Yes

## Storage Permissions in vSphere with Tanzu

vSphere with Tanzu provides a sample role, Workload Storage Manager, that includes a set of privileges for storage operations. You can clone this role to create a similar role.

Privilege Name	Description	Required On
<b>Cns.Searchable</b>	Allows storage administrator to see the Cloud Native Storage UI.	Root vCenter Server
<b>Datastore.Allocate space</b> <b>Datastore.Low level file operations</b>	Allows allocating space on a datastore for a virtual machine, snapshot, clone, or virtual disk. Allows performing read, write, delete, and rename operations in the datastore browser.	Shared datastore where persistent volumes reside
<b>ESX Agent Manager.Modify</b>	Allows modifications to an agent virtual machine such as powering off or deleting the virtual machine.	vSphere Pod
<b>Resource.Assign virtual machine to resource pool</b>	Allows assignment of a virtual machine to a resource pool.	Resource pools

Privilege Name	Description	Required On
<b>Profile-driven storage.Profile-driven storage view</b>	Allows viewing of defined storage policies.	Root vCenter Server
<b>Virtual machine.Change Configuration.Add existing disk</b> <b>Virtual machine.Change Configuration.Add new disk</b> <b>Virtual machine.Change Configuration.Add or remove device</b> <b>Virtual machine.Change Configuration.Change Settings</b> <b>Virtual machine.Change Configuration.Remove disk</b> <b>Virtual machine.Edit Inventory.Create new</b> <b>Virtual machine.Edit Inventory.Remove</b>	Allows creation and deletion of virtual machines. Allows configuration of virtual machine options and devices.	vSphere Pod

## Create Storage Policies for vSphere with Tanzu

Before you enable vSphere with Tanzu, create storage policies to be used in the Supervisor Cluster and namespaces. The policies represent datastores available in the vSphere environment. They control the storage placement of such objects as control plane VMs, pod ephemeral disks, container images, and persistent storage volumes. If you use Tanzu Kubernetes clusters, the storage policies also dictate how the Tanzu Kubernetes cluster nodes are deployed.

Depending on your vSphere storage environment and the needs of DevOps, you can create several storage policies to represent different classes of storage. For example, if your vSphere storage environment has three classes of datastores, Bronze, Silver, and Gold, you can create storage policies for all datastores. You can then use the Bronze datastore for ephemeral and container image virtual disks, and use the Silver and Gold datastores for persistent volume virtual disks. For more information about storage policies, see the [Storage Policy Based Management](#) chapter in the *vSphere Storage* documentation.

The following example creates the storage policy for the datastore tagged as Gold.

If you use vSAN Data Persistence platform you can create storage policies for vSAN Direct or vSAN SNA datastores. For information, see [Create vSAN Direct Storage Policy](#) and [Create vSAN SNA Storage Policy](#).

### Prerequisites

- Make sure that the datastore you reference in the storage policy is shared between all ESXi hosts in the cluster.
- Required privileges: **VM storage policies. Update** and **VM storage policies. View**.

## Procedure

### 1 Add tags to the datastore.

- a Right-click the datastore you want to tag and select **Tags and Custom Attributes > Assign Tag**.
- b Click **Add Tag** and specify the tag's properties.

Property	Description
<b>Name</b>	Specify the name of the datastore tag, for example, <b>Gold</b> .
<b>Description</b>	Add the description of the tag. For example, <b>Datastore for Kubernetes objects</b> .
<b>Category</b>	Select an existing category or create a new category. For example, <b>Storage for Kubernetes</b> .

### 2 In the vSphere Client, open the **Create VM Storage Policy** wizard.

- a Click **Menu > Policies and Profiles**.
- b Under **Policies and Profiles**, click **VM Storage Policies**.
- c Click **Create VM Storage Policy**.

### 3 Enter the policy name and description.

Option	Action
<b>vCenter Server</b>	Select the vCenter Server instance.
<b>Name</b>	Enter the name of the storage policy, for example, <b>Gold Storage Policy</b> .
<b>Description</b>	Enter the description of the storage policy.

### 4 On the **Policy structure** page under **Datastore specific rules**, enable tag-based placement rules.

### 5 On the **Tag based placement** page, create the tag rules.

Select the options using the following example.

Option	Description
<b>Tag category</b>	From the drop-down menu, select the tag's category, such as <b>Storage for Kubernetes</b> .
<b>Usage option</b>	Select <b>Use storage tagged with</b> .
<b>Tags</b>	Click <b>Browse Tags</b> , and select the datastore tag, for example, <b>Gold</b> .

### 6 On the **Storage compatibility** page, review the list of datastores that match this policy.

In this example, only the datastore that is tagged as Gold is displayed.

### 7 On the **Review and finish** page, review the storage policy settings and click **Finish**.

## Results

The new storage policy for the datastore tagged as Gold appears on the list of existing storage policies.

## What to do next

After creating storage policies, a vSphere administrator can perform the following tasks:

- Assign the storage policies to the Supervisor Cluster. The storage policies configured on the Supervisor Cluster ensure that the control plane VMs, pod ephemeral disks, and container images are placed on the datastores that the policies represent. See [Enable Workload Management with NSX-T Data Center Networking](#).
- Assign the storage policies to the vSphere Namespace. Storage policies visible to the namespace determine which datastores the namespace can access and use for persistent volumes. The storage policies appear as matching Kubernetes storage classes in the namespace. They are also propagated to the Tanzu Kubernetes cluster on this namespace. DevOps engineers can use the storage classes in their persistent volume claim specifications. See [Create and Configure a vSphere Namespace](#).

# Change Storage Settings on the Supervisor Cluster

Storage policies assigned to the Supervisor Cluster manage how such objects as a control plane VM, vSphere Pod, and container image cache are placed within datastores in the vSphere storage environment. As a vSphere administrator, you typically configure storage policies when enabling the Supervisor Cluster. If you need to make any changes in the storage policy assignments after initial Supervisor Cluster configuration, perform this task. You can also use this task to activate or deactivate file volume support for ReadWriteMany persistent volumes.

The changes you make to the storage settings apply only to new objects.

## Prerequisites

If you plan to activate file volume support for persistent volumes in ReadWriteMany mode, follow prerequisites in [Creating ReadWriteMany Persistent Volumes in vSphere with Tanzu](#).

## Procedure

- 1 In the vSphere Client, navigate to the host cluster that has vSphere with Tanzu enabled.
- 2 Click the **Configure** tab and click **Storage** under **Namespaces**.
- 3 Change storage policy assignments for the following items.

Option	Description
<b>Control Plane Node</b>	Select the storage policy for placement of the control plane VMs.
<b>Pod Ephemeral Disks</b>	Select the storage policy for placement of the vSphere Pods.
<b>Container Image Cache</b>	Select the storage policy for placement of the cache of container images.



- 4 Enable file volume support to deploy ReadWriteMany persistent volumes.

## Change Storage Settings on a Namespace

Storage policies that a vSphere administrator assigns to a namespace in a Supervisor Cluster control how persistent volumes and Tanzu Kubernetes cluster nodes are placed within vSphere datastores. The persistent volume claims that correspond to persistent volumes can originate from a vSphere Pod or from a Tanzu Kubernetes cluster. You can change the original storage policy assignments.

### Prerequisites

Before deleting a storage policy from vCenter Server or a vSphere Namespace, or changing the storage policy assignment, make sure that no persistent volume claim with the corresponding storage class runs in the namespace. Also, ensure that no Tanzu Kubernetes cluster is using the storage class.

### Procedure

- 1 In the vSphere Client, navigate to the namespace.
  - a From the vSphere Client home menu, select **Workload Management**.
  - b Click the **Namespaces** tab and click the namespace.
- 2 Click the **Storage** tab and click **Storage Policies**.
- 3 Click the **Edit** icon to change storage policy assignments.

## Display Storage Classes in a vSphere Namespace or Tanzu Kubernetes Cluster

After a vSphere administrator creates a storage policy and assigns it to the vSphere Namespace, the storage policy appears as a matching Kubernetes storage class in the namespace and any available Tanzu Kubernetes clusters. As a DevOps engineer, you can verify that the storage class is available.

Your ability to run the commands depends on your permissions.

### Prerequisites

Make sure that your vSphere administrator has created an appropriate storage policy and assigned the policy to the vSphere Namespace.

### Procedure

- 1 Use one of the following commands to verify that the storage classes are available.
  - `kubectl get storageclass`

---

**Note** This command is available only to a user with administrator privileges.

---

You get the output similar to the following. The name of the storage class matches the name of the storage policy on the vSphere side.

NAME	PROVISIONER	AGE
silver	csi.vsphere.vmware.com	2d
gold	csi.vsphere.vmware.com	1d

- **kubectl describe namespace *namespace\_name***

In the output, the name of the storage class appears as a part of the ***storageclass\_name.storageclass.storage.k8s.io/requests.storage*** parameter. For example:

```

-----
Name:                                     namespace_name
Resource                                  Used   Hard
-----
silver.storageclass.storage.k8s.io/requests.storage 1Gi
9223372036854775807
gold.storageclass.storage.k8s.io/requests.storage    0
9223372036854775807

```

- 2 To check the amount of storage space available on the namespace, run the following command.

**kubectl describe resourcequotas -namespace *namespace***

You get the output similar to the following.

```

Name:          ns-my-namespace
Namespace:    ns-my-namespace
Resource      Used   Hard
-----
requests.storage 0     200Gi

```

## Provision a Dynamic Persistent Volume for a Stateful Application

Stateful applications, for example databases, save data between sessions and require persistent storage to store the data. The retained data is called the application's state. You can later retrieve the data and use it in the next session. Kubernetes offers persistent volumes as objects capable of retaining their state and data.

In the vSphere environment, the persistent volume objects are backed by virtual disks that reside on datastores. Datastores are represented by storage policies. After the vSphere administrator creates a storage policy, for example **gold**, and assigns it to a namespace in a Supervisor Cluster, the storage policy appears as a matching Kubernetes storage class in the vSphere Namespace and any available Tanzu Kubernetes clusters.

As a DevOps engineer, you can use the storage class in your persistent volume claim specifications. You can then deploy an application that uses storage from the persistent volume claim. In this example, the persistent volume for the application is created dynamically.

### Prerequisites

Make sure that your vSphere administrator has created an appropriate storage policy and assigned the policy to the namespace.

### Procedure

1 Access your namespace in the vSphere Kubernetes environment.

2 Verify that the storage classes are available.

See [Display Storage Classes in a vSphere Namespace or Tanzu Kubernetes Cluster](#).

3 Create a persistent volume claim.

a Create a YAML file that contains the persistent volume claim configuration.

In this example, the file references the **gold** storage class.

To provision a ReadWriteMany persistent volume, set `accessModes` to `ReadWriteMany`. See [Creating ReadWriteMany Persistent Volumes in vSphere with Tanzu](#).

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: my-pvc
spec:
  accessModes:
    - ReadWriteOnce
  storageClassName: gold
  resources:
    requests:
      storage: 3Gi
```

b Apply the persistent volume claim to the Kubernetes cluster.

```
kubectl apply -f pvc_name.yaml
```

This command dynamically creates a Kubernetes persistent volume and a vSphere volume with a backing virtual disk that satisfies the claim's storage requirements.

c Check the status of the persistent volume claim.

```
kubectl get pvc my-pvc
```

The output shows that the volume is bound to the persistent volume claim.

NAME	STATUS	VOLUME	CAPACITY	ACCESSMODES	STORAGECLASS	AGE
my-pvc	Bound	my-pvc	2Gi	RWO	gold	30s

- 4 Create a pod that mounts your persistent volume.
  - a Create a YAML file that includes the persistent volume.

The file contains these parameters.

```
...
volumes:
  - name: my-pvc
    persistentVolumeClaim:
      claimName: my-pvc
```

- b Deploy the pod from the YAML file.

```
kubectl create -f pv_pod_name.yaml
```

- c Verify that the pod has been created.

```
kubectl get pod
```

NAME	READY	STATUS	RESTARTS	AGE
pod_name	1/1	Ready	0	40s

## Results

The pod that you configured uses persistent storage described in the persistent volume claim.

## What to do next

To monitor health status of the persistent volume, see [Monitor Volume Health in a vSphere Namespace or Tanzu Kubernetes Cluster](#). To review and monitor the persistent volume in the vSphere Client, see [Monitor Persistent Volumes in the vSphere Client](#).

# Provision a Static Persistent Volume in a Tanzu Kubernetes Cluster

You can statically create a block volume in a Tanzu Kubernetes cluster using an unused persistent volume claim (PVC) from the Supervisor Cluster.

The PVC must satisfy the following conditions:

- The PVC is present in the same namespace where the Tanzu Kubernetes cluster resides.
- The PVC is not attached to a vSphere Pod in the Supervisor Cluster or a pod in any Tanzu Kubernetes cluster.

Using static provisioning, you can also reuse in a new Tanzu Kubernetes cluster a PVC that is no longer needed by another Tanzu Kubernetes cluster. To do this, change the `Reclaim policy` of the persistent volume (PV) in the original Tanzu Kubernetes cluster to `Retain`, and then delete the corresponding PVC.

Follow these steps to statically create a PVC in a new Tanzu Kubernetes cluster using the information from the leftover underlying volume.

## Procedure

- 1 Note the name of the original PVC in the Supervisor Cluster.

If you are reusing the PVC from an old Tanzu Kubernetes cluster, you can retrieve the PVC name from the `volumeHandle` of the old PV object in the Tanzu Kubernetes cluster.

- 2 Create a PV.

In the YAML file, specify the values of the following items:

- For `storageClassName`, you can enter the storage class name that is used by your PVC in the Supervisor Cluster.
- For `volumeHandle`, enter the PVC name that you obtained in [Step 1](#).

If you are reusing a volume from another Tanzu Kubernetes cluster, delete the PVC and PV objects from the old Tanzu Kubernetes cluster before creating a PV in the new Tanzu Kubernetes cluster.

Use the following YAML manifest as an example.

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: static-tkg-block-pv
  annotations:
    pv.kubernetes.io/provisioned-by: csi.vsphere.vmware.com
spec:
  storageClassName: gc-storage-profile
  capacity:
    storage: 2Gi
  accessModes:
    - ReadWriteOnce
  persistentVolumeReclaimPolicy: Delete
  claimRef:
    namespace: default
    name: static-tkg-block-pvc
  csi:
    driver: "csi.vsphere.vmware.com"
    volumeAttributes:
      type: "vSphere CNS Block Volume"
      volumeHandle: "supervisor-block-pvc-name" # Enter the PVC name from the Supervisor
      cluster.
```

- 3 Create a PVC to match the PV object you created in [Step 2](#).

Set the `storageClassName` to the same value as in the PV.

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: static-tkg-block-pvc
```

```
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 2Gi
  storageClassName: gc-storage-profile
  volumeName: static-tkg-block-pv
```

#### 4 Verify that the PVC is bound to the PV that you created.

```
$ kubectl get pv,pvc
```

NAME	CAPACITY	ACCESS MODES	RECLAIM POLICY
STATUS CLAIM	STORAGECLASS	REASON	AGE
persistentvolume/static-tkg-block-pv	2Gi	RWO	Delete
Bound default/static-tkg-block-pvc	gc-storage-profile		10s

NAME	STATUS	VOLUME	CAPACITY
ACCESS MODES STORAGECLASS AGE			
persistentvolumeclaim/static-tkg-block-pvc	Bound	static-tkg-block-pv	2Gi
RWO gc-storage-profile 10s			

## Creating ReadWriteMany Persistent Volumes in vSphere with Tanzu

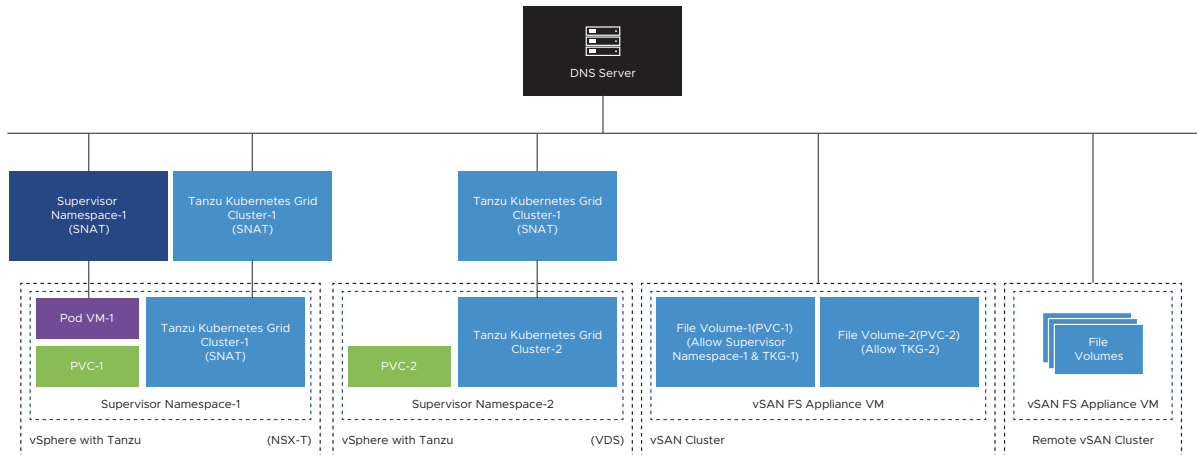
Starting with the vSphere 7.0 Update 3 release, vSphere with Tanzu supports persistent volumes in ReadWriteMany mode. With the ReadWriteMany support, a single volume can be mounted simultaneously by multiple pods or applications running in a cluster. vSphere with Tanzu uses vSAN File Services to provide file shares for the ReadWriteMany persistent volumes.

### Considerations for ReadWriteMany Persistent Volumes

When you enable ReadWriteMany support for persistent volumes in vSphere with Tanzu, keep in mind the following considerations.

- In vSphere 7.0 Update 3, only Tanzu Kubernetes clusters support persistent volumes in ReadWriteMany mode.
- When you enable file volume support for vSphere with Tanzu, be aware of the potential security weaknesses:
  - The volumes are mounted without encryption. The unencrypted data might be accessed while the data transits the network.
  - Access Control Lists (ACLs) is used for the file shares to isolate file share access within a supervisor namespace. It might have risk of IP spoofing.
- Follow these guidelines for networking:
  - Make sure the vSAN File Services is routable from the Workload network and there is no NAT between the Workload network and vSAN File Services IP addresses.

- Use common DNS server for vSAN File Services and the vSphere cluster.
- If your vSphere with Tanzu has NSX-T data center networking, use the SNAT IP of the Supervisor namespace and the SNAT IP of the Tanzu Kubernetes cluster for ACL configuration.
- If you have vSphere with Tanzu with vSphere Distributed Switch (VDS) networking, use the Tanzu Kubernetes cluster VM IP or the IP of the Supervisor namespace for ACL configuration.



- If after enabling file volume support, you later deactivate it, existing ReadWriteMany persistent volumes that you provisioned in the cluster remain unaffected and usable. You will not be able to create new ReadWriteMany persistent volumes.

## Workflow for Enabling ReadWriteMany Support for Persistent Volumes

Follow this process to enable ReadWriteMany support for persistent volumes.

- 1 A vSphere administrator sets up a vSAN cluster with configured vSAN File Services. [Configure File Services.](#)
- 2 A vSphere administrator activates file volume support when enabling the Workload Management platform.
  - [Enable Workload Management with vSphere Networking](#)
  - [Enable Workload Management with NSX-T Data Center Networking](#)
- 3 A DevOps engineer provisions a persistent volume setting the PVC `accessMode` as `ReadWriteMany`.

Several pods can be provisioned with the same PVC.

See [Provision a Dynamic Persistent Volume for a Stateful Application.](#)

## Volume Expansion in vSphere with Tanzu

As a DevOps engineer, you can use the Kubernetes volume expansion feature to expand a persistent block volume after its creation. Both types of clusters, Supervisor Clusters and Tanzu Kubernetes clusters, support offline and online volume expansion.

Storage classes that appear in the vSphere with Tanzu environment have `allowVolumeExpansion` set to `true` by default. This parameter makes it possible to modify the size of an offline or online volume.

A volume is considered to be offline when it is not attached to a node or pod. An online volume is a volume that is available on a node or pod.

The level of support of the volume expansion functionality depends on the vSphere version. You can expand volumes created in the earlier versions of vSphere when you upgrade your vSphere environment to appropriate versions that support expansions.

If you use a Tanzu Kubernetes cluster, make sure to upgrade both the Tanzu Kubernetes cluster and the Supervisor Cluster to the appropriate version for the functionality to be supported. The functionality in the Tanzu Kubernetes cluster depends on the enablement of that feature in the Supervisor Cluster.

For example, if you upgrade the Tanzu Kubernetes cluster to vSphere 7.0 Update 2 and leave the Supervisor Cluster at 7.0 Update 1, the online volume expansion will not work in the Tanzu Kubernetes cluster.

	Supervisor Cluster 7.0	Supervisor Cluster 7.0 Update 1	Supervisor Cluster 7.0 Update 2
Tanzu Kubernetes Cluster 7.0	Offline and online expansions in a Tanzu Kubernetes cluster or Supervisor Cluster: not supported	Offline and online expansions in a Tanzu Kubernetes cluster or Supervisor Cluster: not supported	<ul style="list-style-type: none"> <li>■ Offline and online expansions in a Tanzu Kubernetes cluster: not supported</li> <li>■ Offline and online expansions in a Supervisor Cluster: supported</li> </ul>



Tanzu Kubernetes Cluster 7.0 Update 1	Offline and online expansions in a Tanzu Kubernetes cluster or Supervisor Cluster: not supported	<ul style="list-style-type: none"> <li>■ Offline expansion in a Tanzu Kubernetes cluster: supported</li> <li>■ Offline expansion in a Supervisor Cluster: not supported</li> <li>■ Online expansion in a Tanzu Kubernetes cluster or Supervisor Cluster: not supported</li> </ul>	<ul style="list-style-type: none"> <li>■ Offline expansion in a Tanzu Kubernetes cluster: supported</li> <li>■ Online expansion in a Tanzu Kubernetes cluster: not supported</li> <li>■ Offline and online expansions in a Supervisor Cluster: supported</li> </ul>
Tanzu KubernetesCluster 7.0 Update 2	Offline and online expansions in a Tanzu Kubernetes cluster or Supervisor Cluster: not supported	<ul style="list-style-type: none"> <li>■ Offline expansion in a Tanzu Kubernetes cluster: supported</li> <li>■ Offline expansion in a Supervisor Cluster: not supported</li> <li>■ Online expansion in a Tanzu Kubernetes cluster or Supervisor Cluster: not supported</li> </ul>	Offline and online expansions in a Tanzu Kubernetes cluster or Supervisor Cluster: supported

When you expand the volumes, keep in mind the following:

- You can expand the volumes up to the limits specified by storage quotas. vSphere with Tanzu supports consecutive resize requests for a persistent volume claim object.
- All types of datastores, including VMFS, vSAN, vSAN Direct, vVols, and NFS, support volume expansion.
- You can perform volume expansion for deployments or standalone pods.
- You can resize statically provisioned volumes in a Supervisor Cluster and Tanzu Kubernetes cluster if the volumes have storage classes associated with them.
- You cannot expand volumes created as part of a StatefulSet.
- If a virtual disk that backs a volume has snapshots, it cannot be resized.
- vSphere with Tanzu does not support volume expansion for in-tree or migrated volumes.

## Expand a Persistent Volume in Offline Mode

A volume is considered to be offline when it is not attached to a node or pod. Both types of clusters, Supervisor Clusters and Tanzu Kubernetes clusters, support offline volume expansion.

### Prerequisites

Make sure to upgrade your vSphere environment to an appropriate version that supports offline volume expansion. See [Volume Expansion in vSphere with Tanzu](#).

**Procedure****1** Create a persistent volume claim (PVC) with a storage class.

- a Define a PVC using the following YAML manifest as an example.

In the example, the size of the requested storage is 1 Gi.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: example-block-pvc
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi
  storageClassName: example-block-sc
```

- b Apply the PVC to the Kubernetes cluster.

```
kubectl apply -f example-block-pvc.yaml
```

**2** Patch the PVC to increase its size.

If the PVC is not attached to a node or being used by a pod, use the following command to patch the PVC. In this example, the requested storage increase is 2 Gi.

```
kubectl patch pvc example-block-pvc -p '{"spec": {"resources": {"requests": {"storage": "2Gi"}}}}'
```

This action triggers an expansion in the volume associated with the PVC.

**3** Verify that the size of the volume has increased.

```
kubectl get pv
NAME                                CAPACITY ACCESS MODES RECLAIM POLICY STATUS
CLAIM                               STORAGECLASS          REASON AGE
pvc-9e9a325d-ee1c-11e9-a223-005056ad1fc1  2Gi                RWO          Delete    Bound
default/example-block-pvc             example-block-sc          6m44s
```

**Note** The size of the PVC remains unchanged until the PVC is used by a pod.

The following example shows that the PVC size hasn't changed. If you describe the PVC, you can see the `FilesystemResizePending` condition applied on the PVC.

```
kubectl get pvc
NAME                                STATUS VOLUME                                CAPACITY ACCESS
MODES STORAGECLASS                   AGE
example-block-pvc                   Bound  pvc-9e9a325d-ee1c-11e9-a223-005056ad1fc1  1Gi
RWO                                  example-block-sc  6m57s
```

#### 4 Create a pod to use the PVC.

When the PVC is used by the pod, the filesystem is expanded.

#### 5 Verify that the size of the PVC has been modified.

```
kubectl get pvc
NAME                                STATUS VOLUME                                CAPACITY ACCESS MODES
STORAGECLASS    AGE
example-block-pvc  Bound  pvc-24114458-9753-428e-9c90-9f568cb25788  2Gi      RWO
example-block-sc  2m12s
```

The `FileSystemResizePending` condition has been removed from the PVC. Volume expansion is complete.

#### What to do next

A vSphere administrator can see the new volume size in the vSphere Client. See [Monitor Persistent Volumes in the vSphere Client](#).

## Expand a Persistent Volume in Online Mode

An online volume is a volume that is available on a node or pod. As a DevOps engineer, you can expand an online persistent block volume. Both types of clusters, Supervisor Clusters and Tanzu Kubernetes clusters, support online volume expansion.

#### Prerequisites

Make sure to upgrade your vSphere environment to an appropriate version that supports online volume expansion. See [Volume Expansion in vSphere with Tanzu](#).

#### Procedure

##### 1 Find the persistent volume claim to resize.

```
$ kubectl get pv,pvc,pod
NAME                                CAPACITY  ACCESS MODES
RECLAIM POLICY  STATUS    CLAIM                                STORAGECLASS  REASON  AGE
persistentvolume/pvc-5cd51b05-245a-4610-8af4-f07e77fdc984  1Gi      RWO
Delete          Bound    default/block-pvc  block-sc      4m56s

NAME                                STATUS  VOLUME
CAPACITY  ACCESS MODES  STORAGECLASS  AGE
persistentvolumeclaim/block-pvc  Bound  pvc-5cd51b05-245a-4610-8af4-f07e77fdc984
1Gi      RWO          block-sc      5m3s

NAME          READY  STATUS   RESTARTS  AGE
pod/block-pod  1/1    Running  0         26s
```

Note that the size of storage the volume uses is 1 Gi.

## 2 Patch the PVC to increase its size.

For example, increase the size to 2 Gi.

```
$ kubectl patch pvc block-pvc -p '{"spec": {"resources": {"requests": {"storage": "2Gi"}}}}'
persistentvolumeclaim/block-pvc edited
```

This action triggers an expansion in the volume associated with the PVC.

## 3 Verify that the size of both PVC and PV has increased.

```
$ kubectl get pvc,pv,pod
NAME                                STATUS    VOLUME
CAPACITY  ACCESS MODES  STORAGECLASS  AGE
persistentvolumeclaim/block-pvc    Bound    pvc-5cd51b05-245a-4610-8af4-f07e77fdc984
2Gi          RWO          block-sc      6m18s

NAME                                CAPACITY  ACCESS MODES
RECLAIM POLICY  STATUS    CLAIM                                STORAGECLASS  REASON  AGE
persistentvolume/pvc-5cd51b05-245a-4610-8af4-f07e77fdc984  2Gi          RWO
Delete          Bound    default/block-pvc  block-sc      6m11s

NAME          READY  STATUS    RESTARTS  AGE
pod/block-pod  1/1    Running   0          101s
```

### What to do next

A vSphere administrator can see the new volume size in the vSphere Client. See [Monitor Persistent Volumes in the vSphere Client](#).

## Monitor Persistent Volumes in the vSphere Client

When DevOps engineers deploy a stateful application with a persistent volume claim, vSphere with Tanzu creates a persistent volume object and a matching persistent virtual disk. As a vSphere administrator, you can review details of the persistent volume in the vSphere Client. You can also monitor its storage compliance and health status.

### Procedure

- 1 In the vSphere Client, navigate to the namespace that has persistent volumes.
  - a From the vSphere Client home menu, select **Workload Management**.
  - b Click the namespace.

- 2 Click the **Storage** tab and click **Persistent Volume Claims**.

The vSphere Client lists all persistent volume claim objects and corresponding volumes available in the namespace.

- 3 To view details of a selected persistent volume claim, click the name of the volume in the **Persistent Volume Name** column.

- 4 On the **Container Volumes** page, check the volume's health status and storage policy compliance.
- a Click the **Details** icon, and switch between the **Basics** and **Kubernetes objects** tabs to view additional information for the Kubernetes persistent volume.

To monitor volume health status using the `kubectl` command, see [Monitor Volume Health in a vSphere Namespace or Tanzu Kubernetes Cluster](#).

The screenshot shows the vSphere interface for Container Volumes. At the top, it says "Container providers: Kubernetes" with a "LEARN MORE" link. Below that, there's a "REAPPLY POLICY" button and an "Add filter" input. A table lists container volumes, with the first one selected and its "Details" icon circled in red. The details panel for the selected volume "pvc-53f25d45-28f1-4eaf-bd9b-112336badda4" is open, showing the "Basics" tab. The "Kubernetes objects" section displays the following information:

Type	BLOCK
Volume ID	f3eeb98f-bc26-4de8-b8b2-30f995775ef
Pod	mongod-1
Datastore	nfs0-1
Storage Policy	Gold
Compliance Status	Compliant
Health Status	Accessible

At the bottom of the details panel, it indicates "1-2 of 2 container volumes".

- b Verify the health status of the volume.

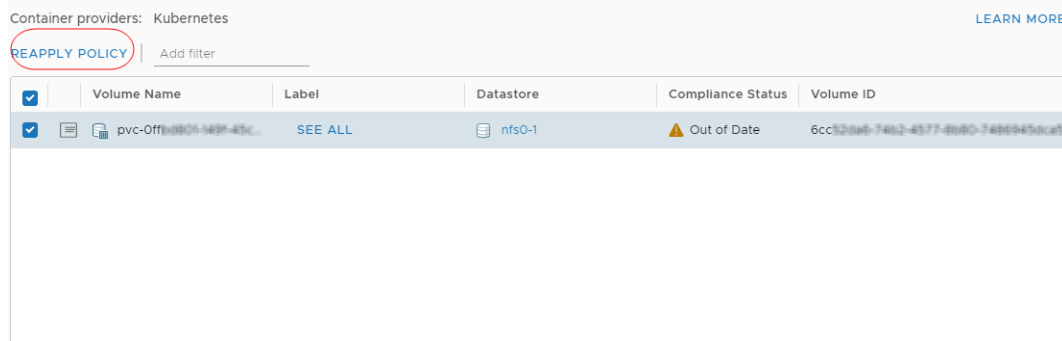
Health Status	Description
Accessible	The persistent volume is accessible and available for use.
Inaccessible	The persistent volume is inaccessible and cannot be used. The persistent volume becomes inaccessible if the datastore that stores the volume cannot be reached by the hosts that connect to the datastore.

- c Verify the storage compliance status.

You can see one of the following in the **Compliance Status** column.

Compliance Status	Description
Compliant	The datastore where the virtual disk backing the volume resides has the storage capabilities that the policy requires.
Out of Date	This status indicates that the policy has been edited, but the new storage requirements have not been communicated to the datastore. To communicate the changes, reapply the policy to the volume that is out of date.
Noncompliant	The datastore supports specified storage requirements, but cannot currently satisfy the storage policy. For example, the status might become Noncompliant when physical resources of the datastore are unavailable. You can bring the datastore into compliance by making changes in the physical configuration of your host cluster, for example by adding hosts or disks to the cluster. If additional resources satisfy the storage policy, the status changes to Compliant.
Not Applicable	The storage policy references datastore capabilities that are not supported by the datastore.

- d If the compliance status is Out of Date, select the volume and click **Reapply Policy**.



The status changes to Compliant.

## Monitor Volume Health in a vSphere Namespace or Tanzu Kubernetes Cluster

As a DevOps engineer, you can check health status of a persistent volume in a bound state.

For each persistent volume in a bound state, the health status appears in the `Annotations: volumehealth.storage.kubernetes.io/messages:` field of the persistent volume claim bound to the persistent volume. Two possible values for health status exist.

Health Status	Description
Accessible	The persistent volume is accessible and available for use.
Inaccessible	The persistent volume is inaccessible and cannot be used. The persistent volume becomes inaccessible if the datastore that stores the volume cannot be reached by the hosts that connect to the datastore.

To monitor volume health status in the vSphere Client, see [Monitor Persistent Volumes in the vSphere Client](#).

### Procedure

- 1 Access your namespace in the vSphere Kubernetes environment.
- 2 Create a persistent volume claim.
  - a Create a YAML file that contains the persistent volume claim configuration.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: my-pvc
spec:
  accessModes:
    - ReadWriteOnce
  storageClassName: gold
  resources:
    requests:
      storage: 2Gi
```

- b Apply the persistent volume claim to the Kubernetes cluster.

```
kubectl apply -f pvc_name.yaml
```

This command creates a Kubernetes persistent volume and a vSphere volume with a backing virtual disk that satisfies the claim's storage requirements.

- c Check whether the persistent volume claim is bound to a volume.

```
kubectl get pvc my-pvc
```

The output shows that the persistent volume claim and the volume are in the bound state.

NAME	STATUS	VOLUME	CAPACITY	ACCESSMODES	STORAGECLASS	AGE
my-pvc	Bound	my-pvc	2Gi	RWO	gold	30s

- 3 Check the health status of the volume.

Run the following command to check the volume health annotation of the persistent volume claim bound to the persistent volume.

```
kubectl describe pvc my-pvc
```

In the following sample output, the `volumehealth.storage.kubernetes.io/messages` field shows the health status as accessible.

```
Name:          my-pvc
Namespace:    test-ns
StorageClass: gold
Status:       Bound
```

```

Volume:      my-pvc
Labels:      <none>
Annotations: pv.kubernetes.io/bind-completed: yes
             pv.kubernetes.io/bound-by-controller: yes
             volume.beta.kubernetes.io/storage-provisioner: csi.vsphere.vmware.com
             volumehealth.storage.kubernetes.io/messages: accessible
Finalizers:  [kubernetes.io/pvc-protection]
Capacity:    2Gi
Access Modes: RWO
VolumeMode:  Filesystem

```

## Using vSAN Data Persistence Platform with Modern Stateful Services

You can use the vSAN Data Persistence platform for modern stateful services that require persistent storage. The platform provides a framework that enables third parties to integrate their service applications with underlying vSphere infrastructure, so that third-party software can run on vSphere with Tanzu optimally.

The benefits of using vSAN Data Persistence include the following:

### Automatic Service Deployment and Scaling

Using the vSphere Client, administrators can install and deploy a modern stateful service on a Supervisor Cluster and grant access to the service namespace to DevOps engineers. The DevOps engineers can provision and scale instances of the stateful service dynamically in a self-service manner through Kubernetes APIs.

### Service Monitoring Integrated with vCenter Server

Partners can build dashboard plugins that integrate with vCenter Server. Using the UI plugins, the vSphere administrators can manage and monitor the stateful services. In addition, vSAN offers health and capacity monitoring capabilities for these integrated third-party services.

### Optimized Storage Configuration with vSAN Direct

vSAN Direct enables modern stateful services to interface directly with the underlying direct-attached storage for optimized I/O and storage efficiency.

The platform supports the following types of services:

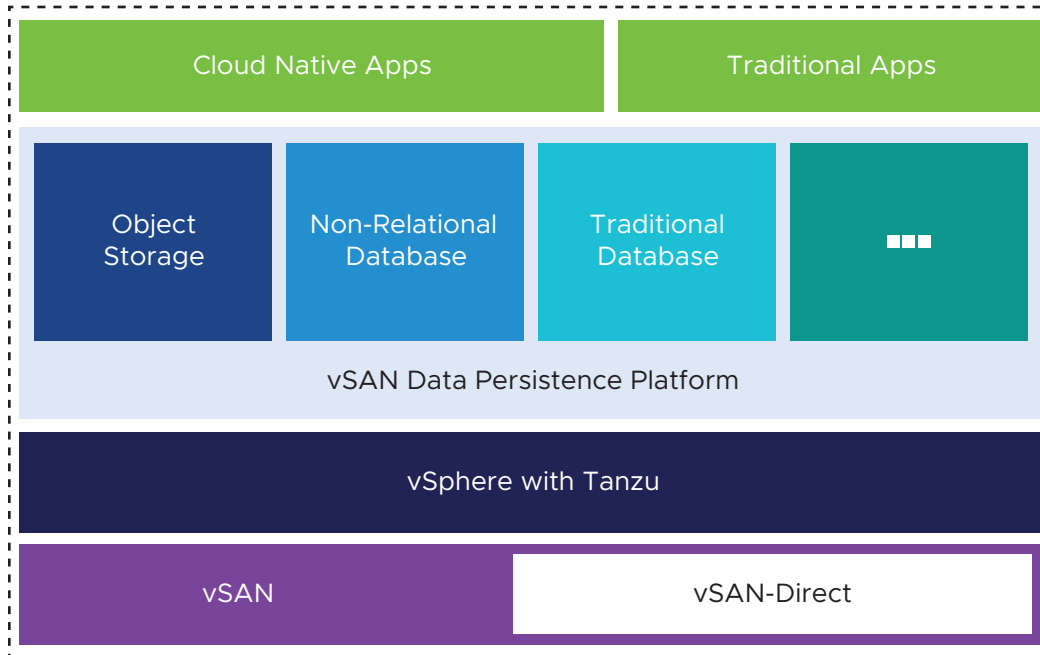
- Object storage, such as MinIO.
- NoSQL databases, also called non-relational databases.
- Traditional databases.



## vSphere Shared Nothing Storage

Most modern stateful services have a Shared Nothing Architecture (SNA). They consume non-replicated local storage and offer their own storage replication, compression, and other data operations. As a result, the services do not benefit when the same operations are performed by the underlying storage.

To avoid duplicating the operations, the vSAN Data Persistence platform offers two vSAN solutions with optimized data paths. The persistent service can run either on vSAN with the SNA storage policy or on a mostly raw local storage called vSAN Direct.



### vSAN with SNA Storage Policy

With this technology, you can use a distributed replicated vSAN datastore with the vSAN host-local SNA policy. As a result, the SNA service application can control placement and take over the duty of maintaining data availability. The technology makes it easy for the persistent service to co-locate its compute instance and a storage object on the same physical ESXi host. With the host-local placement, it is possible to perform such operations as replication at the service layer and not at the storage layer.

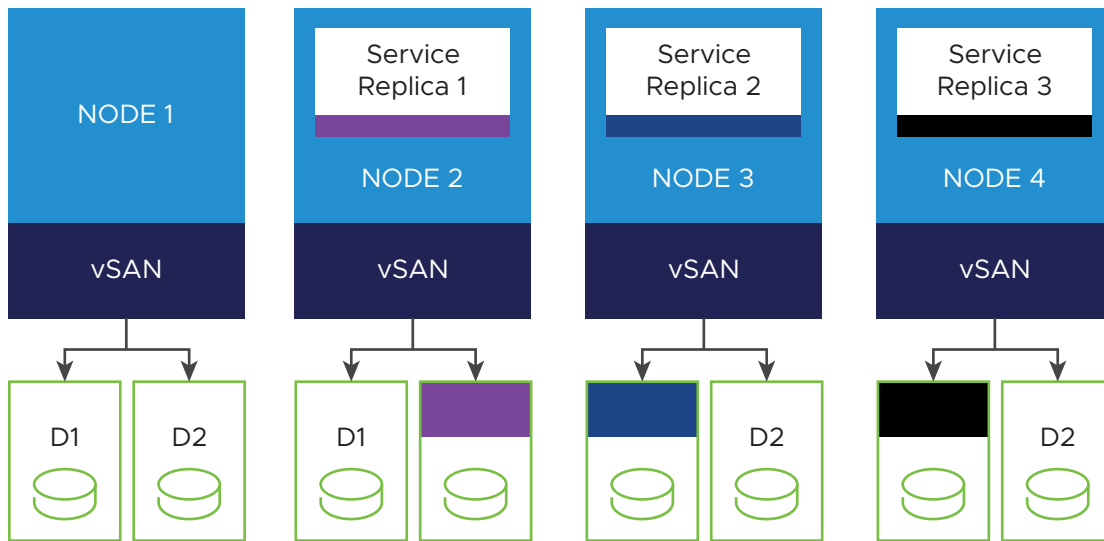
The compute instance, such as a pod, comes up first on one of the nodes in the vSAN cluster. And then the vSAN object created with the vSAN SNA policy automatically has all its data placed on the same node where the pod is running.

The following example illustrates storage deployment of an application that uses the SNA storage class for its persistent volume. vSAN can select any disk group on the node for the persistent volume placement.

Total Copies of Data = 3

Expected Fault Tolerance = 2

Actual Failures Guaranteed to Be Tolerated = 2

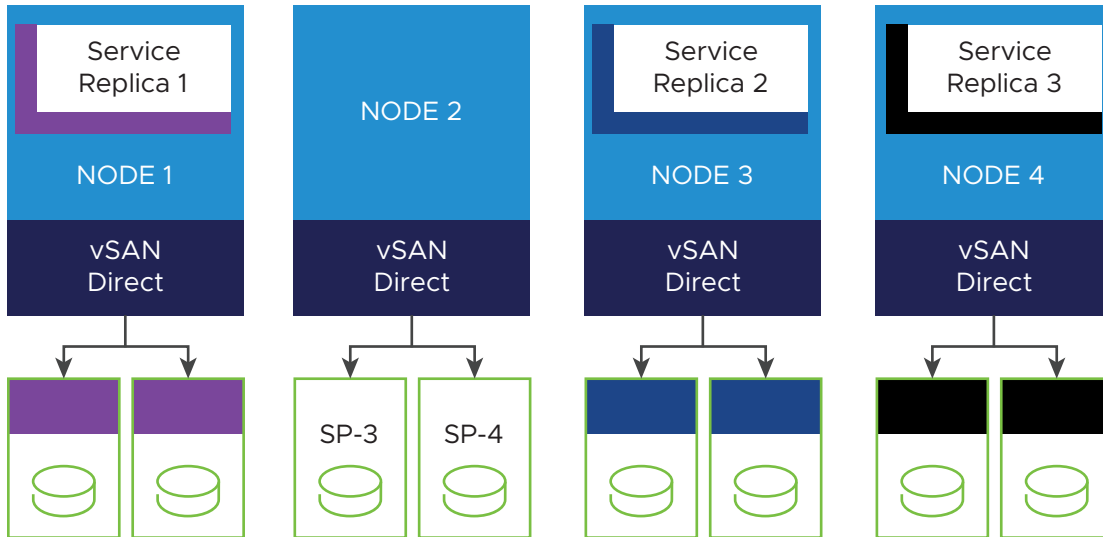


### vSAN Direct

Even though vSAN with the SNA storage policy can place data locally to the compute instance, an overhead exists of a distributed vSAN data path between the application and the physical storage device. With vSAN Direct, the stateful services applications can access mostly raw non-vSAN local storage through a more direct data path, which offers the most performance optimized solution.

With vSAN Direct, the vSphere administrator can claim host-local devices, and then manage and monitor the devices. vSAN Direct provides insights into the device health, performance, and capacity. On every local device it claims, vSAN Direct creates an independent VMFS datastore and makes it available as a placement choice to the application. The VMFS datastores that vSAN Direct manages are exposed as storage pools in Kubernetes. In the vSphere Client, they appear as vSAN Direct datastores.

The following illustrates persistent volumes placed locally on vSAN Direct disks.



## When to Use vSAN with SNA or vSAN Direct

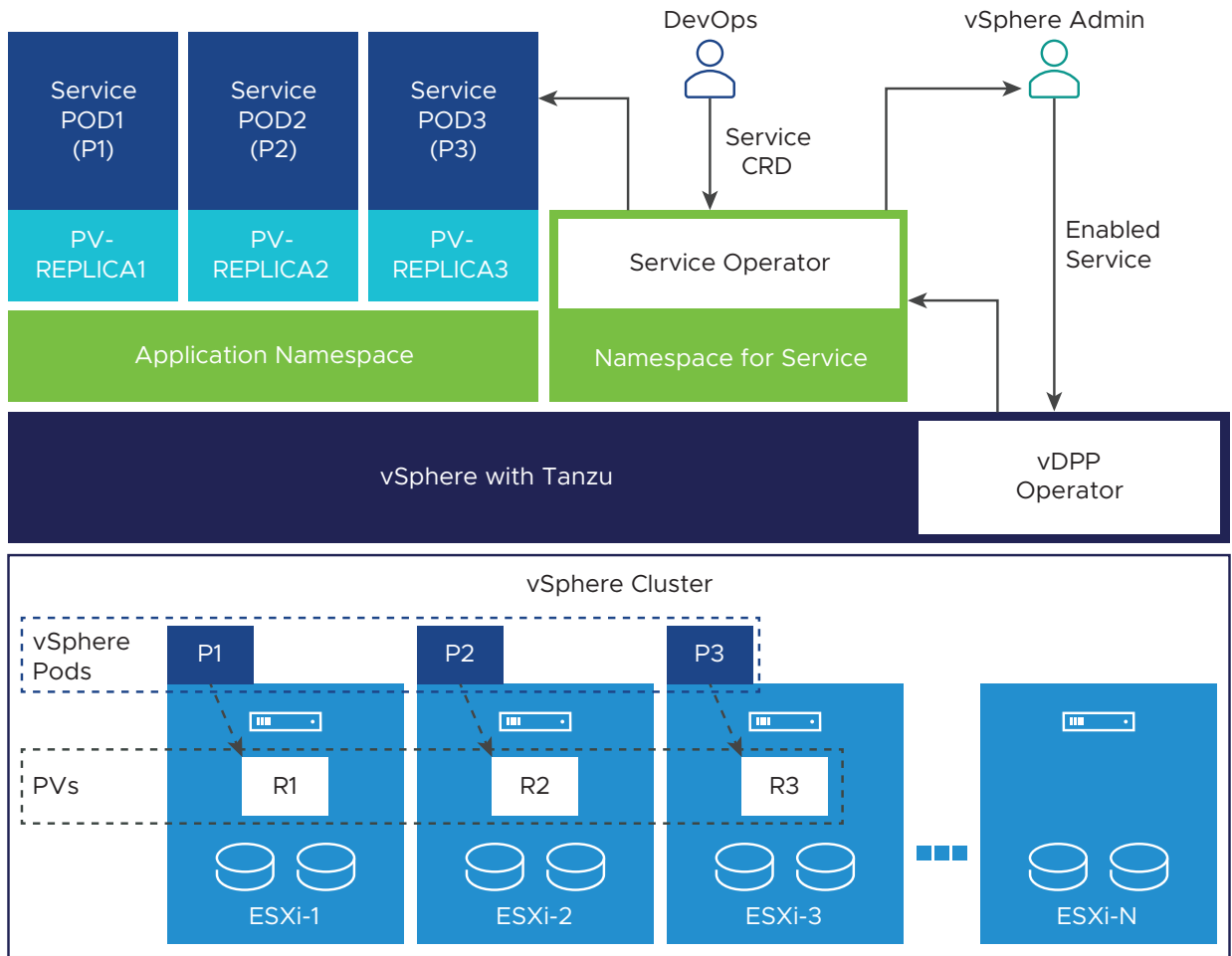
Follow these general recommendations when deciding which type of vSAN to use.

- Use vSAN with SNA when you want the cloud-native stateful application to share the physical infrastructure with other regular VMs or Kubernetes workloads. Each workload can define its own storage policy and can get the best of both worlds from a single cluster.
- Use vSAN Direct if you are creating a dedicated hardware cluster for the shared nothing cloud-native services.

## vSAN Data Persistence Platform Operator

The vSAN Data Persistence platform (vDPP) operator is a component responsible for running and managing partner stateful services integrated with vSphere. The vDPP operator exposes available stateful services to the vSphere administrator. When the vSphere administrator enables a persistent service, for example, MinIO, the vDPP operator deploys an application-specific operator for the service on the supervisor cluster.

The application-specific operators are provided by the third party and must be vDPP compliant. The operator typically offers a CRD which provides a self-service interface for Kubernetes users to instantiate instances. vSphere with Tanzu uses this operator and CRD to provision new service instances and manage and monitor them through the stateful services layer. Most of these operators use stateful sets for deploying their instances.



After the vSphere administrator enables a service, the following takes place.

- The vDPP operator activates a service-specific operator.
- The service-specific operator registers the UI plug-in.
- Storage-optimized storage policies are created.

## Configuration Limits for vSAN Data Persistence Platform

VMware provides configuration limits in the [VMware Configuration Maximums](#) tool.

vSAN Data Persistence Maximums	Limits
Maximum number of persistent volumes per vSAN Data Persistence platform	1000
Maximum number of persistent volumes per service instance on the vSAN Data Persistence platform	60 to 80

## Tag Storage Devices for vSAN Direct

In VMware Cloud Foundation deployments, vSAN automatically claims all local storage devices on your ESXi host. You can make the devices ineligible for regular vSAN and available for vSAN Direct.

This topic describes how you can use the `esxcli` command to mark the devices as vSAN Direct. Alternately, you can use a script. See [Using Script to Tag Storage Devices for vSAN Direct](#).

### Procedure

- 1 Tag local storage device for vSAN Direct.

```
esxcli vsan storage tag add -d diskName -t vsanDirect
```

For example,

```
esxcli vsan storage tag add -d mpv.vmhba0:C0:T1:L0 -t vsanDirect
```

The device becomes ineligible for regular vSAN.

- 2 Remove the vSAN Direct tag from the device.

```
esxcli vsan storage tag remove -d diskName -t vsanDirect
```

For example,

```
esxcli vsan storage tag remove -d mpv.vmhba0:C0:T1:L0 -t vsanDirect
```

## Using Script to Tag Storage Devices for vSAN Direct

In VMware Cloud Foundation deployments, you can use a script to tag HDD devices attached to your ESXi host. After you run the script, the devices become ineligible for regular vSAN and are available for vSAN Direct.

```
#!/usr/bin/env python3

# Copyright 2020 VMware, Inc. All rights reserved.

# Abstract
#
# This script helps manage tagging of Direct Attached HDD disks
# on ESXi systems for vSAN Direct in preparation for a VCF deployment.
#
# It is expected to be used with ESX systems of version 7.0.1 or later.
#

import argparse
from enum import Enum
import logging
import sys
import os
import paramiko
import subprocess
import traceback
import ast
```

```

import getpass
from six.moves import input
from distutils.util import strtobool
from argparse import ArgumentParser

class ParseState(Enum):
    OPEN = 0
    DEVICE = 1

class RemoteOperationError(Exception):
    pass

class EsxVersion:

    def __init__(self, major, minor, release):
        self.major = major
        self.minor = minor
        self.release = release

    def __str__(self):
        return '{}.{}.{}'.format(self.major, self.minor, self.release)

    @staticmethod
    def build(str):
        tokens = str.split(b'.',3)
        return EsxVersion(int(tokens[0]), int(tokens[1]), int(tokens[2]))

class StorageDevice:

    def __init__(self, deviceId, isSSD, isVsanDirectEnabled):
        self.deviceId = str(deviceId.decode())
        self.isSSD = isSSD
        self.isVsanDirectCapable = True
        self.isVsanDirectEnabled = isVsanDirectEnabled

    def __str__(self):
        return '{}:\n\tIs SSD: {}\n\tvsanDirect enabled:{}'.format(
            self.deviceId,
            self.isSSD,
            self.isVsanDirectEnabled)

    @staticmethod
    def strToBool(v):
        return bool(strtobool(str(v.decode())))

    @staticmethod
    def build(deviceId, props):
        vsanDirectEnabled = False
        isLocal = StorageDevice.strToBool(props[b'Is Local'])
        status = props[b'Status']
        isOffline = StorageDevice.strToBool(props[b'Is Offline'])
        isSSD = StorageDevice.strToBool(props[b'Is SSD'])
        isBootDevice = StorageDevice.strToBool(props[b'Is Boot Device'])
        deviceType = props[b'Device Type']
        if deviceType == b'Direct-Access' and isLocal and (not isOffline) and (not

```

```

isBootDevice) and status == b'on':
    return StorageDevice(deviceId, isSSD, vsanDirectEnabled)
else:
    print("Skipping device {}".format(deviceId))
    return None

def parse_arguments():
    """
    Parses the command line arguments to the function
    """
    parser = argparse.ArgumentParser()
    parser.add_argument('--hostname', dest='hostname',
                        help='specify hostname for the ESX Server', required=True)
    parser.add_argument('--username', dest='username',
                        help='specify username to connect to the ESX Server', required=True)
    parser.add_argument('--password', dest='password',
                        help='specify password to connect to the ESX Server', required=False)
    return parser.parse_args()

def get_esx_version(sshClient):
    global logger
    stdin_, stdout_, stderr_ = sshClient.exec_command('vmware -v')
    exit_status = stdout_.channel.recv_exit_status()
    if exit_status != 0:
        logger.error('Command exited with non-zero status: %s' % exit_status)
        logger.error('Error message: %s' % stderr_.read())
        raise RemoteOperationError('Failed to determine ESX version')
    output = stdout_.read()
    tokens = output.split()
    if len(tokens) < 3:
        raise RemoteOperationError('Invalid ESX Version - %s', output)
    return EsxVersion.build(tokens[2])

def check_esx_version(esxVersion):
    return esxVersion.major >= 7 and esxVersion.minor >= 0 and esxVersion.release >= 1

def query_devices(sshClient):
    global logger
    stdin_, stdout_, stderr_ = sshClient.exec_command('esxcli storage core device list')
    exit_status = stdout_.channel.recv_exit_status()
    if exit_status != 0:
        logger.error('Command exited with non-zero status: %s' % exit_status)
        logger.error('Error message: %s' % stderr_.read())
        raise RemoteOperationError('Failed to query core storage device list')
    output = stdout_.read()
    # Build the device list from the output
    return create_device_list(output)

def create_device_list(str):
    devices = []

    deviceId=""
    deviceProps={}

    parseState = ParseState.OPEN

```

```

for line in str.splitlines():
    if parseState == ParseState.OPEN:
        if line.strip():
            deviceId=line.strip()
            parseState = ParseState.DEVICE
    elif parseState == ParseState.DEVICE:
        if line.strip():
            props = line.strip().split(b':',1)
            deviceProps[props[0]] = props[1].strip()
        else:
            if deviceId:
                device = StorageDevice.build(deviceId, deviceProps)
                if device:
                    devices.append(device)
            else:
                logger.debug("Skipping device {}".format(deviceId))
            deviceId=""
            deviceProps={}
            parseState = ParseState.OPEN
    if deviceId:
        device = StorageDevice.build(deviceId, deviceProps)
        if device:
            devices.append(device)
return devices

def tag_device_for_vsan_direct(sshClient, deviceId):
    global logger
    logger.info("Tagging device [{}] for vSAN Direct".format(deviceId))
    command = "esxcli vsan storage tag add -d " + deviceId + " -t vsanDirect"
    stdin_, stdout_, stderr_ = sshClient.exec_command(command)
    exit_status = stdout_.channel.recv_exit_status()
    if exit_status != 0:
        logger.error('Command exited with non-zero status: %s' % exit_status)
        logger.error('Error message: %s' % stderr_.read())
        raise RemoteOperationError('Failed to tag device [{}] for vSAN
Direct'.format(deviceId))
    logger.info('Successfully tagged device [{}] for vSAN Direct'.format(deviceId))

def untag_device_for_vsan_direct(sshClient, deviceId):
    global logger
    logger.info("Untagging device [{}] for vSAN Direct".format(deviceId))
    command = "esxcli vsan storage tag remove -d " + deviceId + " -t vsanDirect"
    stdin_, stdout_, stderr_ = sshClient.exec_command(command)
    exit_status = stdout_.channel.recv_exit_status()
    if exit_status != 0:
        logger.error('Command exited with non-zero status: %s' % exit_status)
        logger.error('Error message: %s' % stderr_.read())
        raise RemoteOperationError('Failed to untag device [{}] for vSAN
Direct'.format(deviceId))
    logger.info('Successfully untagged device [{}] for vSAN Direct'.format(deviceId))

def get_vsan_info_for_device(sshClient, deviceId):
    global logger
    command = "vdq -q -d {}".format(deviceId)
    stdin_, stdout_, stderr_ = sshClient.exec_command(command)

```



```

exit_status = stdout_.channel.recv_exit_status()
if exit_status != 0:
    logger.error('Command exited with non-zero status: %s' % exit_status)
    logger.error('Error message: %s' % stderr_.read())
    raise RemoteOperationError('Failed to query vsan direct status on device [%s]' %
deviceId)
output = stdout_.read()
return ast.literal_eval(str(output.decode()))

def update_vsan_direct_status(sshClient, devices):
    for device in devices:
        vsanInfo = get_vsan_info_for_device(sshClient, device.deviceId)
        device.isVsanDirectEnabled = vsanInfo[0]['IsVsanDirectDisk'].strip() == "1"
        device.isVsanDirectCapable = vsanInfo[0]['State'].strip() == 'Eligible for use by
VSAN'

def getVsanDirectCapableDevices(devices):
    selectDevices = []
    # Cull devices incapable of vSAN Direct
    for device in devices:
        if device.isVsanDirectCapable:
            selectDevices.append(device)
    return selectDevices

def print_devices(devices):
    print("Direct-Attach Devices:")
    print("=====")
    iDevice = 0
    for device in devices:
        iDevice = iDevice + 1
        print ("{}. {}".format(iDevice, device))
    print("=====")

def tag_devices(sshClient, devices):
    for device in devices:
        tag_device_for_vsan_direct(sshClient, device.deviceId)

def untag_devices(sshClient, devices):
    for device in devices:
        untag_device_for_vsan_direct(sshClient, device.deviceId)

def tag_all_hdd_devices(sshClient, devices):
    hddDevices = []
    for device in devices:
        if not device.isSSD:
            hddDevices.append(device)
    if len(hddDevices) > 0:
        tag_devices(sshClient, hddDevices)

def show_usage():
    print ("=====")
    print ("commands: {tag-all-hdd, tag, untag}")
    print ("\tttag <comma separated serial numbers of devices>")
    print ("\tuntag <comma separated serial numbers of devices>")
    print ("\tttag-all-hdd")

```

```

print ("=====")

def main():
    global logger
    logger.info('Tag disks for vSAN Direct')

    try:
        # Parse arguments
        args = parse_arguments()

        # 1. Setup SSH connection to ESX system
        sshClient = paramiko.SSHClient()
        sshClient.load_system_host_keys()
        sshClient.set_missing_host_key_policy(paramiko.AutoAddPolicy())
        passwd = args.password
        if passwd == None:
            passwd = getpass.getpass(prompt='Password: ')
        logger.info('Connecting to ESX System (IP: %s)' % args.hostname)
        sshClient.connect(args.hostname, username=args.username, password=passwd)
        # version check
        esxVersion = get_esx_version(sshClient)
        print('ESX Version on {} is {}'.format(args.hostname, esxVersion))
        logger.info('Checking ESX Version...')
        if not check_esx_version(esxVersion):
            raise Exception('ESX Version must be 7.0.1 or greater')

        print ('This script helps tag direct-attached disks for vSAN Direct on ESX')
        print ('Note: Only disks of type HDD are supported at this time.')
        print ()
        print ("For help, type help")
        show_usage()

    while True:
        # get device list
        print("Querying devices...")
        devices = query_devices(sshClient)
        # update devices with vSAN Direct status
        update_vsan_direct_status(sshClient, devices)
        # cull device list
        selectDevices = getVsanDirectCapableDevices(devices)
        # List the devices for the user to see
        print_devices(selectDevices)
        # find out what the user wants to do to these devices
        args = input('Command> ').split()
        if len(args) == 0:
            break
        cmd = args[0]
        if cmd == 'q' or cmd == 'quit' or cmd == 'exit':
            break
        elif cmd == 'help':
            show_usage()
        elif cmd == 'tag-all-hdd':
            print("Tagging all HDD devices...")
            tag_all_hdd_devices(sshClient, selectDevices)
        elif cmd == 'tag' or cmd == 'untag':

```

```

chosenDevices = []
if len(args) > 1:
    serials = args[1].split(',')
    for serialStr in serials:
        serial = int(serialStr)
        if serial < 1 or serial > len(selectDevices):
            raise Exception("Error: Serial {} is out of range".format(serial))
        chosenDevices.append(selectDevices[serial-1])
if len(chosenDevices) == 0:
    print("No devices specified")
    continue
if cmd == 'tag':
    print("Tagging devices...")
    tag_devices(sshClient, chosenDevices)
else:
    print("Untagging devices...")
    untag_devices(sshClient, chosenDevices)
else:
    print ("Error: Unrecognized command - %s" % cmd)
except paramiko.ssh_exception.AuthenticationException as e:
    logger.error(e)
    sys.exit(5)
except Exception as e:
    logger.error('Disk tagging failed with error: %s' % e)
    logger.error(traceback.format_exc())
    sys.exit(1)
finally:
    # Close SSH client
    try:
        sshClient.close()
    except:
        pass

# Set up logging
logging.basicConfig()
logger = logging.getLogger('tag-disks-for-vsan-direct')

if __name__ == "__main__":
    main()

```

## Set Up vSAN Direct for vSphere with Tanzu

As a vSphere administrator, set up vSAN Direct to be used with vSAN Data Persistence platform. Use unclaimed storage devices local to your ESXi host.

### Prerequisites

If vSAN automatically claims all local storage devices in your deployment, use the `esxcli` command to tag the devices you want to be available for vSAN Direct. See [Tag Storage Devices for vSAN Direct](#). Alternately, you can use a script. For information, see [Using Script to Tag Storage Devices for vSAN Direct](#).

## Procedure

- 1 In the vSphere Client, navigate to the vSAN cluster.
- 2 Click the **Configure** tab.
- 3 Under vSAN, click **Disk Management**.
- 4 Click **Claim Unused Disks**.
- 5 On the **Claim Unused Disks** dialog box, click the **vSAN Direct** tab.
- 6 Select a device to claim and select a check box in the **Claim for vSAN Direct** column.

**Note** If you claimed the devices for a regular vSAN datastore, these devices do not appear in the **vSAN Direct** tab.

Claim Unused Disks

Total Claimed 1.95 TB (100%) Unclaimed storage 0.00 B (0%)

■ vSAN Capacity 1.46 TB (75%)
 ■ vSAN Cache 400.00 GB (20%)
 ■ vSAN Direct 100.00 GB (5%)

vSAN vSAN Direct

vSAN Direct storage is optimized for shared-nothing architecture. It can be used by supervisor services. Each selected disk for vSAN Direct will form a new datastore.

Group by: Disk model/size

Disk Model/Serial Number	Claim for vSAN Direct	Drive Type	Disk Distribution/Host	Transport Type	Adapter
VMware Virtual disk, 100...	<input checked="" type="checkbox"/>	HDD	1 disk on 1 host	Parallel SCSI	
Local VMware Disk (mp...	<input checked="" type="checkbox"/>	HDD	10.78.176.237	Parallel SCSI	vmhba0

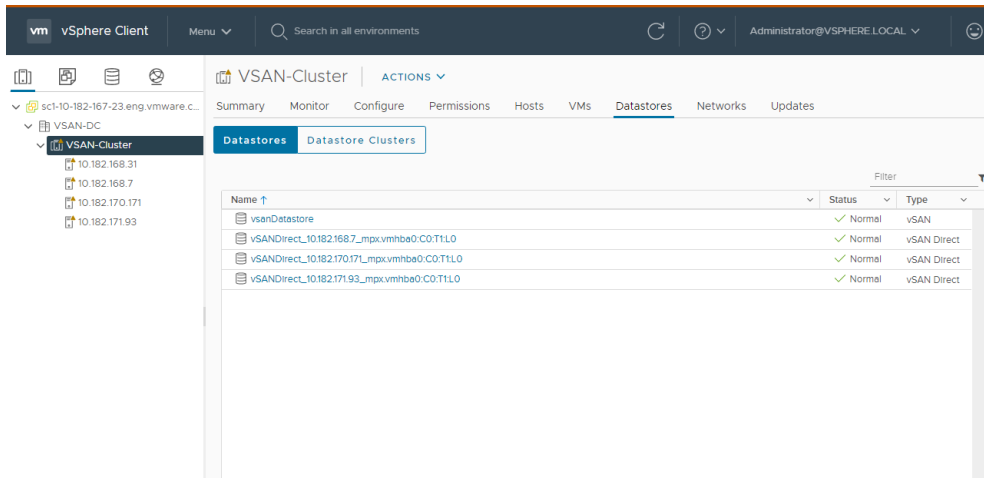
2 items

CANCEL
CREATE

- 7 Click **Create**.

For each device you claim, vSAN Direct creates a new datastore.

8 Click the **Datstores** tab to display all vSAN Direct datstores in your cluster.



### What to do next

You can use vSAN Direct with external storage. For more information, see [Use External Storage with vSAN Direct](#).

## Enable Stateful Services in vSphere with Tanzu

vSphere with Tanzu integrates with several third-party services that use the vSAN Data Persistence platform for their persistent storage needs. As a vSphere administrator, enable the services on vCenter Server.

Starting with the vSphere with Tanzu 7.0 Update 3 release, you can download available third-party services from a VMware supported repository.

When you enable the stateful service, you first register the service with vCenter Server using the downloaded YAML file that describes the service. You then install the service on Supervisor Clusters so that your DevOps engineers can use the service in Kubernetes workloads.

### Prerequisites

- Required privilege: **Supervisor Services.Manage Supervisor Services**
- Make sure that your Supervisor Cluster uses the NSX-T Data Center networking stack. vSAN Data Persistence platform does not support vSphere Distributed Switch (vDS) networking. For information on setting up NSX-T, see [Configuring NSX-T Data Center for vSphere with Tanzu](#).

- Download a partner service YAML file from the repository maintained by VMware.

When you download the service YAML files, make sure to use correct service version compatible with your version of vSphere.

If you installed earlier versions of partner services, MinIO and Cloudian Hyperstore, upgrade them to compatible versions after upgrading vSphere to version 7.0 Update 3. The newer versions of partner operators fix certain issues and use new platform features. For more information, see the partner documentation.

**Table 10-1. Compatibility Matrix for vSphere and Partner Services**

vSphere Version	Partner Service	Service Version	Kubernetes Version
vSphere 7.0 Update 3	MinIO	2.0.0	1.19, 1.20, 1.21
	Cloudian	1.2.0	1.19, 1.20, 1.21

Use one of the following methods to download the YAML file:

- In the <https://vmwaresaas.jfrog.io/> repository, navigate to an appropriate partner folder in **Artifacts > vDPP-Partner-YAML** and select a YAML file to download.

The latest version of the partner YAML is located in the top level partner directory.

- Use the `wget` or `curl` commands to download the YAML files.

For example:

```
wget https://vmwaresaas.jfrog.io/artifactory/vDPP-Partner-YAML/Cloudian/Hyperstore/SupervisorService/hyperstore-supervisor-service.yaml
```

## Procedure

- 1 Configure vSAN or vSAN Direct storage.

For information on setting up vSAN storage, see the *Administering VMware vSAN*. To set up vSAN Direct, see [Set Up vSAN Direct for vSphere with Tanzu](#).

vSAN Direct datastores appear in Kubernetes as StoragePools.

- 2 Add a stateful service to the vCenter Server system.

See [Add a Supervisor Service to vCenter Server](#).

- 3 Install the service on Supervisor Clusters.

See [Install a Supervisor Service on Supervisor Clusters](#).

After you enable the service, the vSAN Data Persistence platform performs the following actions to create necessary resources for the service:

- Creates a namespace for this service in the supervisor cluster.
- Creates storage policies to be used with vSAN Shared-Nothing-Architecture (SNA) and vSAN Direct datastores.

In vSphere 7.0 Update 2 and later, the vSAN Direct storage policy is capability-based. If you created tag-based policies in vSphere 7.0 Update 1, they are automatically converted to capability-based after an upgrade to vSphere 7.0 Update 2 and later.

If you want to create new storage policies and assign them to the service namespace instead of the default, see [Create vSAN Direct Storage Policy](#) and [Create vSAN SNA Storage Policy](#).

- Creates DevOps roles, including the roles with edit and view permissions.

When the service operator is deployed, its custom CRDs are installed in the Supervisor Cluster. Users with the edit permission can CRUD resources of these CRDs in the namespace. Users with the view permission can only view resources of this CRD.

- If the third party has provided a custom UI plugin, it appears in the vSphere Client. The vSphere administrator can use the plugin to manage the service.

- 4 Select the namespace created for the service and click the **Summary** tab to verify that all appropriate resources for the service have been created.

The screenshot shows the vSphere Client interface for the namespace 'hyperstore-domain-c63'. The 'Summary' tab is active, displaying the following information:

- Status:** Created 11/12/20. Config Status: Running. Kubernetes Status: Active. Location: test-vpx-1605142085-30509-... wdc-rdops-vm04-dhcp-43-113.
- Permissions:** You haven't given any devops access to this namespace. Add some permissions to let your devops team directly manage this namespace. (ADD PERMISSIONS)
- Storage:** Persistent Volume Claims: 0. Storage Policies: hyperstore-vsan-direct... (No limit), hyperstore-vsan-sna-thl... (No limit). (EDIT STORAGE)
- Capacity and Usage:** CPU: 0 MHz (No limit), Memory: 5.12 GB (No limit), Storage: 0 MB (No limit). (EDIT LIMITS)
- Tanzu Kubernetes:** To support Tanzu Kubernetes clusters this namespace needs access to a content library. You can configure it for the cluster this namespace is hosted on. (ADD LIBRARY)
- vSphere Pods:** 3 pods are shown in the 'Running' state. A legend indicates Running (blue), Pending (yellow), and Failed (red).

## What to do next

- The DevOps engineer uses the `kubectl` command to access the service namespace and uses the third-party CRDs to deploy instances of the third-party application service. For more information, see the third-party documentation.

To verify that the namespace you use for stateful services has appropriate storage classes, see [Check Storage Policies Available for Stateful Services](#).

- If the third party has provided a custom UI plugin, the vSphere administrator can use the plugin to manage and monitor the service.

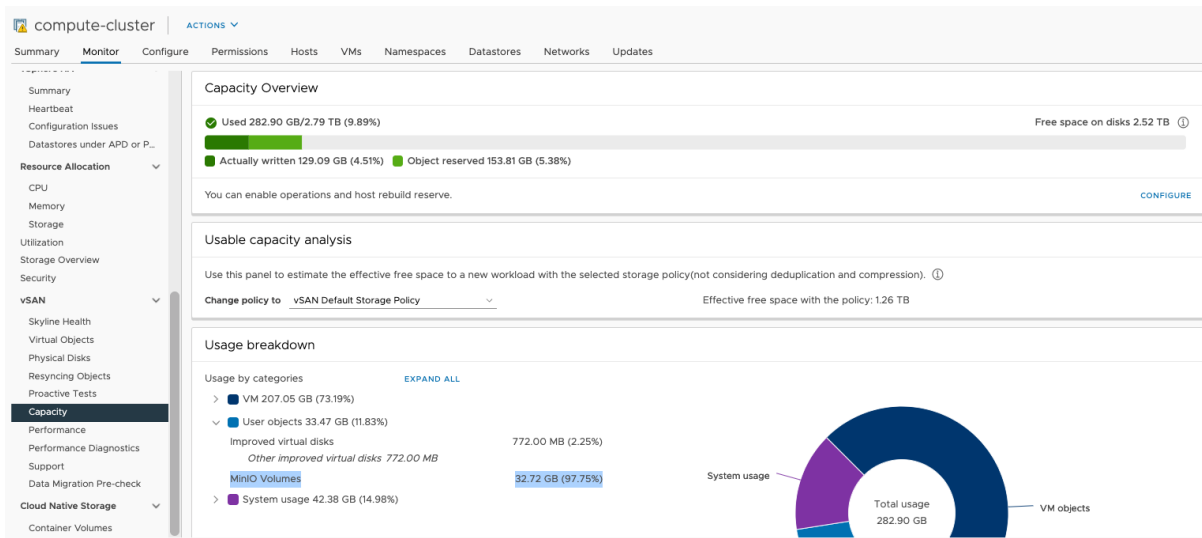
For more information, see the third-party UI plugin documentation. In addition, the vSphere administrator can use the Skyline Health checks to monitor the services. See [Monitor Stateful Services in vSphere with Tanzu](#)

## Monitor Stateful Services in vSphere with Tanzu

After you enable integrated third-party stateful services, use vSAN health and capacity monitoring capabilities to view status and analyze space usage of the service objects.

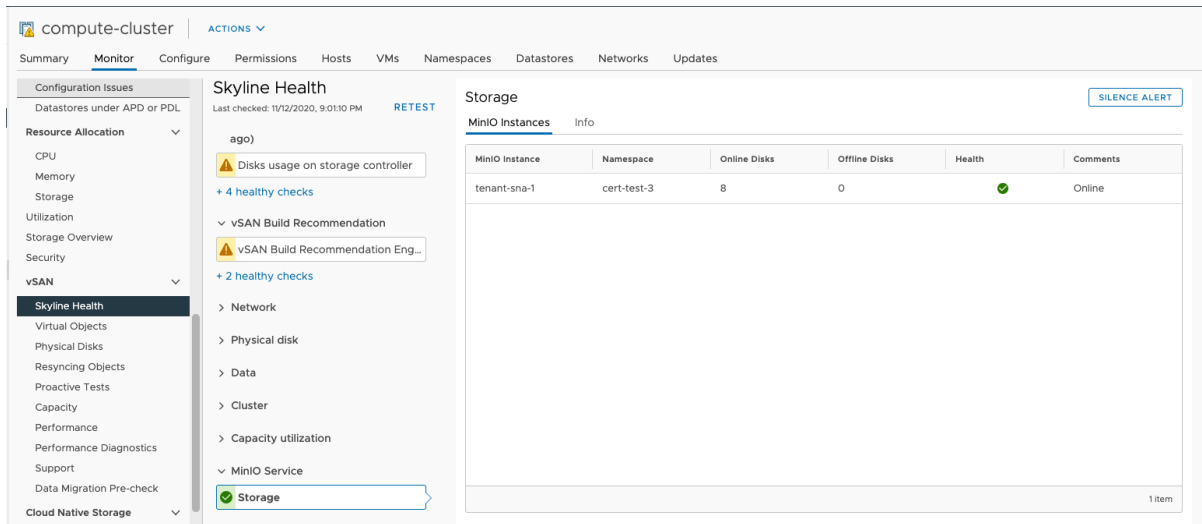
### Procedure

- 1 In the vSphere Client, navigate to the Supervisor Cluster.
- 2 Click the **Monitor** tab.
- 3 Monitor virtual objects that run in the namespace corresponding to the enabled service.
  - a Under **vSAN**, click **Virtual Objects**.  
You can browse the virtual objects, for example, MinIO operator objects, and check their state.
  - b To view the object's placement across the physical infrastructure, select a specific object and click **VIEW PLACEMENT DETAILS**.
- 4 Monitor capacity that the service objects use.
  - a Under **vSAN**, click **Capacity**.
  - b In the **Usage breakdown** pane, display your service objects under **User objects**.



- 5 Monitor health of your service instances.
  - a Under **vSAN**, select **Skyline Health**.
  - b Select an individual service health check to view the detailed information.





## Check Storage Policies Available for Stateful Services

As a DevOps engineer, verify that the namespace you use for stateful services in the vSphere with Tanzu environment has appropriate storage classes. The storage classes can be vSAN Shared-Nothing-Architecture (SNA) and vSAN Direct.

The vSAN Data Persistence platform automatically creates these storage classes in the namespace after a vSphere administrator enables the stateful service. See [Enable Stateful Services in vSphere with Tanzu](#).

They can also be assigned to the namespace by a vSphere administrator. See [Create vSAN Direct Storage Policy](#) and [Create vSAN SNA Storage Policy](#).

### Procedure

- ◆ Verify that the storage policies to be used with vSAN SNA and vSAN Direct are available in your namespace.

```
# kubectl get sc
NAME                                PROVISIONER                RECLAIMPOLICY  VOLUMEBINDINGMODE
ALLOWVOLUMEEXPANSION  AGE
sample-vsan-direct-thick  csi.vsphere.vmware.com  Delete         WaitForFirstConsumer
true                    3m36s
sample-vsan-sna-thick    csi.vsphere.vmware.com  Delete         WaitForFirstConsumer
true                    13m
```

## Create vSAN SNA Storage Policy

If you use vSAN with vSAN Data Persistence platform, you can create a vSAN Shared Nothing Architecture (SNA) storage policy to be used with the namespace where stateful services run.

## Procedure

- 1 In the vSphere Client, open the **Create VM Storage Policy** wizard.
  - a In the **Home** menu, click **Policies and Profiles**.
  - b Under **Policies and Profiles**, click **VM Storage Policies**.
  - c Click **Create**.
- 2 Enter the policy name and description.

Option	Action
<b>vCenter Server</b>	Select the vCenter Server instance.
<b>Name</b>	Enter the name of the storage policy, for example, <b>Sample SNA Thick</b> .
<b>Description</b>	Enter the description of the storage policy.

- 3 On the **Policy structure** page under **Datastore specific rules**, enable rules for vSAN storage placement.
- 4 On the **vSAN** page, click the **Availability** tab and select the following values. The values are only applicable for SNA workloads on the vSAN Data Persistence platform. They cannot be used for provisioning VM workloads.

Option	Description
<b>Option</b>	Value
<b>Site disaster tolerance</b>	<b>None - standard cluster</b>
	<b>Note</b> vSAN Data Persistence platform supports only standard clusters.
<b>Failures to tolerate</b>	<b>No data redundancy with host affinity</b>

Thick provisioning enforced for SNA workloads and is selected as a value for object space reservation on the **Advanced Policy Rules** tab. You cannot change this value.

- 5 On the **Storage compatibility** page, review the list of vSAN datastores that match this policy.
- 6 On the **Review and finish** page, review the storage policy settings and click **Finish**.  
To change any settings, click **Back** to go to the relevant page.

## What to do next

After you create the policy, you can assign it to the namespace where your stateful service runs. See [Change Storage Settings on a Namespace](#).

## Create vSAN Direct Storage Policy

If you use vSAN Direct with vSAN Data Persistence platform, you can create a capability based storage policy to be used with the namespace where stateful services run.

## Procedure

- 1 In the vSphere Client, open the **Create VM Storage Policy** wizard.
  - a In the **Home** menu, click **Policies and Profiles**.
  - b Under **Policies and Profiles**, click **VM Storage Policies**.
  - c Click **Create**.
- 2 Enter the policy name and description.

Option	Action
<b>vCenter Server</b>	Select the vCenter Server instance.
<b>Name</b>	Enter the name of the storage policy, for example, <b>Sample vSAN Direct Thick</b> .
<b>Description</b>	Enter the description of the storage policy.

- 3 On the **Policy structure** page under **Datastore specific rules**, enable rules for vSAN Direct storage placement.
- 4 On the **vSAN Direct rules** page, specify vSAN Direct as a storage placement type.
- 5 On the **Storage compatibility** page, review the list of vSAN Direct datastores that match this policy.
- 6 On the **Review and finish** page, review the storage policy settings and click **Finish**.  
To change any settings, click **Back** to go to the relevant page.

## What to do next

After you create the policy, you can assign it to the namespace where your stateful service runs. See [Change Storage Settings on a Namespace](#).

# Deploying Workloads to vSphere Pods

# 11

As a DevOps engineer, you can deploy and manage the life cycle of vSphere Pods within the resources boundaries of a namespace that is running on a Supervisor Cluster. You must have write permissions on a namespace to deploy vSphere Pods on it.

This chapter includes the following topics:

- [Get and Use the Supervisor Cluster Context](#)
- [Deploy an Application to a vSphere Pod on a vSphere Namespace](#)
- [Deploy an Application to a vSphere Pod Using the Embedded Harbor Registry](#)
- [Scale a vSphere Pod Application](#)
- [Deploy a Confidential vSphere Pod](#)

## Get and Use the Supervisor Cluster Context

After the vSphere administrator provides you with the IP address of the Kubernetes control plane on the Supervisor Cluster, you can log in to the Supervisor Cluster and obtain the contexts to which you have access. Contexts correspond to the namespaces on the Supervisor Cluster.

### Prerequisites

- Get the IP address of the Kubernetes control plane on the Supervisor Cluster from your vSphere administrator.
- Get your user account in vCenter Single Sign-On.
- Verify with your vSphere administrator that you have permissions to access the contexts that you need.
- Verify that the certificate served by the Kubernetes control plane is trusted on your system, either by having the signing CA installed as a Trust Root or by adding the certificate as a Trust Root directly.

### Procedure

- 1 In a browser window, open the URL of the Kubernetes control plane.
- 2 Verify that the SHA256 checksum of the `vsphere-plugin.zip` matches the checksum from the `sha256sum.txt` file.

- 3 Download the `vsphere-plugin.zip` file on your machine and set it on your OS's executable search path.
- 4 In a command prompt window, run the following command to log in to vCenter Server:

```
kubectl vsphere login --server=https://<server_address> --vsphere-username <your user account name>
```

- 5 To view details of the configuration contexts which you can access to, run the following `kubectl` command:

```
kubectl config get-contexts
```

The CLI displays the details for each available context.

- 6 To switch between contexts, use the following command:

```
kubectl config use-context <example-context-name>
```

## Results

The login API on the Kubernetes control plane is invoked. An authenticating proxy redirects a request for authentication to vCenter Single Sign-On. vCenter Server returns a JSON Web token and adds it to the `kubeconfig` file. That token is sent to the Kubernetes control plane with every new `kubectl` command to authenticate the user.

## Deploy an Application to a vSphere Pod on a vSphere Namespace

You can deploy an application on a namespace on a Supervisor Cluster. Once the application is deployed, the respective number of vSphere Pods are created on the Supervisor Cluster within the namespace.

You can also deploy applications from images that are stored in the Harbor image registry. See [Deploy an Application to a vSphere Pod Using the Embedded Harbor Registry](#).

### Prerequisites

- Get the IP address of the Kubernetes control plane on the Supervisor Cluster from your vSphere administrator.
- Get your user account in vCenter Single Sign-On.
- Verify with your vSphere administrator that you have permissions to access the contexts that you need.

### Procedure

- 1 Authenticate with the Supervisor Cluster.

See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

- 2 Switch to the context where you want to deploy the application.

```
kubectl config use-context <namespace>
```

- 3 Deploy the application.

```
kubectl apply -f <application name>.yaml
```

## Deploy an Application to a vSphere Pod Using the Embedded Harbor Registry

You can use images that are stored in Harbor Registry to deploy vSphere Pods in namespaces on the Supervisor Cluster.

### Prerequisites

- Push images to a project in Harbor Registry that has the same name as the namespace where you want to deploy your application. See [Push Images to the Embedded Harbor Registry](#) .
- Add the contents of the `vsphere-plugin.zip` to the execution file path of your environment.

### Procedure

- 1 Create a YAML file that contains the following parameters:

```
...
namespace: <namespace-name>
...
spec:
...
image: <image registry URL>/<namespace name>/<image name>
```

- 2 Login to the Supervisor Cluster:

```
kubectl vsphere login --server=https://<server_adress> --vsphere-username <your user
account name>
```

- 3 Switch to the namespace where you want to deploy the application.

```
kubectl config use-context <namespace>
```

- 4 Deploy a vSphere Pod from that YAML file:

```
kubectl apply -f <yaml file name>.yaml
```

- 5 Run the following command to verify that the image is pulled from the Harbor Registry and the vSphere Pod is in running state:

```
kubectl describe pod/<yaml name>
```

## Results

The YAML file that you created is deployed to the specified namespace by using the image from the project on Harbor Registry that is named after the namespace.

## Example:

Create and deploy the following YAML file on the namespace demoapp1 by using the busybox image from the demoapp1 project in Harbor Registry:

```
apiVersion: v1
kind: Pod
metadata:
  name: busybox
  namespace: demoapp1
spec:
  containers:
  - name: busybox
    image: <harbor_IP>/demoapp1/busybox:latest
    command:
      - sleep
      - "3600"
    imagePullPolicy: IfNotPresent
  restartPolicy: Always
```

## Scale a vSphere Pod Application

You can scale up and down the number of replicas for each application that is running on a Supervisor Cluster.

### Prerequisites

- Get the IP address of the Kubernetes control plane on the Supervisor Cluster from your vSphere administrator.
- Get your user account in vCenter Single Sign-On.
- Verify with your vSphere administrator that you have permissions to access the contexts that you need.

### Procedure

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server <control plane load balancer IP address> --vsphere-username
<vSphere user account name>
```

- 2 Scale up or scale down an application.

```
kubectl get deployments
kubectl scale deployment <deployment-name> --replicas=<number-of-replicas>
```

## Deploy a Confidential vSphere Pod

With vSphere with Tanzu, you can run confidential vSphere Pods on a Supervisor Cluster. A confidential vSphere Pod uses a hardware technology that keeps the guest OS memory encrypted, protecting it against access from the hypervisor.

Starting from vSphere 7.0 Update 2, you can create confidential vSphere Pods by adding Secure Encrypted Virtualization-Encrypted State (SEV-ES) as an extra security enhancement. SEV-ES prevents CPU registers from leaking information in registers to components like the hypervisor. SEV-ES can also detect malicious modifications to a CPU register state. For more information about using SEV-ES technology in the vSphere environment, see [Securing Virtual Machines with AMD Secure Encrypted Virtualization-Encrypted State](#).

### Prerequisites

To enable SEV-ES on an ESXi host, a vSphere administrator must follow these guidelines:

- Use the hosts that support the SEV-ES functionality. Currently, SEV-ES supports only AMD EPYC 7xx2 CPUs (code named *Rome*) and later CPUs.
- Use the ESXi version of 7.0 Update 2 or later.
- Enable SEV-ES in an ESXi system's BIOS configuration. See your system's documentation for more information about accessing the BIOS configuration.
- When enabling SEV-ES in the BIOS, enter a value for the **Minimum SEV non-ES ASID** setting equal the number of SEV-ES VMs and confidential vSphere Pods on the host plus one. For example, if you plan to run 100 SEV-ES VMs and 128 vSphere Pods, enter at least 229. You can enter a setting as high as 500.



**Procedure****1** Create a YAML file that contains the following parameters.

- a In annotations, enable the confidential vSphere Pods feature.

```
...
annotations:
  vmware/confidential-pod: enabled
...
```

- b Specify memory resources for containers.

Make sure to set memory requests and memory limits to the same value, as in this example.

```
resources:
  requests:
    memory: "512Mi"
  limits:
    memory: "512Mi"
```

Use the following YAML file as an example:

```
apiVersion: v1
kind: Pod
metadata:
  name: photon-pod
  namespace: my-podvm-ns
  annotations:
    vmware/confidential-pod: enabled
spec: # specification of the pod's contents
  restartPolicy: Never
  containers:
  - name: photon
    image: wcp-docker-ci.artifactory.eng.vmware.com/vmware/photon:1.0
    command: ["/bin/sh"]
    args: ["-c", "while true; do echo hello, world!; sleep 1; done"]
    resources:
      requests:
        memory: "512Mi"
      limits:
        memory: "512Mi"
```

**2** Log in to the Supervisor Cluster.

```
kubectl vsphere login --server=https://<server_adress> --vsphere-username <your user
account name>
```

**3** Switch to the namespace where you want to deploy the application.

```
kubectl config use-context <namespace>
```

- 4 Deploy a confidential vSphere Pod from the YAML file.

```
kubectl apply -f <yaml file name>.yaml
```

---

**Note** When the vSphere Pod is deployed, DRS places it to the ESXi node that supports SEV-ES. If no such node is available, the vSphere Pod is marked as failed.

---

The confidential vSphere Pod that is launched provides hardware memory encryption support for all workloads that are running on that pod.

- 5 Run the following command to verify that the confidential vSphere Pod has been created.

```
kubectl describe pod/<yaml name>
```

#### What to do next

A vSphere administrator can view the confidential vSphere Pod. In the vSphere Client, it appears with the **Encryption Mode: Confidential Compute** tag.

vm vSphere Client
Menu ▾ 🔍 Search

- 📁 un-vc-client eng vmware...
- 📁 Paó Alto
  - 📁 Test xyz
  - 📁 Jinderdesk Hosts
  - 📁 test abc
- 📁 Wensathee
  - 📁 Production
  - 📁 Cluster 1
    - 📁 m-03 eng vmwa...
    - 📁 m-04 eng vmwa...
    - 📁 Namespace( RP)
      - 📁 work-auth
        - 📁 k8-Cluster -1
          - 📁 k8s-vm-2
          - 📁 k8s-vm-2
          - 📁 k8s-vm-3
        - 📁 k8-Cluster-2
        - 📁 K8S Cluster 3
        - 📁 pod-vm-1
        - 📁 pod-vm-2
      - 📁 finance-app

📁 pod-vm-1
ACTION ▾

Summary
Monitor
Configure
Compute
Storage

**Status**

Running ✔

Tue, 12 Feb 2019 14:57:30

**Namespace**

work-auth

**Node**

m-04 eng vmware.com

**Restart Policy**

Inactive

**Containers**

8 Total 4 1 3

- 📁 Container 1  
Imagename 1
- 📁 Container 2  
Imagename 2
- 📁 Container 3  
Imagename 3

VIEW ALL

**Metadata**

**UID** fd726e00-180f-11e8-8fa1-0050568e3cc9

**Labels**

Application Windows
Application Windows

Application Windows
and 9 more

**QoS Class** BestEffort

**Encryption mode** Confidential Compute

VIEW YAML

# Deploying and Managing Virtual Machines in vSphere with Tanzu

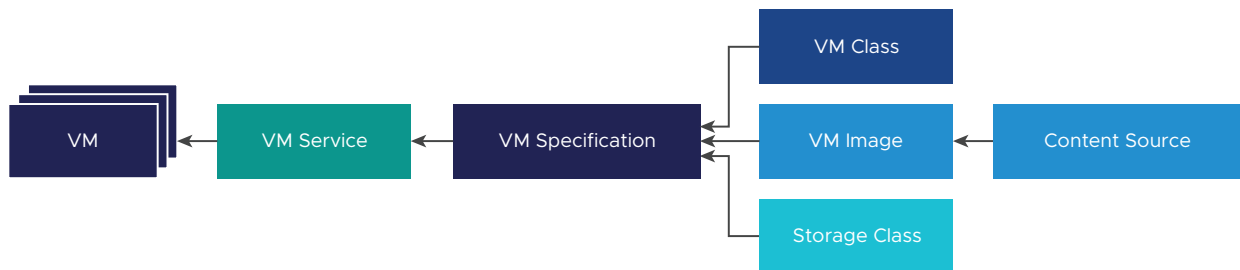
# 12

vSphere with Tanzu offers a VM Service functionality that enables DevOps engineers to deploy and run VMs, in addition to containers, in a common, shared Kubernetes environment. You can use the VM Service to manage the lifecycle of virtual machines in a vSphere Namespace. VM Service manages stand-alone VMs and VMs that make up Tanzu Kubernetes clusters.

Generally, your business needs and goals dictate your decision to run workloads in a VM rather than in a container. For information about when to run a VM, see [Using Virtual Machines in vSphere with Tanzu](#).

## Concepts of VM Service

To describe the state of a VM to be deployed in a vSphere Namespace, you use such parameters as a VM class, a VM image, and a storage class. The VM Service then brings together these specifications to create stand-alone VMs or VMs that support Tanzu Kubernetes clusters.



### VM Service

The VM Service is a component of vSphere with Tanzu that provides a declarative, Kubernetes-style API for management of VMs and associated vSphere resources. The VM Service enables the vSphere administrators to deliver resources and provide templates, such as VM classes and VM images, to Kubernetes. DevOps engineers can use these resources to describe the desired state of a VM. After the DevOps engineers specify the VM state, the VM Service converts the desired state in to a realized state against backing infrastructure resources.

A VM created through the VM Service can be managed only from the Kubernetes namespace with the `kubectl` commands. vSphere administrators cannot manage the VM from the vSphere Client, but can display its details and monitor resources it uses. For information, see [Monitor Virtual Machines Available in vSphere with Tanzu](#).

## VM Class

The VM class is a VM specification that can be used to request a set of resources for a VM. The VM class is controlled and managed by a vSphere administrator, and defines such parameters as the number of virtual CPUs, memory capacity, and reservation settings. The defined parameters are backed and guaranteed by the underlying infrastructure resources of a Supervisor Cluster.

A vSphere administrator can create custom VM classes.

In addition, Workload Management offers several default VM classes. Generally, each default class type comes in two editions: guaranteed and best effort. A guaranteed edition fully reserves resources that a VM specification requests. A best effort class edition does not and allows resources to be overcommitted. Typically, a guaranteed type is used in a production environment.

Examples of default VM classes include the following.

Class	CPU	Memory (GB)	Reserved CPU and Memory
<code>guaranteed-large</code>	4	16	Yes
<code>best-effort-large</code>	4	16	No
<code>guaranteed-small</code>	2	4	Yes
<code>best-effort-small</code>	2	4	No

The vSphere administrator can assign any number of existing VM classes to make them available to DevOps engineers within a specific namespace.

The VM class provides a simplified experience for the DevOps engineers. The DevOps don't need to understand the full configuration of each VM that they plan to create. Instead, they can select a VM class from available options, and the VM Service manages the VM configuration.

On the Kubernetes side, the VM classes appear as `VirtualMachineClass` and `VirtualMachineClassBinding` resources.

## VM Image

A VM image is a template that contains a software configuration, including an operating system, applications, and data.

When DevOps engineers create VMs, they can select images from the content library associated with the namespace. To the DevOps, the images are exposed as `VirtualMachineImage` objects.

VM Service supports a limited number of VM images and guest OSes. Compatible VM images appear on VMware Marketplace as OVF. Make sure to use only those VM images that are supported by VM Service. To find compatible images, search for **VM Service image** on the [VMware Cloud Marketplace](#) web site. See an example of the VM Service image for CentOS at [VM Service Image for CentOS](#).

### Content Source

A DevOps engineer uses a content library as a source of images to create a VM. Similar to VM classes, a vSphere administrator can assign existing content libraries to a namespace to make them available to DevOps engineers.

### Storage Class

VM Service uses storage classes for placing virtual disks and dynamically attaching persistent volumes. For more information about storage classes, see [Chapter 10 Using Persistent Storage in vSphere with Tanzu](#).

### VM Specification

DevOps engineers describe the desired state of a VM in a YAML file that brings together the VM image, the VM class, and the storage class.

### Networking

VM Service does not have any specific requirements and relies on the network configuration available in vSphere with Tanzu. VM Service supports both types of networking, the vSphere networking or NSX-T. When VMs are deployed, an available network provider allocates static IP addresses to the VMs. For information, see [Chapter 4 Networking for vSphere with Tanzu](#).

## vSphere Administrator Workflow for Provisioning a VM

As a vSphere administrator, you set guardrails for the policy and governance of the VMs, and deliver VM resources, such as VM classes and VM templates to DevOps engineers. After a VM is deployed, you can monitor it using the vSphere Client.

Step	Description	Instructions
1	Create and manage VM classes.	<ul style="list-style-type: none"> <li>■ <a href="#">Create a VM Class in vSphere with Tanzu</a></li> <li>■ To use NVIDIA vGPU, configure a PCI device in the VM class. See <a href="#">Add PCI Devices to a VM Class in vSphere with Tanzu</a>.</li> <li>■ <a href="#">Edit or Delete a VM Class in vSphere with Tanzu</a></li> </ul>
2	Associate a set of VM classes with a namespace.	<a href="#">Associate a VM Class with a Namespace in vSphere with Tanzu</a>

Step	Description	Instructions
3	Create and manage content libraries.	<ul style="list-style-type: none"> <li>■ For stand-alone VMs, see <a href="#">Creating and Managing Content Libraries for Stand-Alone VMs in vSphere with Tanzu</a>.</li> <li>■ For Tanzu Kubernetes clusters, see <a href="#">Creating and Managing Content Libraries for Tanzu Kubernetes releases</a>.</li> </ul>
4	Associate a content library with a namespace.	<ul style="list-style-type: none"> <li>■ For stand-alone VMs, see <a href="#">Associate a VM Content Library with a Namespace in vSphere with Tanzu</a>.</li> <li>■ For Tanzu Kubernetes clusters, see <a href="#">Configure a vSphere Namespace for Tanzu Kubernetes releases</a>.</li> </ul>
5	Associate storage classes with a namespace.	<a href="#">Create and Configure a vSphere Namespace</a>
6	Monitor deployed VMs.	<a href="#">Monitor Virtual Machines Available in vSphere with Tanzu</a>

## DevOps Engineer Workflow for Provisioning a VM

DevOps engineers with permissions, can review available VM resources and deploy VMs into the namespace. They use the `kubectl` command to perform the following tasks.

Step	Description	Instructions
1	List VM classes, images, and other resources associated with the namespace.	<a href="#">View VM Resources Available on a Namespace in vSphere with Tanzu</a>
2	Create a VM.	<ul style="list-style-type: none"> <li>■ For stand-alone VMs, see <a href="#">Deploy a Virtual Machine in vSphere with Tanzu</a>.</li> <li>■ For Tanzu Kubernetes cluster VMs, see <a href="#">Workflow for Provisioning Tanzu Kubernetes Clusters</a>.</li> </ul>

This chapter includes the following topics:

- [Create a VM Class in vSphere with Tanzu](#)
- [Add PCI Devices to a VM Class in vSphere with Tanzu](#)
- [Edit or Delete a VM Class in vSphere with Tanzu](#)
- [Associate a VM Class with a Namespace in vSphere with Tanzu](#)
- [Manage VM Classes on a Namespace in vSphere with Tanzu](#)
- [View VM Resources Available on a Namespace in vSphere with Tanzu](#)
- [Deploy a Virtual Machine in vSphere with Tanzu](#)

- [Monitor Virtual Machines Available in vSphere with Tanzu](#)

## Create a VM Class in vSphere with Tanzu

As a vSphere administrator, create custom VM classes to be used for a VM deployment in a namespace in vSphere with Tanzu. Custom VM classes can be used by stand-alone VMs that run in namespaces and by VMs hosting a Tanzu Kubernetes cluster.

A VM class is a template that defines CPU, memory, and reservations for VMs. The VM class helps to set guardrails for the policy and governance of VMs by anticipating development needs and accounting for resource availability and constraints. vSphere with Tanzu offers several default VM classes. You can use them as is, edit, or delete them.

You can also create custom VM classes. When you create new classes, keep in mind the following considerations.

- VM classes that you create in a vCenter Server instance are available to all vCenter Server clusters and all namespaces in these clusters.
- VM classes are available to all namespaces in vCenter Server. However, DevOps engineers can use only those VM classes that you associate with a particular namespace.

### Prerequisites

Required privileges:

- **Namespaces.Modify cluster-wide configuration**
- **Namespaces.Modify namespace configuration**
- **Virtual Machine Classes.Manage Virtual Machine Classes**

### Procedure

- 1 Go to the **VM Service** page.
  - a From the vSphere Client home menu, select **Workload Management**.
  - b Click the **Services** tab and click **Manage** on the **VM Service** pane.
- 2 On the **VM Service** page, click **VM Classes** and click **Create VM Class**.



### 3 On the **Configuration** page, specify the general VM class attributes.

VM Class Attribute	Description
Name	<p>Identifies the VM class. Enter a unique DNS compliant name that follows these requirements:</p> <ul style="list-style-type: none"> <li>■ Use a unique name that does not duplicate the names of default or custom VM classes in your environment.</li> <li>■ Use alphanumeric string with maximum length of 63 characters.</li> <li>■ Do not use uppercase letters or spaces.</li> <li>■ Use a dash anywhere except as a first or last character. For example, <b>vm-class1</b>.</li> </ul> <p>After you create the VM class, you cannot change its name.</p>
vCPU Count	<p>Defines the number of virtual CPUs (vCPUs) for a VM. This is a VM hardware configuration. When a DevOps user assigns the VM class to a VM, this count becomes the configured number of vCPUs for the VM.</p>
CPU Resource Reservation	<p>Optional parameter. Specifies the guaranteed minimum CPU resource allocation for a virtual machine. This value is expressed in percentage (%). Value of 0 % defines no CPU reservation.</p> <p>The percentage you enter is multiplied by the minimum CPU available among all the cluster nodes. The resulting value, in MHz, specifies the amount of CPU resources that vSphere guarantees for a VM.</p>
Memory	<p>Defines the memory configured for a VM in MB, GB, or TB. This is a VM hardware configuration. When a DevOps user assigns the VM class policy to a VM, the VM receives the amount of memory defined by this attribute.</p> <p>The value must be between 4 MB and 24 TB and a multiple of 4 MB.</p>
Memory Resource Reservation	<p>Optional parameter. Defines the reserved amount of memory that is configured for a VM. The value of the attribute ranges between 0 and 100%.</p> <p>If you add PCI devices to the VM class configuration, set the parameter to 100%.</p>

### 4 (Optional) To add PCI devices, on the **Configuration** page, select **Yes** from the **PCI Devices** drop-down menu and click **Next**.

If you select this option, the memory resource reservation value automatically changes to 100%.

For requirements and additional details, see [Add PCI Devices to a VM Class in vSphere with Tanzu](#).

### 5 On the **Review and Confirm** page, review the details and click **Finish**.

## What to do next

After you create a VM class, you can edit its parameters or delete it from your environment. See [Edit or Delete a VM Class in vSphere with Tanzu](#).

To make the VM class available to DevOps engineers, associate it with a namespace. The association of the VM class occurs on a per namespace level. See [Associate a VM Class with a Namespace in vSphere with Tanzu](#).

## Attributes of VM Classes in vSphere with Tanzu

As a vSphere administrator, you can create or edit virtual machine (VM) classes that VMs in a vSphere Namespace use. For each VM class, you specify a subset of available attributes.

The following table lists all attributes that you can define within a VM class.

VM Class Attribute	Description
Name	<p>Identifies the VM class. Enter a unique DNS compliant name that follows these requirements:</p> <ul style="list-style-type: none"> <li>■ Use a unique name that does not duplicate the names of default or custom VM classes in your environment.</li> <li>■ Use alphanumeric string with maximum length of 63 characters.</li> <li>■ Do not use uppercase letters or spaces.</li> <li>■ Use a dash anywhere except as a first or last character. For example, <b>vm-class1</b>.</li> </ul> <p>After you create the VM class, you cannot change its name.</p>
vCPU Count	<p>Defines the number of virtual CPUs (vCPUs) for a VM. This is a VM hardware configuration. When a DevOps user assigns the VM class to a VM, this count becomes the configured number of vCPUs for the VM.</p>
CPU Resource Reservation	<p>Optional parameter. Specifies the guaranteed minimum CPU resource allocation for a virtual machine. This value is expressed in percentage (%). Value of 0 % defines no CPU reservation.</p> <p>The percentage you enter is multiplied by the minimum CPU available among all the cluster nodes. The resulting value, in MHz, specifies the amount of CPU resources that vSphere guarantees for a VM.</p>

VM Class Attribute	Description
Memory	<p>Defines the memory configured for a VM in MB, GB, or TB. This is a VM hardware configuration. When a DevOps user assigns the VM class policy to a VM, the VM receives the amount of memory defined by this attribute.</p> <p>The value must be between 4 MB and 24 TB and a multiple of 4 MB.</p>
Memory Resource Reservation	<p>Optional parameter. Defines the reserved amount of memory that is configured for a VM. The value of the attribute ranges between 0 and 100%.</p> <p>If you add PCI devices to the VM class configuration, set the parameter to 100%.</p>

## Add PCI Devices to a VM Class in vSphere with Tanzu

If ESXi hosts in your vSphere with Tanzu environment have one or more NVIDIA GRID GPU graphics devices, you can configure VMs to use the NVIDIA GRID virtual GPU (vGPU) technology. You can also configure other PCI devices on an ESXi host to make them available to a VM in a passthrough mode.

### NVIDIA GRID GPU

NVIDIA GRID GPU graphics devices are designed to optimize complex graphics operations and enable them to run at high performance without overloading the CPU. NVIDIA GRID vGPU provides unparalleled graphics performance, cost-effectiveness, and scalability by sharing a single physical GPU among multiple VMs as separate vGPU-enabled passthrough devices.

When you configure NVIDIA vGPU for a VM, you add a PCI device for vGPU to a VM class.

The following considerations apply when you use NVIDIA vGPU:

- VMs with vGPU devices that are managed by VM Service are automatically powered off when an ESXi host enters maintenance mode. This might temporarily affect workloads running in the VMs. The VMs are automatically powered on after the host exits the maintenance mode.

### Dynamic DirectPath I/O

Using Dynamic DirectPath I/O, the VM can directly access the physical PCI and PCIe devices connected to a host.

You can use Dynamic DirectPath I/O to assign multiple PCI passthrough devices to a VM. Each passthrough device can be specified by its PCI vendor and device identifier.

### Prerequisites

- Verify that the host machine is supported in the [VMware Compatibility Guide](#), and check with the vendor to verify the host meets power and configuration requirements. Install a PCI device on the ESXi host.

- To configure NVIDIA vGPU, follow these prerequisites:
  - Use vSphere version 7.0 Update 3 or later.
  - Configure ESXi host graphics settings with at least one device in **Shared Direct** mode. See [Configuring Host Graphics](#).
  - Install NVIDIA vGPU software. NVIDIA provides a vGPU software package that includes the following components.
 

For more information, see appropriate NVIDIA Virtual GPU Software documentation.

    - vGPU Manager that a vSphere administrator installs on the ESXi host. See [VMware Knowledge Base article 2033434](#).
    - Guest VM driver that a DevOps engineer installs in the VM after deploying and booting the VM. See [Install the NVIDIA Guest Driver in a VM in vSphere with Tanzu](#).
- To configure Dynamic DirectPath I/O for PCI passthrough devices, follow these prerequisites:
  - Use vSphere version 7.0 Update 3 MP01.
  - Connect the PCI devices to the host and mark them as available for passthrough. See [Mark a PCI Device as Passthrough](#).
- Required privileges:
  - **Namespaces.Modify cluster-wide configuration**
  - **Namespaces.Modify namespace configuration**
  - **Virtual Machine Classes.Manage Virtual Machine Classes**

#### Procedure

- 1 Add a PCI device to a VM class when you create or edit an existing VM class.

Option	Action
<b>Create a new VM class</b>	<ol style="list-style-type: none"> <li>a From the vSphere Client home menu, select <b>Workload Management</b>.</li> <li>b Click the <b>Services</b> tab and click <b>Manage</b> on the <b>VM Service</b> pane.</li> <li>c On the <b>VM Service</b> page, click <b>VM Classes</b> and click <b>Create VM Class</b>.</li> <li>d On the <b>Configuration</b> page, specify the general VM class attributes. See <a href="#">Attributes of VM Classes in vSphere with Tanzu</a>. Make sure that the memory resource reservation value is set to 100%.</li> <li>e To add PCI devices, on the <b>Configuration</b> page, select <b>Yes</b> from the <b>PCI Devices</b> drop-down menu and click <b>Next</b>.</li> </ol>
<b>Edit a VM class</b>	<ol style="list-style-type: none"> <li>a From the vSphere Client home menu, select <b>Workload Management</b>.</li> <li>b Click the <b>Services</b> tab and click <b>Manage</b> on the <b>VM Service</b> pane.</li> <li>c On the <b>VM Service</b> page, click <b>VM Classes</b>.</li> <li>d In the existing VM class pane, click <b>Manage</b> and click <b>Edit</b>. Make sure that the memory resource reservation value is set to 100%.</li> <li>e To add PCI devices, on the <b>Configuration</b> page, select <b>Yes</b> from the <b>PCI Devices</b> drop-down menu and click <b>Next</b>.</li> </ol>

- 2 On the **PCI Devices** page, expand the **Add PCI Device** menu, select the access type and other appropriate options, and click **Next**.

Option	Action
<b>NVIDIA GRID vGPU</b>	Specify the following options: <ul style="list-style-type: none"> <li>■ <b>Model.</b> Name of physical device. Select the device from the list of devices available on the host.</li> <li>■ <b>GPU Sharing.</b> Indicates how physical GPU is shared across VMs. For example, <b>Time Sharing</b>.</li> <li>■ <b>GPU Mode.</b> The GPU mode within a VM. For example, <b>Compute</b> is a configuration that is optimized for high-performance computing applications. While <b>Workstation</b> is used for graphics intensive workloads.</li> <li>■ <b>GPU Memory.</b> Minimum GPU memory in GB per VM.</li> <li>■ <b>Number of vGPUs.</b> Number of vGPU devices per VM.</li> </ul>
<b>Dynamic DirectPath IO</b>	From the <b>PCI Device</b> list, select the PCI passthrough devices by their vendor, model name, or hardware label.

- 3 On the **Review and Confirm** page, review the details and click **Finish**.

#### Results

A **GPUs** tag on the VM class pane indicates that the VM class is GPU-enabled.

## Edit or Delete a VM Class in vSphere with Tanzu

As a vSphere administrator, you can create custom VM classes for VMs in a vSphere Namespace. After you create a VM class, you can edit its parameters. You can also edit default VM classes that vSphere with Tanzu offers. If you no longer need an existing VM class, you can delete it from your environment.

Editing a VM class does not result in automatic reconfiguring of the VMs that were previously deployed from this class. For example, if a DevOps user created a Tanzu Kubernetes cluster with the VM class and you later change the VM class definition, existing Tanzu Kubernetes VMs remain unaffected. New Tanzu Kubernetes VMs will use the modified class definition.

**Caution** If you scale out a Tanzu Kubernetes cluster after editing a VM class used by that cluster, new cluster nodes use the updated class definition, but existing cluster nodes continue to use the initial class definition, resulting in a mismatch. Both control plane and worker nodes can be scaled. For information about scaling, [Scale a Tanzu Kubernetes Cluster Using the Tanzu Kubernetes Grid Service v1alpha1 API](#).

When you delete a VM class, it is removed from all associated namespaces. DevOps users can no longer self-service VMs using this VM class. VMs that have already been created with this VM class are not affected.

## Prerequisites

- Verify that you have at least one VM class. See [Create a VM Class in vSphere with Tanzu](#).
- Required privileges:
  - **Namespaces.Modify cluster-wide configuration**
  - **Namespaces.Modify namespace configuration**
  - **Virtual Machine Classes.Manage Virtual Machine Classes**

## Procedure

- 1 In the vSphere Client, display available VM classes.
  - a From the vSphere Client home menu, select **Workload Management**.
  - b Click the **Services** tab and click the **VM Service** pane.
  - c On the **VM Service** page, click **VM Classes**.
 

All default or user-created VM classes appear under **Available VM Classes**.
- 2 Edit or delete an existing VM class.

Option	Description
<b>Edit a VM class</b>	<ol style="list-style-type: none"> <li>a In the selected VM class pane, click <b>Manage</b> and click <b>Edit</b>.</li> <li>b Modify the VM class parameters. See <a href="#">Attributes of VM Classes in vSphere with Tanzu</a>.</li> </ol> <p><b>Note</b> You cannot change the name of the VM class.</p>
<b>Delete a VM class</b>	<ol style="list-style-type: none"> <li>a In the selected VM class pane, click <b>Manage</b> and click <b>Delete</b>.</li> <li>b Confirm that you want to delete the VM class.</li> </ol>

## What to do next

To make a VM class available to DevOps engineers, associate the VM class with a namespace. The association of the VM class occurs on a per namespace level. See [Associate a VM Class with a Namespace in vSphere with Tanzu](#).

# Associate a VM Class with a Namespace in vSphere with Tanzu

As a vSphere administrator, you can add a VM class to one or more namespaces on a Supervisor Cluster. When you add a VM class to a namespace, you make the class available to DevOps users, so that they can start self-servicing VMs in the Kubernetes namespace environment. The VM classes you assign to the namespace are also used by the VMs that make up Tanzu Kubernetes clusters.

You can add multiple VM classes to a single namespace. Different VM classes serve as indicators of different levels of service. If you publish multiple VM classes, DevOps users can select between all custom and default classes when creating and managing virtual machines in the namespace.

---

**Note** To be able to deploy a Tanzu Kubernetes cluster in a newly created namespace, DevOps engineers need to have access to VM classes. As a vSphere administrator, you must explicitly associate default or custom VM classes to any new namespace where the Tanzu Kubernetes cluster is deployed. Existing namespaces, where Tanzu Kubernetes clusters have been already provisioned, continue to have automatic access to default VM classes. But you can also associate custom VM classes with any existing namespace.

---

### Prerequisites

Use default VM classes that VMware provides or create new classes. See [Create a VM Class in vSphere with Tanzu](#).

Required privileges:

- **Namespaces.Modify cluster-wide configuration**
- **Namespaces.Modify namespace configuration**
- **Virtual Machine Classes.Manage Virtual Machine Classes**

### Procedure

- 1 In the vSphere Client, go to the namespace.
  - a From the vSphere Client home menu, select **Workload Management**.
  - b Click the **Namespaces** tab and click the namespace.
- 2 Add a VM class.
  - a On the **VM Service** pane, click **Add VM Class**.
  - b Select one or several VM classes and click **OK**.

### Results

The VM classes you added become available in the namespace for the DevOps to self-service VMs. These classes can also be used by the VMs that make up Tanzu Kubernetes clusters.

### What to do next

After you associate a VM class with a namespace, you can add more VM classes or remove the class to unpublish it from the namespace. See [Manage VM Classes on a Namespace in vSphere with Tanzu](#).

## Manage VM Classes on a Namespace in vSphere with Tanzu

As a vSphere administrator, you can associate a VM class with one or more namespaces on a Supervisor Cluster. After you associate a VM class with a namespace, you can add more VM classes or remove the class to unpublish it from the Kubernetes namespace.

### Prerequisites

- Verify that at least one VM class is associated with the namespace. See [Associate a VM Class with a Namespace in vSphere with Tanzu](#).
- If you want to remove a VM class from a namespace, verify that it is not used by Tanzu Kubernetes Grid Service. Removing it can affect operations Tanzu Kubernetes Grid Service.
- Required privileges:
  - **Namespaces.Modify cluster-wide configuration**
  - **Namespaces.Modify namespace configuration**
  - **Virtual Machine Classes.Manage Virtual Machine Classes**

### Procedure

- 1 In the vSphere Client, go to the namespace.
  - a From the vSphere Client home menu, select **Workload Management**.
  - b Click the **Namespaces** tab and click the namespace.
- 2 Add or remove a VM class.
  - a On the **VM Service** pane, click **Manage VM Class**.
  - b Perform one of the following operations.

Option	Description
<b>Remove a VM class</b>	Deselect the VM class and click <b>OK</b> .
<b>Add a VM class</b>	Select one or several VM classes and click <b>OK</b> .

## View VM Resources Available on a Namespace in vSphere with Tanzu

To be able to deploy a stand-alone VM in vSphere with Tanzu, a DevOps engineer must have access to specific VM resources. As a DevOps engineer, verify that you can access these resources and view VM classes and VM templates available in your environment. You can also list storage classes and other items you might need to self-service a VM.

This task covers commands you use to access resources available for a deployment of a stand-alone VM. For information about resources necessary to deploy Tanzu Kubernetes clusters and VMs that make up the clusters, see [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).



## Prerequisites

A vSphere administrator has performed these steps:

- Created a namespace and associated it with storage policies. See [Create and Configure a vSphere Namespace](#).
- Associated default or custom VM classes with a namespace. See [Associate a VM Class with a Namespace in vSphere with Tanzu](#).
- Created a content library and associated it with a namespace. See [Associate a VM Content Library with a Namespace in vSphere with Tanzu](#).

---

**Note** If a content library is protected by a security policy, all library items must be compliant. If a protected library includes a mix of compliant and non-compliant items, the `kubectl get virtualmachineimages` command fails to present VM images to the DevOps engineers.

---

## Procedure

- 1 Access your namespace in the Kubernetes environment.

See [Get and Use the Supervisor Cluster Context](#).

- 2 To view VM classes available in your namespace, run the following command.

```
kubectl get virtualmachineclassbindings
```

You can see the following output:

NAME	VIRTUALMACHINECLASS	AGE
best-effort-large	best-effort-large	44m
best-effort-medium	best-effort-medium	44m
best-effort-small	best-effort-small	44m
best-effort-xsmall	best-effort-xsmall	44m
custom	custom	44m

- 3 To view details of a specific VM class, run the following commands.

- `kubectl describe virtualmachineclasses name_vm_class`

If a VM class includes a vGPU device, you can see its profile under `spec: hardware: devices: vgpuDevices`.

```
.....
spec:
  hardware:
    cpus: 4
    devices:
      vgpuDevices:
        - profileName: grid_v100-q4
.....
```

- `kubectl get virtualmachineclasses -o wide`

If the VM class includes a vGPU or a passthrough device, the output shows it in the `VGPUDevicesProfileNames` or `PassthroughDeviceIDs` column.

#### 4 View the VM images.

```
kubectl get virtualmachineimages
```

The output you see is similar to the following.

NAME	VERSION	OSTYPE	FORMAT
IMAGESUPPORTED	AGE		
centos-stream-8-vmervice-v1alpha1-xxxxxxxxxxxxx		centos8_64Guest	ovf
true	4d3h		

#### 5 To describe a specific image, use the following command.

```
kubectl describe virtualmachineimage/centos-stream-8-vmervice-v1alpha1-xxxxxxxxxxxxx
```

VMs with vGPU devices require images that have boot mode set to EFI, such as CentOS. Make sure to have access to these images. For information about supported images, search for **VM Service image** on the [VMware Cloud Marketplace](#) web site.

#### 6 Verify that you can access storage classes.

```
kubectl get resourcequotas
```

For more information, see [Display Storage Classes in a vSphere Namespace or Tanzu Kubernetes Cluster](#).

NAME	AGE	REQUEST	LIMIT
my-ns-ubuntu-storagequota	24h	wcpglobal-storage-profile.storageclass.storage.k8s.io/requests.storage: 0/9223372036854775807	

#### 7 If you are using vSphere Distributed Switch for your workload networking, obtain the name of the network.

**Note** You use this information to specify the `networkName` parameter in the VM YAML file when the `networkType` is **vsphere-distributed**. You do not need to obtain and specify the network name if you use VMware NSX-T.

```
kubectl get network
```

NAME	AGE
primary	7d2h

#### What to do next

You can now deploy VMs. See [Deploy a Virtual Machine in vSphere with Tanzu](#).

# Deploy a Virtual Machine in vSphere with Tanzu

As a DevOps engineer, you can provision a VM and its guest OS in a declarative manner by writing VM deployment specifications in a Kubernetes YAML file.

## Prerequisites

- Verify that you have available resources to deploy a VM in your namespace. See [View VM Resources Available on a Namespace in vSphere with Tanzu](#).
- If you use NVIDIA vGPU or other PCI devices for your VMs, the following considerations apply:
  - Make sure to use appropriate VM class with PCI configuration. See [Add PCI Devices to a VM Class in vSphere with Tanzu](#).
  - VMs with vGPU devices require images that have boot mode set to EFI, such as CentOS. Make sure to have access to these images. For information about supported images, search for **VM Service image** on the [VMware Cloud Marketplace](#) web site.
  - VMs with vGPU devices that are managed by VM Service are automatically powered off when an ESXi host enters maintenance mode. This might temporarily affect workloads running in the VMs. The VMs are automatically powered on after the host exits the maintenance mode.

## Procedure

- 1 Prepare the VM YAML file.

In the file, specify the following parameters:

Option	Description
<b>apiVersion</b>	Specifies the version of the VM Service API. Such as <code>vmoperator.vmware.com/v1alpha1</code> .
<b>kind</b>	Specifies the type of Kubernetes resource to create. The only available value is <code>VirtualMachine</code> .
<b>spec.imageName</b>	Specifies the content library image the VM should use. For example, <code>centos-stream-8-vm-service-v1alpha1-xxxxxxxxxxxxxx</code> .
<b>spec.storageClass</b>	Identifies the storage class to be used for storage of the persistent volumes. For example, <code>wcpglobal-storage-profile</code> .
<b>spec.className</b>	Specifies the name of the VM class that describes the virtual hardware settings to be used. For example, <code>custom</code> .

Option	Description
<b>spec.networkInterfaces</b>	<p>Specifies network-related settings for the VM.</p> <ul style="list-style-type: none"> <li>networkType. Values for this key can be <b>nsx-t</b> or <b>vsphere-distributed</b>.</li> <li>networkName. Specify the name only if networkType is <b>vsphere-distributed</b>. You can obtain this information using the <code>kubectl get network</code> command.</li> </ul> <p>If networkType is <b>nsx-t</b>, you do not need to indicate networkName.</p>
<b>spec.vmMetadata</b>	<p>Includes additional metadata to pass to the VM. You can use this key to customize the guest OS image and set such items as the <code>hostname</code> of the VM and <code>user-data</code>, including passwords, ssh keys, and so on. The example YAML below uses <code>ConfigMap</code> to store the metadata.</p>

Use the following as an example of a YAML file `vmsvc-centos-vm.yaml`.

```

apiVersion: vmoperator.vmware.com/v1alpha1
kind: VirtualMachine
metadata:
  name: vmsvc-centos-vm
  namespace: my-ns-centos
spec:
  imageName: centos-stream-8-vmervice-v1alpha1-xxxxxxxxxxxxx
  className: custom
  powerState: poweredOn
  storageClass: wcpglobal-storage-profile
  networkInterfaces:
  - networkName: "primary"
    networkType: vsphere-distributed
  vmMetadata:
    configMapName: vmsvc-centos-nginx-cm
    transport: OvfEnv
---
apiVersion: v1
kind: ConfigMap
metadata:
  name: vmsvc-centos-nginx-cm
  namespace: my-ns-centos
data:
  user-data: >-

I2Nsb3VklWNvbmZpZwoKcGFzc3dvcnQ6IFZNV0FSRQpzc2hfcHdhXRoOiB0cnVlCgp1c2VyczoKICAtIG5hbWU6IHZ
td2FyZQogICAgc3VkbzogQUxMPShBTEwpIE5PUEFTU1dEOkFMTAogICAgbG9ja19wYXNzd2Q6IGZhbHNlCiAgICAgIF
Bhc3N3b3JkIHNdCB0byBBZG1pbiEyMwogICAgcGFzc3dkOiAnJDEkc2FsdCRTT0MzM2ZWYkeVWnhlSXdENXl3MXUxJ
wogICAgc2h1bGw6IC9iaW4vYmFzaAoKd3JpdGVfZmlsZXM6CiAgLSBjb250ZW50OiB8CiAgICAgICAgIFZNU1ZDIFNheXMg
SGVsbG8gV29ybGQKICAgIHhhdGg6IC9oZWxsb3dvcmxkCg==

```

ConfigMap contains the cloud-config blob that specifies the username and password for the guest OS. In this example, `user-data` in `vmsvc-centos-nginx-cm` ConfigMap represents the following snippet in base64 format:

```
#cloud-config
password: VMWARE
ssh_pwauth: true
users:
  - name: vmware
    sudo: ALL=(ALL) NOPASSWD:ALL
    lock_passwd: false
    passwd: '$1$salt$SOC33fVbA/ZxeIwD5ywlul'
    shell: /bin/bash
write_files:
  - content: |
      VMSVC Says Hello World
    path: /helloworld
```

For more information about cloud-config specifications, see <https://cloudinit.readthedocs.io/en/latest/topics/examples.html>.

## 2 Deploy the VM.

```
kubectl apply -f vmsvc-centos-vm.yaml
```

## 3 Verify that the VM has been created.

```
kubectl get vm -n my-ns-centos
NAME                AGE
vmsvc-centos-vm    28s
```

## 4 Check the status of the VM and associated events.

```
kubectl describe virtualmachine vmsvc-centos-vm
```

The output is similar to the following. From the output, you can also obtain the IP address of the VM, which appears in the `Vm Ip` field.

```
Name:                vmsvc-centos-vm
Namespace:           my-ns-centos
Annotations:         vmoperator.vmware.com/image-supported-check: disabled
API Version:         vmoperator.vmware.com/v1alpha1
Kind:                VirtualMachine
Metadata:
  Creation Timestamp: 2021-03-23T19:07:36Z
  Finalizers:
    virtualmachine.vmoperator.vmware.com
  Generation:        1
  Managed Fields:
  ...
  ...
Spec:
  Class Name:        custom
```

```

Image Name:  vmservice-centos-20-10-server-cloudimg-amd64
Network Interfaces:
  Network Name:  primary
  Network Type:  vsphere-distributed
Power State:  poweredOn
Storage Class:  wcpglobal-storage-profile
Vm Metadata:
  Config Map Name:  vmsvc-centos-nginx-cm
  Transport:  OvfEnv
Status:
Bios UUID:  4218ec42-aeb3-9491-fe22-19b6f954ce38
Change Block Tracking:  false
Conditions:
  Last Transition Time:  2021-03-23T19:08:59Z
  Status:  True
  Type:  VirtualMachinePrereqReady
Host:  10.185.240.10
Instance UUID:  50180b3a-86ee-870a-c3da-90ddbaffc950
Phase:  Created
Power State:  poweredOn
Unique ID:  vm-73
Vm Ip:  10.161.75.162
Events:  <none>
...

```

## 5 Verify that the VM IP is reachable.

```

ping 10.161.75.162
PING 10.161.75.162 (10.161.75.162): 56 data bytes
64 bytes from 10.161.75.162: icmp_seq=0 ttl=59 time=43.528 ms
64 bytes from 10.161.75.162: icmp_seq=1 ttl=59 time=53.885 ms
64 bytes from 10.161.75.162: icmp_seq=2 ttl=59 time=31.581 ms

```

### Results

A VM created through the VM Service can be managed only by DevOps from the Kubernetes namespace. Its life cycle cannot be managed from the vSphere Client, but vSphere administrators can monitor the VM and its resources. For more information, see [Monitor Virtual Machines Available in vSphere with Tanzu](#).

### What to do next

For additional details, see the [Introducing Virtual Machine Provisioning](#) blog.

If the VM includes a PCI device configured for vGPU, install the NVIDIA display driver. See [Install the NVIDIA Guest Driver in a VM in vSphere with Tanzu](#).

## Install the NVIDIA Guest Driver in a VM in vSphere with Tanzu

After you create and boot a VM in your vSphere with Tanzu environment, install the NVIDIA vGPU graphics driver in the VM to fully enable GPU operation.

## Prerequisites

- Create a VM with NVIDIA vGPU device. The VM must reference the VM class that includes a vGPU definition. See [Add PCI Devices to a VM Class in vSphere with Tanzu](#).
- Verify that you downloaded the vGPU software package from the NVIDIA download site, uncompressed the package, and have the guest drive component ready. For information, see appropriate NVIDIA Virtual GPU Software documentation.

---

**Note** The version of the driver component must correspond to the version of the vGPU Manager that a vSphere administrator installed on the ESXi host. See [Add PCI Devices to a VM Class in vSphere with Tanzu](#).

---

## Procedure

- 1 Copy the NVIDIA vGPU software Linux driver package, for example `NVIDIA-Linux-x86_64-version-grid.run`, to the guest VM.
- 2 Before attempting to run the driver installer, terminate all applications.
- 3 Start the NVIDIA vGPU driver installer.

```
sudo ./NVIDIA-Linux-x86_64-version-grid.run
```

- 4 Accept the NVIDIA software license agreement and select **Yes** to update the X configuration settings automatically.
- 5 Verify that the driver has been installed.

For example,

```
~$ nvidia-smi
Wed May 19 22:15:04 2021
+-----+
| NVIDIA-SMI 460.63      Driver Version: 460.63      CUDA Version: 11.2      |
+-----+-----+-----+-----+-----+
| GPU   Name           Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf    Pwr:Usage/Cap|      Memory-Usage | GPU-Util  Compute M. |
|                                           MIG M.         |
+-----+-----+-----+-----+-----+
|    0   GRID V100-4Q           On         | 00000000:02:00.0 Off  |            N/A       |
| N/AN/AP0      N/A/  N/A|    304MiB /  4096MiB |      0%      Default  |
|                                           |            N/A       |
+-----+-----+-----+-----+-----+

+-----+
| Processes:
| GPU   GI    CI          PID    Type    Process name          GPU Memory
|       ID    ID
+-----+-----+-----+-----+-----+
| No running processes found
+-----+
```

# Monitor Virtual Machines Available in vSphere with Tanzu

As a vSphere administrator, use the vSphere Client to monitor a VM that was deployed by DevOps in the Kubernetes environment.

You cannot manage the VM lifecycle from the vSphere Client.

## Prerequisites

A DevOps engineer has deployed a VM. See [Deploy a Virtual Machine in vSphere with Tanzu](#).

## Procedure

- 1 In the vSphere Client, navigate to the host cluster that has vSphere with Tanzu enabled.
- 2 Under **Namespaces**, expand the namespace where a VM was deployed.
- 3 Select the VM to view and click the **Summary** tab.

Make sure that you see the **Developer Managed** tag at the top of the **Summary** page.

The page displays information about the VM, including its guest OS and IP addresses.

The screenshot shows the vSphere Client interface for a VM named 'centos-vm'. The VM is in a 'Powered On' state and is tagged as 'Developer Managed'. The Summary page displays the following information:

- Guest OS:** CentOS 8 (64-bit)
- Compatibility:** ESXi 7.0 and later (VM version 17)
- VMware Tools:** Running, version:11328 (Guest Managed)
- DNS Name:** centos-vm
- IP Addresses:** 10.182.59.181
- Host:** 10.182.51.8
- Managed By:** WCP Service

Performance metrics on the right side of the page are:

- CPU USAGE:** 167 MHz
- MEMORY USAGE:** 20 MB
- STORAGE USAGE:** 3.83 GB

The 'Related Objects' section shows the VM is associated with the following objects:

Object Type	Object Name
Cluster	test-vpx-1615189204-9031-wcp.sanit...
Host	10.182.51.8
Namespace	vm-service-test



- 4 Click **Switch to New View** in the upper-right corner of the page to display additional details such as the VM class and VM image, as well as the namespace, where the VM runs.

The screenshot displays the vSphere Client interface for a VM named 'centos-vm'. The interface is divided into several sections:

- Header:** Shows 'vSphere Client' and a search bar. A notification at the top indicates 'There are expired or expiring licenses in your inventory.' with a 'MANAGE YOUR LICENSES' button.
- Navigation:** A left sidebar shows a tree view of namespaces, with 'vm-service-test' expanded to show 'centos-vm'.
- VM Summary:** Displays the VM name 'centos-vm', its state 'Developer Managed', and a timestamp '3/18/2021, 3:16:35 PM'. It also shows 'VM Replication Groups' and a 'CHECK COMPLIANCE' button.
- VM Details:** A section showing:
  - Namespace:** vm-service-test
  - VM Class:** best-effort-xsmall
  - VM Image:** centos-stream-8-vm-service-v1alpha1.20210222
- vSphere HA:** A section showing the status of various HA features:
  - vSphere HA Protection:** Protected (indicated by a green checkmark)
  - Proactive HA:** Disabled
  - Host failure:** Restart VMs (indicated by a green checkmark)
  - Host Isolation:** Power off and restart VMs (indicated by a green checkmark)
  - Datastore with Permanent Device Loss:** Disabled
  - Datastore with All Paths Down:** Disabled
  - Guest not heartbeating:** Disabled

# Provisioning and Operating TKGS Clusters

# 13

vSphere with Tanzu provides convenient tooling and straightforward workflows for provisioning and operating Tanzu Kubernetes clusters. Refer to the procedures and examples to create and customize clusters with various configurations to meet your needs.

This chapter includes the following topics:

- [Workflow for Provisioning Tanzu Kubernetes Clusters](#)
- [Virtual Machine Classes for Tanzu Kubernetes Clusters](#)
- [Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API](#)
- [Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API](#)
- [Delete a Tanzu Kubernetes Cluster](#)
- [Specify a Default Text Editor for Kubectl](#)
- [Monitor Tanzu Kubernetes Cluster Status Using kubectl](#)
- [Monitor Tanzu Kubernetes Cluster Status Using the vSphere Client](#)
- [Check Tanzu Kubernetes Cluster Readiness](#)
- [Check Tanzu Kubernetes Cluster Health](#)
- [Check Tanzu Kubernetes Machine Health](#)
- [Get Tanzu Kubernetes Cluster Secrets](#)
- [Use Tanzu Kubernetes Cluster Networking Commands](#)
- [Use Tanzu Kubernetes Cluster Operational Commands](#)
- [View Tanzu Kubernetes Cluster Lifecycle Status](#)
- [View the Full Resource Hierarchy for a Tanzu Kubernetes Cluster](#)

## Workflow for Provisioning Tanzu Kubernetes Clusters

You provision Tanzu Kubernetes clusters by invoking the Tanzu Kubernetes Grid Service declarative API using kubectl and a cluster specification defined using YAML. After you provision a cluster, you operate it and deploy workloads to it using kubectl.

The workflow provides an end-to-end procedure for the cluster provisioning process. Each of the steps has links for more information about the specific task.

### Prerequisites

Complete the following prerequisites:

- Install or update your environment to support the Tanzu Kubernetes Grid Service v1alpha2 API. See [Requirements for Using the Tanzu Kubernetes Grid Service v1alpha2 API](#).

---

**Note** If you are using the Tanzu Kubernetes Grid Service v1alpha1 API, see [Workflow for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API](#).

---

- Create a vSphere Namespace where you plan to provision Tanzu Kubernetes clusters. See [Create and Configure a vSphere Namespace](#).

The initial namespace configuration requires the following:

- Edit permissions for one or more DevOps engineers to access the namespace using vCenter Single Sign-On credentials.
- Tag-based shared storage policy for the namespace.
- Capacity and usage quotas for the namespace, verified and adjusted, as necessary.
- Create a content library for Tanzu Kubernetes releases on a shared datastore and synchronize the releases you want to use. See [Creating and Managing Content Libraries for Tanzu Kubernetes releases](#).
- Associate the content library and the virtual machine classes with the vSphere Namespace. See [Configure a vSphere Namespace for Tanzu Kubernetes releases](#).

### Procedure

- 1 Download and install the Kubernetes CLI Tools for vSphere. See [Download and Install the Kubernetes CLI Tools for vSphere](#).
- 2 Using the vSphere Plugin for kubectl, authenticate with the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

```
kubectl vsphere login --server=IP-ADDRESS --vsphere-username USERNAME
```

- 3 Using kubectl, switch context to the vSphere Namespace where you plan to provision the Tanzu Kubernetes cluster.

```
kubectl config get-contexts
```

```
kubectl config use-context SUPERVISOR-NAMESPACE
```

For example:

```
kubectl config use-context tkgs-cluster-ns
```

- 4 List the available virtual machine class bindings. See [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).

Use the following command to list all VM class bindings that are available in the vSphere Namespace where you deploy the cluster.

```
kubectl get virtualmachineclassbindings
```

---

**Note** The command `kubectl get virtualmachineclasses` lists all the VM classes present on the Supervisor Cluster. Because you must associate VM classes with the vSphere Namespace, you can only use those VM classes that are bound to the target namespace.

---

- 5 Get the available persistent volume storage classes.

```
kubectl describe storageclasses
```

- 6 List the available Tanzu Kubernetes releases.

```
kubectl get tanzukubernetesreleases
```

Or, using the shortcut:

```
kubectl get tkr
```

---

**Note** The minimum Tanzu Kubernetes release that supports the v1alpha2 API is `v1.21.2---vmware.1-tkg.1.13da849`. See [List of Tanzu Kubernetes releases](#).

---

- 7 Construct the YAML file for provisioning a Tanzu Kubernetes cluster.

- a Start with one of the example YAML files.

See [Example YAML for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API](#).

- b Use the information you gleaned from the output of the preceding commands to populate the cluster YAML, including the following:
  - Target vSphere Namespace
  - Storage class for control plane and worker nodes, and Kubernetes workloads
  - Virtual machine classes
  - TKR NAME

- c Customize the cluster as needed by referring to the full list of cluster configuration parameters.

See [Configuration Parameters for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API](#).

- d Save the file as `tkgs-cluster-1.yaml`, or similar.

**8** Provision the cluster by running the following `kubectl` command.

```
kubectl apply -f CLUSTER-NAME.yaml
```

For example:

```
kubectl apply -f tkgs-cluster-1.yaml
```

Expected result:

```
tanzukubernetescluster.run.tanzu.vmware.com/tkgs-cluster-1 created
```

**9** Monitor the deployment of cluster nodes using `kubectl`. See [Monitor Tanzu Kubernetes Cluster Status Using `kubectl`](#).

```
kubectl get tanzukubernetesclusters
```

Sample result:

NAMESPACE	NAME	CONTROL PLANE		WORKER		TKR
		AGE	READY	TKR COMPATIBLE	UPDATES AVAILABLE	
tkgs-cluster	tkgs-cluster-1	3		3		v1.21.2---vmware.1-
tkg.1.13da849	38h	True	True			[1.21.2+vmware.1-tkg.1.13da849]

**10** Monitor the deployment of cluster nodes using the vSphere Client. See [Monitor Tanzu Kubernetes Cluster Status Using the vSphere Client](#).

For example, in the vSphere inventory you should see the virtual machine nodes being deployed in the namespace.

**11** Run additional commands to verify cluster provisioning. See [Use Tanzu Kubernetes Cluster Operational Commands](#).

For example:

```
kubectl get tanzukubernetescluster,cluster-api,virtualmachinesetresourcepolicy,virtualmachineservice,virtualmachine
```

---

**Note** For additional troubleshooting, see [Troubleshooting Tanzu Kubernetes Clusters](#).

---

- 12** Using the vSphere Plugin for kubectl, log in to the cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).

```
kubectl vsphere login --server=IP-ADDRESS --vsphere-username USERNAME \
--tanzu-kubernetes-cluster-name CLUSTER-NAME --tanzu-kubernetes-cluster-namespace
NAMESPACE-NAME
```

- 13** Verify cluster provisioning using the following kubectl commands.

```
kubectl cluster-info
```

```
kubectl get nodes
```

```
kubectl get namespaces
```

```
kubectl api-resources
```

- 14** Deploy an example workload and verify cluster creation. See [Deploy Workloads on Tanzu Kubernetes Clusters](#).

---

**Note** Tanzu Kubernetes clusters have pod security policy enabled. Depending on the workload and user, you might need to create an appropriate RoleBinding or custom PodSecurityPolicy. See [Using Pod Security Policies with Tanzu Kubernetes Clusters](#).

---

- 15** Operationalize the cluster by deploying TKG Extensions. See [Deploy TKG Extensions on Tanzu Kubernetes Clusters](#).

## Virtual Machine Classes for Tanzu Kubernetes Clusters

To size Tanzu Kubernetes cluster nodes, you specify the virtual machine class. vSphere with Tanzu provides default classes, and you can create your own. To use a class, associate it with the target vSphere Namespace and reference the class in the manifest.

### About Virtual Machine Classes

A virtual machine class is a request for resource reservations on the VM for processing power (CPU and memory (RAM)). For example, guaranteed-large with 4 CPU and 16 GB RAM.

There are two class reservation types: guaranteed and best effort. Guaranteed class fully reserves its configured resources. This means that for a given cluster the `spec.policies.resources.requests` matches the `spec.hardware` settings. Best effort class allows resources to be overcommitted. Typically the guaranteed class type is used for production workloads. See [Attributes of VM Classes in vSphere with Tanzu](#).

---

**Note** The VM disk size is set by the OVA template, not the VM class definition. For Tanzu Kubernetes releases, the disk size is 16GB. See [About Tanzu Kubernetes release Distributions](#).

---

## Using Virtual Machine Classes

To use a virtual machine class with a Tanzu Kubernetes cluster, the VM class must be bound to the vSphere Namespace where the cluster is provisioned. To do this, you associate the class with the target namespace. See [Configure a vSphere Namespace for Tanzu Kubernetes releases](#).

To list the VM classes available in the target vSphere Namespace, use the command `kubectl get virtualmachineclassbinding`. To view all virtual machine classes present on the Supervisor Cluster, run the command `kubectl describe virtualmachineclasses`. Note, however, that because only bound classes can be used to provision a cluster, the latter command is informational-only. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).

---

**Note** The requirement to associate VM classes with the vSphere Namespace only applies to new clusters. Existing Tanzu Kubernetes clusters using default VM classes continue to function without requiring namespace association.

---

## Default Virtual Machine Classes

The table [Table 13-1. Default Virtual Machine Classes](#) lists default virtual machine class types that are used as deployment sizes for Tanzu Kubernetes cluster nodes.

To avoid overcommitting resources, production workloads should use the guaranteed class type. To avoid running out of memory, do not use the small or extra small class size for any worker node where you are deploying workloads in any environment (development, test, or production).

**Table 13-1. Default Virtual Machine Classes**

Class	CPU	Memory (GB)	Reserved CPU and Memory
guaranteed-8xlarge	32	128	Yes
best-effort-8xlarge	32	128	No
guaranteed-4xlarge	16	128	Yes
best-effort-4xlarge	16	128	No
guaranteed-2xlarge	8	64	Yes
best-effort-2xlarge	8	64	No
guaranteed-xlarge	4	32	Yes
best-effort-xlarge	4	32	No
guaranteed-large	4	16	Yes
best-effort-large	4	16	No
guaranteed-medium	2	8	Yes
best-effort-medium	2	8	No

Table 13-1. Default Virtual Machine Classes (continued)

Class	CPU	Memory (GB)	Reserved CPU and Memory
guaranteed-small	2	4	Yes
best-effort-small	2	4	No
guaranteed-xsmall	2	2	Yes
best-effort-xsmall	2	2	No

## Custom Virtual Machine Classes

vSphere with Tanzu supports custom virtual machine classes for use with Tanzu Kubernetes clusters. Once you have defined a custom VM class, you must associate it with the target vSphere Namespace before you can use it with a cluster. See [Create a VM Class in vSphere with Tanzu](#).

## Editing Virtual Machine Classes

VM class definitions are not immutable. Any VM class can be [Edit or Delete a VM Class in vSphere with Tanzu](#), including the [Virtual Machine Classes for Tanzu Kubernetes Clusters](#). If a VM class is edited, existing Tanzu Kubernetes cluster nodes remain unaffected. New Tanzu Kubernetes clusters will use the modified class definition.

---

**Caution** If you edit a VM class that is in use by a Tanzu Kubernetes cluster, and then scale out that cluster, the new node(s) will use the edited class definition, but the existing nodes will use the initial class definition, resulting in a mismatch of classes.

---

## Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API

This section describes how to provision Tanzu Kubernetes clusters using the Tanzu Kubernetes Grid Service v1alpha2 API.

### Requirements for Using the Tanzu Kubernetes Grid Service v1alpha2 API

To use the Tanzu Kubernetes Grid Service v1alpha2 API for provisioning Tanzu Kubernetes clusters, adhere to the full list of requirements.

### Requirements for Using the Tanzu Kubernetes Grid Service v1alpha2 API

The Tanzu Kubernetes Grid Service v1alpha2 API provides a robust set of enhancements for provisioning Tanzu Kubernetes clusters. For more information, see [Configuration Parameters for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API](#).



To take advantage of the new functionality provided by the Tanzu Kubernetes Grid Service v1alpha2 API, your environment must satisfy each of the following requirements.

Requirement	Reference
<p><b>Workload Management</b> is enabled with supported networking, either NSX-T Data Center or native vSphere vDS.</p> <hr/> <p><b>Note</b> A particular feature may require a specific type of networking. If so this is called out in the topic for that feature.</p> <hr/> <p>The vCenter Server hosting <b>Workload Management</b> is updated to version 7 Update 3 or later.</p> <hr/> <p>All ESXi hosts supporting the vCenter Server cluster where <b>Workload Management</b> is enabled are updated to version 7 Update 3 or later.</p> <hr/> <p>vSphere Namespaces is updated to v0.0.11 or later.</p> <hr/> <p>Supervisor Cluster is updated to v1.21.0+vmware.wcp.2 or later.</p> <hr/> <p>You must use Tanzu Kubernetes release v1.21.2---vmware.1-tkg.1.ee25d55 or later.</p>	<p>See <a href="#">Prerequisites for Configuring vSphere with Tanzu on a Cluster</a>.</p> <p>See <a href="#">Enable Workload Management with NSX-T Data Center Networking</a>.</p> <p>See <a href="#">Enable Workload Management with vSphere Networking</a>.</p> <hr/> <p>Refer to the <b>vCenter Server Update and Patch Releases</b> release notes.</p> <p>For update instructions, see <a href="#">Upgrading the vCenter Server Appliance</a>.</p> <hr/> <p>Refer to the <b>ESXi Update and Patch Release Notes</b>.</p> <p>For update instructions, see <a href="#">Upgrading ESXi Hosts</a>.</p> <hr/> <p>For release details, see the <a href="#">vSphere with Tanzu Release Notes</a>.</p> <p>For update instructions, see <a href="#">Chapter 17 Updating the vSphere with Tanzu Environment</a>.</p> <hr/> <p>For release details, see the <a href="#">vSphere with Tanzu Release Notes</a>.</p> <p>For update instructions, see <a href="#">Update the Supervisor Cluster by Performing a vSphere Namespaces Update</a>.</p> <hr/> <p>For release details, see <a href="#">List of Tanzu Kubernetes releases</a>.</p> <p>For instructions on provisioning new clusters, see <a href="#">Example YAML for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API</a>.</p> <p>For instructions on updating an existing cluster, see <a href="#">Updating a Tanzu Kubernetes Release After the Cluster Spec Is Converted to the Tanzu Kubernetes Grid Service v1alpha2 API</a>.</p>

## Configuration Parameters for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API

The Tanzu Kubernetes Grid Service declarative v1alpha2 API exposes several parameters for configuring Tanzu Kubernetes clusters. Refer to the list and description of all parameters and usage guidelines to provision and customize your clusters.

## YAML Specification for Provisioning a Tanzu Kubernetes Cluster Using the Tanzu Kubernetes Grid Service v1alpha2 API

The YAML specification lists all available parameters for provisioning a Tanzu Kubernetes cluster using the Tanzu Kubernetes Grid Service v1alpha2 API.

```

apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
metadata:
  name: string
  namespace: string
spec:
  topology:
    controlPlane:
      replicas: int32
      vmClass: string
      storageClass: string
      volumes:
        - name: string
          mountPath: string
          capacity:
            storage: size in GiB
    tkr:
      reference:
        name: string
      nodeDrainTimeout: int64
  nodePools:
  - name: string
    labels: map[string]string
    taints:
      - key: string
        value: string
        effect: string
        timeAdded: time
    replicas: int32
    vmClass: string
    storageClass: string
    volumes:
      - name: string
        mountPath: string
        capacity:
          storage: size in GiB
    tkr:
      reference:
        name: string
      nodeDrainTimeout: int64
  settings:
    storage:
      classes: [string]
      defaultClass: string
    network:
      cni:
        name: string
    pods:
      cidrBlocks: [string]

```

```

services:
  cidrBlocks: [string]
serviceDomain: string
proxy:
  httpProxy: string
  httpsProxy: string
  noProxy: [string]
trust:
  additionalTrustedCAs:
    - name: string
      data: string

```

## Annotated YAML Specification for Provisioning a Tanzu Kubernetes Cluster Using the Tanzu Kubernetes Grid Service v1alpha2 API

The annotated YAML specification lists all available parameters for provisioning a Tanzu Kubernetes cluster using the Tanzu Kubernetes Grid Service v1alpha2 API with documentation for each field.

```

apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
#metadata defines cluster information
metadata:
  #name for this Tanzu Kubernetes cluster
  name: string
  #namespace vSphere Namespace where to provision this cluster
  namespace: string
#spec defines cluster configuration
spec:
  #topology describes the number, purpose, organization
  #of nodes and the resources allocated for each
  #nodes are grouped into pools based on their purpose
  #`controlPlane` is special kind of a node pool
  #`nodePools` is for groups of worker nodes
  #each node pool is homogeneous: its nodes have the same
  #resource allocation and use the same storage
  topology:
    #controlPlane defines the topology of the cluster
    #controller, including the number of nodes and
    #the resources allocated for each
    #control plane must have an odd number of nodes
    controlPlane:
      #replicas is the number of nodes in the pool
      #the control plane can have 1 or 3 nodes
      #defaults to 1 if `nil`
      replicas: int32
    #vmClass is the name of the VirtualMachineClass
    #which describes the virtual hardware settings
    #to be used for each node in the node pool
    #vmClass controls the CPU and memory available
    #to the node and the requests and limits on
    #those resources; to list available vm classes run
    #`kubectl describe virtualmachineclasses`
    vmClass: string

```

```

#storageClass to be used for storage of the disks
#which store the root filesystems of the nodes
#to list available storage classes run
#`kubectl describe storageclasses`
storageClass: string
#volumes is the optional set of PVCs to create
#and attach to each node; use for high-churn
#control plane components such as etcd
volumes:
  #name of the PVC to be used as the suffix (node.name)
  - name: string
    #mountPath is the directory where the volume
    #device is mounted; takes the form /dir/path
    mountPath: string
    #capacity is the PVC capacity
    capacity:
      #storage to be used for the disk
      #volume; if not specified defaults to
      #`spec.controlPlane.storageClass`
      storage: size in GiB
#tkr.reference.name is the TKR NAME
#to be used by control plane nodes; supported
#format is `v1.21.2---vmware.1-tkg.1.ee25d55`
tkr:
  reference:
    name: string
#nodeDrainTimeout is the total amount of time
#the controller will spend draining a node
#the default value is 0 which means the node is
#drained without any time limit
nodeDrainTimeout: int64
#nodePools is an array that describes a group of
#worker nodes in the cluster with the same configuration
nodePools:
  #name of the worker node pool
  #must be unique in the cluster
  - name: string
    #labels are an optional map of string keys and values
    #to organize and categorize objects
    #propagated to the created nodes
    labels: map[string]string
    #taints specifies optional taints to register the
    #Node API object with; user-defined taints are
    #propagated to the created nodes
    taints:
      #key is the taint key to be applied to a node
      - key: string
        #value is the taint value corresponding to the key
        value: string
        #effect is the effect of the taint on pods
        #that do not tolerate the taint; valid effects are
        #`NoSchedule`, `PreferNoSchedule`, `NoExecute`
        effect: string
      #timeAdded is the time when the taint was added
      #only written by the system for `NoExecute` taints

```

```

    timeAdded: time
#replicas is the number of nodes in the pool
#worker nodePool can have from 0 to 150 nodes
#value of `nil` means the field is not reconciled,
#allowing external services like autoscalers
#to choose the number of nodes for the nodePool
#by default CAPI's `MachineDeployment` will pick 1
replicas: int32
#vmClass is the name of the VirtualMachineClass
#which describes the virtual hardware settings
#to be used for each node in the pool
#vmClass controls the CPU and memory available
#to the node and the requests and limits on
#those resources; to list available vm classes run
#`kubectl describe virtualmachineclasses`
vmClass: string
#storageClass to be used for storage of the disks
#which store the root filesystems of the nodes
#to list available storage classes run
#`kubectl describe ns`
storageClass: string
#volumes is the optional set of PVCs to create
#and attach to each node for high-churn worker node
#components such as the container runtime
volumes:
  #name of this PVC to be used as the suffix (node.name)
  - name: string
    #mountPath is the directory where the volume
    #device is mounted; takes the form /dir/path
    mountPath: string
    #capacity is the PVC capacity
    capacity:
      #storage to be used for the disk
      #volume; if not specified defaults to
      #`topology.nodePools[*].storageClass`
      storage: size in GiB
#tkr.reference.name points to the TKR NAME
#to be used by `spec.topology.nodePools[*]` nodes; supported
#format is `v1.21.2---vmware.1-tkg.1.ee25d55`
tkr:
  reference:
    name: string
#nodeDrainTimeout is the total amount of time
#the controller will spend draining a node
#the default value is 0 which means the node is
#drained without any time limit
nodeDrainTimeout: int64
#settings are optional runtime configurations
#for the cluster, including persistent storage
#for pods and node network customizations
settings:
  #storage defines persistent volume (PV) storage entries
  #for container workloads; note that the storage used for
  #node disks is defined by `topology.controlPlane.storageClass`
  #and by `spec.topology.nodePools[*].storageClass`

```

```

storage:
  #classes is a list of persistent volume (PV) storage
  #classes to expose for container workloads on the cluster
  #any class specified must be associated with the
  #vSphere Namespace where the cluster is provisioned
  #if omitted, all storage classes associated with the
  #namespace will be exposed in the cluster
  classes: [string]
  #defaultClass treats the named storage class as the default
  #for the cluster; because all namespaced storage classes
  #are exposed if specific `classes` are not named,
  #classes is not required to specify a defaultClass
  #many workloads, including TKG Extensions and Helm,
  #require a default storage class
  #if omitted, no default storage class is set
  defaultClass: string
#network defines custom networking for cluster workloads
network:
  #cni identifies the CNI plugin for the cluster
  #use to override the default CNI set in the
  #tkgservicesonfiguration spec, or when customizing
  #network settings for the default CNI
  cni:
    #name is the name of the CNI plugin to use; supported
    #values are `antrea`, `calico`, `antrea-nsx-routed`
    name: string
  #pods configures custom networks for pods
  #defaults to 192.168.0.0/16 if CNI is `antrea` or `calico`
  #defaults to empty if CNI is `antrea-nsx-routed`
  #custom subnet size must equal or exceed /24
  #cannot overlap with Supervisor Cluster workload network
  pods:
    #cidrBlocks is an array of network ranges; supplying
    #multiple ranges may not be supported by all CNI plugins
    cidrBlocks: [string]
  #services configures custom network for services
  #defaults to 10.96.0.0/12
  #cannot overlap with Supervisor Cluster workload network
  services:
    #cidrBlocks is an array of network ranges; supplying
    #multiple ranges many not be supported by all CNI plugins
    cidrBlocks: [string]
  #serviceDomain specifies the service domain for the cluster
  #defaults to `cluster.local`
  serviceDomain: string
  #proxy configures proxy server to be used inside the cluster
  #if omitted no proxy is configured
  proxy:
    #httpProxy is the proxy URI for HTTP connections
    #to endpoints outside the cluster
    #takes form `http://<user>:<pwd>@<ip>:<port>`
    httpProxy: string
    #httpsProxy is the proxy URL for HTTPS connections
    #to endpoints outside the cluster
    #takes the from `http://<user>:<pwd>@<ip>:<port>`

```

```

httpsProxy: string
#noProxy is the list of destination domain names, domains,
#IP addresses, and other network CIDRs to exclude from proxying
#must include Supervisor Cluster Pod, Egress, Ingress CIDRs
noProxy: [string]
#trust configures additional certificates for the cluster
#if omitted no additional certificate is configured
trust:
#additionalTrustedCAs are additional trusted certificates
#can be additional CAs or end certificates
additionalTrustedCAs:
#name is the name of the additional trusted certificate
#must match the name used in the filename
- name: string
#data holds the contents of the additional trusted cert
#PEM Public Certificate data encoded as base64 string
#such as `LS0tLS1C...LS0tCg==` where "..." is the
#middle section of the long base64 string
data: string

```

## Example YAML for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API

The Tanzu Kubernetes Grid Service API provides intelligent defaults and an array of options for customizing Tanzu Kubernetes clusters. Refer to the examples to provision clusters of various types with different configurations and customizations to meet your needs.

### Example YAML for Provisioning a Default Tanzu Kubernetes Cluster Using the Tanzu Kubernetes Grid Service v1alpha2 API

The following example YAML is the minimal configuration required to invoke the Tanzu Kubernetes Grid Service and provision a Tanzu Kubernetes cluster that uses all available default settings.

---

**Note** Currently all `tkr.reference.name` fields must match. In the future different Tanzu Kubernetes releases for node pools may be supported.

---

```

apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
metadata:
  name: tkgs-v2-cluster-default
  namespace: tkgs-cluster-ns
spec:
  topology:
    controlPlane:
      replicas: 3
      vmClass: guaranteed-medium
      storageClass: vwt-storage-policy
    tkr:
      reference:
        name: v1.21.2---vmware.1-tkg.1.ee25d55
  nodePools:

```

```

- name: worker-nodepool-a1
  replicas: 3
  vmClass: guaranteed-large
  storageClass: vwt-storage-policy
  tkr:
    reference:
      name: v1.21.2---vmware.1-tkg.1.ee25d55

```

## Example YAML for Provisioning a Custom Tanzu Kubernetes Cluster Using the Tanzu Kubernetes Grid Service v1alpha2 API

The following example YAML is a custom configuration for invoking the Tanzu Kubernetes Grid Service and provision a Tanzu Kubernetes cluster using the v1alpha2 API.

**Note** Currently all `tkr.reference.name` fields must match. In the future different Tanzu Kubernetes releases for node pools may be supported.

```

apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
metadata:
  name: tkgs-v2-cluster-custom
  namespace: tkgs-cluster-ns
spec:
  topology:
    controlPlane:
      replicas: 3
      vmClass: guaranteed-medium
      storageClass: vwt-storage-policy
      volumes:
        - name: etcd
          mountPath: /var/lib/etcd
          capacity:
            storage: 4Gi
    tkr:
      reference:
        name: v1.21.2---vmware.1-tkg.1.ee25d55
  nodePools:
    - name: worker-nodepool-a1
      replicas: 3
      vmClass: guaranteed-large
      storageClass: vwt-storage-policy
      volumes:
        - name: containerd
          mountPath: /var/lib/containerd
          capacity:
            storage: 16Gi
      tkr:
        reference:
          name: v1.21.2---vmware.1-tkg.1.ee25d55
    - name: worker-nodepool-a2
      replicas: 2
      vmClass: guaranteed-medium
      storageClass: vwt-storage-policy

```



```

tkr:
  reference:
    name: v1.21.2---vmware.1-tkg.1.ee25d55
- name: worker-nodepool-a3
  replicas: 1
  vmClass: guaranteed-small
  storageClass: vwt-storage-policy
tkr:
  reference:
    name: v1.21.2---vmware.1-tkg.1.ee25d55
settings:
  storage:
    defaultClass: vwt-storage-policy
  network:
    cni:
      name: antrea
    services:
      cidrBlocks: ["198.53.100.0/16"]
    pods:
      cidrBlocks: ["192.0.5.0/16"]
    serviceDomain: managedcluster.local
  proxy:
    httpProxy: http://<user>:<pwd>@<ip>:<port>
    httpsProxy: http://<user>:<pwd>@<ip>:<port>
    noProxy: [10.246.0.0/16,192.168.144.0/20,192.168.128.0/20]
  trust:
    additionalTrustedCAs:
      - name: CompanyInternalCA-1
        data: LS0tLS1C...LS0tCg==
      - name: CompanyInternalCA-2
        data: MTLtMT1C...MT0tPg==

```

## Updating a Tanzu Kubernetes Release After the Cluster Spec Is Converted to the Tanzu Kubernetes Grid Service v1alpha2 API

To update the Tanzu Kubernetes release after the cluster specification has been converted to the v1alpha2 API, which is typically done by changing the Tanzu Kubernetes release version, you may need to do some pre-processing of the spec to avoid errors.

### Auto-Conversion of Cluster Specs

To update your vSphere with Tanzu environment to the Tanzu Kubernetes Grid Service v1alpha2 API, you update the Supervisor Cluster where the service runs.

Once the Tanzu Kubernetes Grid Service is running the v1alpha2 API, the system automatically converts all existing Tanzu Kubernetes cluster specifications from the v1alpha1 format to the v1alpha2 format. During the auto-conversion process, the system creates and populates the expected fields for each cluster manifest. [API Deprecations and Additions](#) lists the cluster specification fields that are new and deprecated in the v1alpha2 API.

To update the Tanzu Kubernetes release version for a cluster whose manifest has been auto-converted to the v1alpha2 format, you need to perform some manual pre-processing to avoid errors. [Cluster Update Examples](#) lists various options.

## API Deprecations and Additions

The table lists the cluster specification settings that are deprecated in the v1alpha2 API and replaced by new settings.

Deprecated Settings	New Settings	Comments
<code>spec.distribution.version</code> <code>spec.distribution.fullVersion</code>	<code>spec.topology.controlPlane.tkr.reference.name</code> <code>spec.topology.nodePools[*].tkr.reference.name</code>	Must use the TKR NAME format. See the examples.
<code>spec.topology.workers</code>	<code>spec.topology.nodePools[*]</code>	In a converted cluster, the block <code>spec.topology.workers</code> becomes <code>spec.topology.nodePools[0]</code> . The first entry in the <code>nodePools</code> list is <code>name: workers</code> .
<code>spec.topology.controlPlane.count</code> <code>spec.topology.workers.count</code>	<code>spec.topology.controlPlane.replicas</code> <code>spec.topology.nodePools[*].replicas</code>	<code>count</code> is replaced by <code>replicas</code>
<code>spec.topology.controlPlane.class</code> <code>spec.topology.workers.class</code>	<code>spec.topology.controlPlane.vmClasses</code> <code>spec.topology.nodePools[*].vmClasses</code>	<code>class</code> is replaced by <code>vmClass</code>
N/A	<code>spec.topology.nodePools[*].labels</code>	Optional key-pair values to organize and categorize objects; labels are propagated to the created nodes
N/A	<code>spec.topology.nodePools[*].taints</code>	Optional taints to register the nodes with; user-defined taints are propagated to the created nodes

## TKR NAME Format Is Required

In addition to the `spec.distribution.version` fields being deprecated, the DISTRIBUTION format for specifying the Tanzu Kubernetes release version is not supported. This means that you cannot use the following string formats to reference the target release: `1.21.2+vmware.1-tkg.1.ee25d55`, `1.21.2`, and `1.21`.

When referencing the Tanzu Kubernetes release version in a v1alpha2 API cluster spec, you must use the TKR NAME format, not the deprecated DISTRIBUTION format. Although the deprecated format is displayed in the UPDATES AVAILABLE column, the only supported format is the one listed in the TKR NAME column.

```
kubectl get tanzukubernetescluster
NAMESPACE      NAME                CONTROL PLANE  WORKER  TKR
NAME           AGE  READY  TKR COMPATIBLE  UPDATES AVAILABLE
tkgs-cluster-1 test-cluster      3           3           v1.21.2---vmware.1-
tkg.1.ee25d55  38h   True   True           [1.21.2+vmware.1-tkg.1.ee25d55]
```

## Cluster Update Examples

Because changing the `spec.distribution.version` is the most common way to trigger a rolling update of the cluster (see [Update Tanzu Kubernetes Clusters](#)), and this field is deprecated in the v1alpha2 API, there are some considerations to be aware of and some pre-processing recommendations to follow to avoid potential cluster update problems.

The following examples demonstrate how to update the version of a Tanzu Kubernetes cluster that was provisioned using the v1alpha1 API to a system that is running the v1alpha2 API.

### Cluster Upgrade Example 1: Use a Single TKR NAME Reference in the Control Plane

The recommended approach is to remove all `nodePools[*].tkr.reference.name` blocks from the converted spec and update the `controlPlane.tkr.reference.name` with the TKR NAME of the target release. In this case the same Tanzu Kubernetes release is propagated to all `nodePools[*]` nodes.

In the future, the Tanzu Kubernetes release versions can be different across `controlPlane` and `nodePools[*]`. Currently, however, all releases in a cluster must match so putting a single TKR NAME reference in `controlPlane` is sufficient.

For example:

```
apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
metadata:
  name: tkgs-cluster-update-example1
  namespace: tkgs-cluster-ns
spec:
  settings:
    network:
      cni:
        name: antrea
    pods:
      cidrBlocks:
        - 192.0.2.0/16
      serviceDomain: cluster.local
    services:
      cidrBlocks:
        - 198.51.100.0/12
```

```

topology:
  controlPlane:
    replicas: 3
    storageClass: vwt-storage-policy
    tkr:
      reference:
        name: v1.21.2---vmware.1-tkg.1.ee25d55
      vmClass: best-effort-medium
  nodePools:
  - name: workers
    replicas: 3
    storageClass: vwt-storage-policy
    vmClass: best-effort-medium

```

## Cluster Upgrade Example 2: Use a TKR NAME Reference for Each Node Pool

The second example is to put the TKR NAME in the `tkr.reference.name` block for both the `controlPlane` and `nodePools[*]` topologies.

This approach has the advantage of being ready for future releases when the Tanzu Kubernetes release can be different across node pools. Currently, they must match.

For example:

```

apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
metadata:
  name: tkgs-cluster-update-example2
  namespace: tkgs-cluster-ns
spec:
  settings:
    network:
      cni:
        name: antrea
    pods:
      cidrBlocks:
      - 192.0.2.0/16
    serviceDomain: cluster.local
    services:
      cidrBlocks:
      - 198.51.100.0/12
  topology:
    controlPlane:
      replicas: 3
      storageClass: vwt-storage-policy
      vmClass: best-effort-medium
      tkr:
        reference:
          name: v1.21.2---vmware.1-tkg.1.ee25d55
    nodePools:
  - name: workers
    replicas: 3
    storageClass: vwt-storage-policy

```

```

vmClass: best-effort-medium
tkr:
  reference:
    name: v1.21.2---vmware.1-tkg.1.ee25d55

```

### Cluster Upgrade Example 3: Use Deprecated Distribution Fields

The final option is to use the deprecated fields `spec.distribution.fullVersion` and `spec.distribution.version`, and manually remove all `tkr.reference.name` blocks. You must include both fields with one using the TKR NAME format and the other nulled out. Version shortcuts such as `v1.21.2` and `v1.21` are not supported.

---

**Note** For the Tanzu Kubernetes release on Ubuntu, the use of `spec.distribution.version` is not supported.

---

The following example uses the `fullVersion` with the TKR NAME and a null (empty) value in the `version` field. All `tkr.reference.name` entries are removed.

```

apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
metadata:
  name: tkgs-cluster-update-example3a
  namespace: tkgs-cluster-ns
spec:
  distribution:
    fullVersion: v1.21.2---vmware.1-tkg.1.ee25d55
    version: ""
  settings:
    network:
      cni:
        name: antrea
    pods:
      cidrBlocks:
        - 192.0.2.0/16
      serviceDomain: cluster.local
    services:
      cidrBlocks:
        - 198.51.100.0/12
  topology:
    controlPlane:
      replicas: 3
      storageClass: vwt-storage-policy
      vmClass: best-effort-medium
    nodePools:
      - name: workers
        replicas: 3
        storageClass: vwt-storage-policy
        vmClass: best-effort-medium

```

Alternatively you can use the `version` field with the TKR NAME and a null (empty) value in the `fullVersion` field. Even though you are using the `version` field, version shortcuts are not supported. All `tkr.reference.name` entries are removed.

```

apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
metadata:
  name: tkgs-cluster-update-example3b
  namespace: tkgs-cluster-ns
spec:
  distribution:
    fullVersion: ""
    version: v1.21.2---vmware.1-tkg.1.ee25d55
  settings:
    network:
      cni:
        name: antrea
      pods:
        cidrBlocks:
          - 192.0.2.0/16
      serviceDomain: cluster.local
      services:
        cidrBlocks:
          - 198.51.100.0/12
  topology:
    controlPlane:
      replicas: 3
      storageClass: vwt-storage-policy
      vmClass: best-effort-medium
    nodePools:
      - name: workers
        replicas: 3
        storageClass: vwt-storage-policy
        vmClass: best-effort-medium

```

## Configuring a Tanzu Kubernetes Cluster with a Routable Pod Network Using the v1alpha2 API

You can configure a Tanzu Kubernetes cluster to use routable pod networking by specifying the `antrea-nsx-routed` as the CNI for your cluster.

### Introducing Routable Pod Networking

The [Kubernetes network model](#) requires that a pod in the node network of a cluster be able to communicate with all pods on all nodes in the same cluster without network address translation (NAT). To satisfy this requirement, each Kubernetes pod is given an IP address that is allocated from a dedicated pods network.

When you provision a Tanzu Kubernetes cluster using the `antrea` or `calico` CNI plugins, the system creates the default pods network `192.168.0.0/16`. This subnet is a private address space that is only unique within the cluster and not routable on the internet. Although you can customize the `network.pods.cidrBlocks`, the pods network cannot be routable using these CNI plugins. For more information, see [Configuration Parameters for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API](#).

The Tanzu Kubernetes Grid Service v1alpha2 API supports routable pod networking using the `antrea-nsx-routed` CNI plugin. This network interface is a customized Antrea plugin configured to support routable pod networks for Tanzu Kubernetes clusters. In the cluster spec, the `pods CIDR blocks` field must be explicitly null so that IP address management (IPAM) is handled by the Supervisor Cluster.

Enabling routable pod networking lets pods be directly addressed from a client external to the cluster. In addition, pod IP addresses are preserved so external network services and servers can identify the source pods and apply policies based on IP addresses. Supported traffic patterns including the following:

- Traffic is allowed between a Tanzu Kubernetes cluster pod and a vSphere Pod in the same vSphere Namespace.
- Traffic is dropped between a Tanzu Kubernetes cluster pod and a vSphere Pod in different vSphere Namespaces.
- Supervisor Cluster control plane nodes can reach Tanzu Kubernetes cluster pods.
- Tanzu Kubernetes cluster pods can reach the external network.
- External network cannot reach Tanzu Kubernetes cluster pods. Traffic is dropped by distributed firewall (DFW) isolation rules on the Tanzu Kubernetes cluster nodes.

## System Requirements for Routable Pods

Routable pods networking requires the Supervisor Cluster to be configured with NSX-T Data Center. You cannot use routable pods with native vSphere vDS networking.

Routable pods requires the Tanzu Kubernetes Grid Service v1alpha2 API. See [Requirements for Using the Tanzu Kubernetes Grid Service v1alpha2 API](#).

## NSX-T Configuration Requirements for Routable Pods

Other than the base requirements, there is no special NSX-T configuration required to use routable pods networks with Tanzu Kubernetes clusters. A vSphere with Tanzu environment running vSphere U3 with NSX-T includes the NCP version to support routable pods networks. There is no extra NSX-T configuration needed.

NCP creates an IP Pool for the routable pods network from one of two sources:

- If the Workload Network is configured with a Namespace Network, NCP will create one or more IP pools from the IP blocks specified for this Namespace Network.

- If there is no Namespace Network specified for the Workload Network, NCP will create one or more IP pools from the Supervisor Cluster Pod CIDR.

For more information, see [Add Workload Networks to a Supervisor Cluster Configured with VDS Networking](#) and [Change Workload Network Settings on a Supervisor Cluster Configured with NSX-T Data Center](#).

## Supervisor Cluster Configuration Requirements for Routable Pods

Other than the base requirements, there is no special Supervisor Cluster configuration required to use routable pods networks with Tanzu Kubernetes clusters.

If routable pods networking is enabled as described below, the Tanzu Kubernetes cluster pods CIDR is allocated from the IP pool created from the Namespace Network or, if none, from the Supervisor Cluster Pod CIDR.

You must make sure that the Supervisor Cluster Services CIDR which allocates the IP addresses for cluster nodes does not overlap with the Namespace Network CIDR or the with Supervisor Cluster Pod CIDR.

## Example Cluster Configuration for Routable Pods

The following example YAML shows how to configure a cluster with a routable pods network. It is a custom configuration for invoking the Tanzu Kubernetes Grid Service and provision a Tanzu Kubernetes cluster using the v1alpha2 API.

The cluster spec declares `antrea-nsx-routed` as the CNI to enable routable pods networking. When the CNI is `antrea-nsx-routed` is specified, the `pod CIDRBlock` field must be empty. If `antrea-nsx-routed` is specified, cluster provisioning will fail if NSX-T networking is not being used.

```
apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
metadata:
  name: tkgs-v2-cluster-routable-pods
  namespace: tkgs-cluster-ns
spec:
  topology:
    controlPlane:
      replicas: 3
      vmClass: guaranteed-medium
      storageClass: vwt-storage-policy
    tkr:
      reference:
        name: v1.21.2---vmware.1-tkg.1.ee25d55
  nodePools:
  - name: worker-nodepool-a1
    replicas: 3
    vmClass: guaranteed-large
    storageClass: vwt-storage-policy
    tkr:
      reference:
        name: v1.21.2---vmware.1-tkg.1.ee25d55
```



```

settings:
  storage:
    defaultClass: vwt-storage-policy
  network:
    #`antrea-nsx-routed` is the required CNI
    #for routable pods
    cni:
      name: antrea-nsx-routed
    services:
      cidrBlocks: ["10.97.0.0/24"]
      serviceDomain: tanzukubernetescluster.local
      #`pods.cidrBlocks` value must be empty
      #when `antrea-nsx-routed` is the CNI
    pods:
      cidrBlocks:

```

## Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha2 API

You can customize the Tanzu Kubernetes Grid Service with global settings for key features, including the container network interface (CNI), proxy server, and TLS certificates. Be aware of trade-offs and considerations when implementing global versus per-cluster functionality.

### TkgServiceConfiguration v1alpha2 Specification

The `TkgServiceConfiguration` specification provides fields for configuring the Tanzu Kubernetes Grid Service instance.

```

apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TkgServiceConfiguration
metadata:
  name: tkg-service-configuration-spec
spec:
  defaultCNI: string
  proxy:
    httpProxy: string
    httpsProxy: string
    noProxy: [string]
  trust:
    additionalTrustedCAs:
      - name: string
        data: string
  defaultNodeDrainTimeout: time

```

**Caution** Configuring the Tanzu Kubernetes Grid Service is a global operation. Any change you make to the `TkgServiceConfiguration` specification applies to all Tanzu Kubernetes clusters provisioned by that service. If a rolling update is initiated, either manually or by upgrade, clusters are updated by the changed service specification.

## Annotated TkgServiceConfiguration v1alpha2 Specification

The following YAML lists and described the configurable fields for each of the TkgServiceConfiguration specification parameters. For examples, see [Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API](#).

```

apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TkgServiceConfiguration
metadata:
  name: tkg-service-configuration-spec
spec:
  #defaultCNI is the default CNI for all Tanzu Kubernetes
  #clusters to use unless overridden on a per-cluster basis
  #supported values are antrea, calico, antrea-nsx-routed
  #defaults to antrea
  defaultCNI: string
  #proxy configures a proxy server to be used inside all
  #clusters provisioned by this TKGS instance
  #if implemented all fields are required
  #if omitted no proxy is configured
  proxy:
    #httpProxy is the proxy URI for HTTP connections
    #to endpoints outside the clusters
    #takes the form http://<user>:<pwd>@<ip>:<port>
    httpProxy: string
    #httpsProxy is the proxy URI for HTTPS connections
    #to endpoints outside the clusters
    #takes the from http://<user>:<pwd>@<ip>:<port>
    httpsProxy: string
    #noProxy is the list of destination domain names, domains,
    #IP addresses, and other network CIDRs to exclude from proxying
    #must include Supervisor Cluster Pod, Egress, Ingress CIDRs
    noProxy: [string]
  #trust configures additional trusted certificates
  #for the clusters provisioned by this TKGS instance
  #if omitted no additional certificate is configured
  trust:
    #additionalTrustedCAs are additional trusted certificates
    #can be additional CAs or end certificates
    additionalTrustedCAs:
      #name is the name of the additional trusted certificate
      #must match the name used in the filename
      - name: string
        #data holds the contents of the additional trusted cert
        #PEM Public Certificate data encoded as a base64 string
        data: string
  #defaultNodeDrainTimeout is the total amount of time the
  #controller spends draining a node; default is undefined
  #which is the value of 0, meaning the node is drained
  #without any time limitations; note that `nodeDrainTimeout`
  #is different from `kubectl drain --timeout`
  defaultNodeDrainTimeout: time

```

## No Proxy Field Requirements

You get the required `spec.proxy.noProxy` CIDR values from the **Workload Network** on the Supervisor Cluster. You must not proxy the Pods, Ingress, and Egress CIDRs by including them in the `noProxy` field.

The screenshot shows the configuration page for a compute cluster, specifically the Network settings for the Workload Network. The left sidebar contains a navigation menu with categories like Services, Configuration, Licensing, Namespaces, vSAN, and Supervisor Ser... The main content area is titled 'Network' and lists various network settings. Three settings are highlighted with red boxes: Pod CIDRs (10.246.0.0/16), Ingress CIDRs (192.168.144.0/20), and Egress CIDRs (192.168.128.0/20). Each of these highlighted settings has an 'EDIT' link next to it.

Setting	Value	Action
Pod CIDRs	10.246.0.0/16	EDIT
Ingress CIDRs	192.168.144.0/20	EDIT
Egress CIDRs	192.168.128.0/20	EDIT

Keep in mind the following when you are configuring the `noProxy` field:

- You do not need to include the Supervisor Cluster Services CIDR in the `noProxy` field. Tanzu Kubernetes clusters do not interact with such services.
- The endpoints `localhost` and `127.0.0.1` are automatically not proxied. You do not need to add them to the `noProxy` field.
- The Pod and Service CIDRs for Tanzu Kubernetes clusters are automatically not proxied. You do not need to add them to the `noProxy` field.

## When To Use Global or Per-Cluster Configuration Options

The `TkgServiceConfiguration` is a global specification that impacts all Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service instance.

Before editing the `TkgServiceConfiguration` specification, be aware of the per-cluster alternatives that might satisfy your use case instead of a global configuration.

**Table 13-2. Global vs. Per-Cluster Configuration Options**

Setting	Global Option	Per-Cluster Option
Default CNI	Edit the <code>TkgServiceConfiguration</code> spec. See <a href="#">Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API</a> .	Specify the CNI in the cluster specification. For example, Antrea is the default CNI. To use Calico, specify it in the cluster YAML. See <a href="#">Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API</a>
Proxy Server	Edit the <code>TkgServiceConfiguration</code> spec. See <a href="#">Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API</a> .	Include the proxy server configuration parameters in the cluster spec. See <a href="#">Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API</a> .
Trust Certificates	Edit the <code>TkgServiceConfiguration</code> spec. There are two use cases: configuring an external container registry and certificate-based proxy configuration. See <a href="#">Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API</a>	Yes, you can include custom certificates on a per-cluster basis or override the globally-set <code>trust</code> settings in the cluster specification. See <a href="#">Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API</a> .

**Note** If a global proxy is configured on the `TkgServiceConfiguration`, that proxy information is propagated to the cluster manifest after the initial deployment of the cluster. The global proxy configuration is added to the cluster manifest only if there is no proxy configuration fields present when creating the cluster. In other words, per-cluster configuration takes precedence and will overwrite a global proxy configuration. For more information, see [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#).

Before editing the `TkgServiceConfiguration` specification, be aware of the ramifications of applying the setting at the global level.

Field	Applied	Impact on Existing Clusters If Added/ Changed	Per-Cluster Overriding on Cluster Creation	Per-Cluster Overriding on Cluster Update
<code>defaultCNI</code>	Globally	None	Yes, you can override the global setting on cluster creation	No, you cannot change the CNI for an existing cluster; if you used the globally set default CNI on cluster creation, it cannot be changed
<code>proxy</code>	Globally	None	Yes, you can override the global setting on cluster creation	Yes, with U2+, you can override the global setting on cluster update
<code>trust</code>	Globally	None	Yes, you can override the global setting on cluster creation	Yes, with U2+, you can override the global setting on cluster update

## Propagating Global Configuration Changes to Existing Clusters

Settings made at the global level in the `TkgServiceConfiguration` are not automatically propagated to existing clusters. For example, if you make a changes to either the `proxy` or the `trust` settings in the `TkgServiceConfiguration`, such changes will not affect clusters that are already provisioned.

To propagate a global change to an existing cluster, you must patch the Tanzu Kubernetes cluster to make the cluster inherit the changes made to the `TkgServiceConfiguration`.

For example:

```
kubectl patch tkc <CLUSTER_NAME> -n <NAMESPACE> --type merge -p "{\"spec\":{\"settings\":{\"network\":{\"proxy\": null}}}}"
```

```
kubectl patch tkc <CLUSTER_NAME> -n <NAMESPACE> --type merge -p "{\"spec\":{\"settings\":{\"network\":{\"trust\": null}}}}"
```

## Examples for Configuring the Tanzu Kubernetes Grid Service Using the v1alpha2 API

Refer to the examples to customize the Tanzu Kubernetes Grid Service v1alpha2 API with global configuration settings for the container network interface, proxy server, and TLS certificates.

## Configuring the Tanzu Kubernetes Grid Service Using the v1alpha2 API

You can customize the Tanzu Kubernetes Grid Service by changing the default CNI, adding a global proxy server, and adding trusted certificates. See [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#).

```
apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TkgServiceConfiguration
metadata:
  name: tkg-service-v2-configuration-example
spec:
  defaultCNI: antrea
  proxy:
    #supported format is `http://<user>:<pwd>@<ip>:<port>`
    httpProxy: http://admin:PaSsWoRd@10.66.100.22:80
    httpsProxy: http://admin:PaSsWoRd@10.66.100.22:80
    noProxy: [10.246.0.0/16,192.168.144.0/20,192.168.128.0/20]
  trust:
    additionalTrustedCAs:
      - name: CompanyInternalCA-1
        data: LS0tLS1C...LS0tCg==
        #where "... " is the middle section of the long base64 string
      - name: CompanyInternalCA-2
        data: MTLtMT1C...MT0tPg==
  defaultNodeDrainTimeout: 0
```

**Caution** Editing the Tanzu Kubernetes Grid Service specification results in global changes to all clusters provisioned by that service, including new clusters and existing clusters that are upgraded manually or automatically.

### Prerequisite: Configure Kubectl Editing

To scale a Tanzu Kubernetes cluster, you update the cluster manifest using the command `kubectl edit tanzukubernetescluster/CLUSTER-NAME`. The `kubectl edit` command opens the cluster manifest in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable. For instructions on setting up the environment variable, see [Specify a Default Text Editor for Kubectl](#).

When you save the specification changes, `kubectl` reports that the edits were successfully recorded. To cancel, simply close the editor without saving.

### Configure the Default CNI

The Tanzu Kubernetes Grid Service provides a default container network interface (CNI) for Tanzu Kubernetes clusters. The default configuration lets you create clusters without the need to specify the CNI. You can change the default CNI by editing the service specification.

The Tanzu Kubernetes Grid Service supports two CNIs: Antrea and Calico, with Antrea being the default. For more information, see [Tanzu Kubernetes Cluster Networking](#).

You can override the default CNI by explicitly specifying the CNI to use. Alternatively, you can change the default CNI by editing the TKG Service controller for CNIs.

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the target vSphere Namespace.

```
kubectl config use-context tkgs-cluster-ns
```

- 3 List the default CNI.

```
kubectl get tkgserviceconfigurations
```

Example result:

NAME	DEFAULT CNI
tkg-service-configuration	antrea

- 4 Load for editing the Tanzu Kubernetes Grid Service specification.

```
kubectl edit tkgserviceconfigurations tkg-service-configuration
```

The system opens the `tkg-service-configuration` specification in the default text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable.

- 5 Edit the `spec.defaultCNI` value.

For example, change from:

```
spec:
  defaultCNI: antrea
```

Change to:

```
spec:
  defaultCNI: calico
```

- 6 To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the change in the text editor, `kubectl` updates the `tkg-service-configuration` service specification.

- 7 Verify that the default CNI is updated.

```
kubectl get tkgserviceconfigurations
```

The default CNI is updated. Any cluster provisioned with default network settings uses the default CNI.

NAME	DEFAULT CNI
tkg-service-configuration	calico

## Configure a Global Proxy Server

To enable a global proxy server, add the proxy server parameters to the `TkgServiceConfiguration`. For a description of the required fields, see [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#).

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the target vSphere Namespace.

```
kubectl config use-context tkgs-cluster-ns
```

- 3 Get the current configuration.

```
kubectl get tkgserviceconfigurations
```

Example result:

NAME	DEFAULT CNI
tkg-service-configuration	antrea

- 4 Load for editing the Tanzu Kubernetes Grid Service specification.

```
kubectl edit tkgserviceconfigurations tkg-service-configuration
```

The system opens the `tkg-service-configuration` specification in the default text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable.

- 5 Add the `spec.proxy` subsection with each required field, including `httpProxy`, `httpsProxy`, and `noProxy`.

```
apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TkgServiceConfiguration
metadata:
  ...
  name: tkg-service-configuration-example
  resourceVersion: "44170525"
  selfLink: /apis/run.tanzu.vmware.com/v1alpha1/tkgserviceconfigurations/tkg-service-configuration
  uid: 10347195-5f0f-490e-8ae1-a758a724c0bc
spec:
  defaultCNI: antrea
```



```

proxy:
  httpProxy: http://<user>:<pwd>@<ip>:<port>
  httpsProxy: http://<user>:<pwd>@<ip>:<port>
  noProxy: [SVC-POD-CIDRs, SVC-EGRESS-CIDRs, SVC-INGRESS-CIDRs]

```

- 6 Populate each proxy field with the appropriate values. For a description of each field, see [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#).

The required values for the `noProxy` field come from the **Workload Network** on the Supervisor Cluster. Refer to the picture at the above topic on where to get these values.

For example:

```

apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TkgServiceConfiguration
metadata:
  ...
  name: tkg-service-configuration-example
  resourceVersion: "44170525"
  selfLink: /apis/run.tanzu.vmware.com/v1alpha1/tkgserviceconfigurations/tkg-service-configuration
  uid: 10347195-5f0f-490e-8ae1-a758a724c0bc
spec:
  defaultCNI: antrea
  proxy:
    httpProxy: http://user:password@10.186.102.224:3128
    httpsProxy: http://user:password@10.186.102.224:3128
    noProxy: [10.246.0.0/16,192.168.144.0/20,192.168.128.0/20]

```

- 7 To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the changes in the text editor, `kubectl` updates Tanzu Kubernetes Grid Service with the configuration defined in the `tkg-service-configuration` service specification.

- 8 Verify that the Tanzu Kubernetes Grid Service is updated with the proxy settings.

```
kubectl get tkgserviceconfigurations -o yaml
```

- 9 To verify, provision a Tanzu Kubernetes cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).

Use the following command to confirm that the cluster is using the proxy.

```
kubectl get tkc CLUSTER-NAME -n NAMESPACE -o yaml
```

## Certificate-Based Proxy Configuration

Using a proxy server to route internet traffic is a hard requirement for some environments. For example, a company in a highly regulated industry such as a financial institution requires all internet traffic go through a corporate proxy.

You can configure the Tanzu Kubernetes Grid Service to provision Tanzu Kubernetes clusters to use a proxy server for outbound HTTP/S traffic. For more information, see [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#).

As shown in the example, you can add trusted certificates for the proxy server to the `TkgServiceConfiguration` specification.

```
apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TkgServiceConfiguration
metadata:
  name: tkg-service-configuration-example
spec:
  defaultCNI: antrea
  proxy:
    httpProxy: http://user:password@10.186.102.224:3128
    httpsProxy: http://user:password@10.186.102.224:3128
    noProxy: [10.246.0.0/16,192.168.144.0/20,192.168.128.0/20]
  trust:
    additionalTrustedCAs:
      - name: first-cert-name
        data: base64-encoded string of a PEM encoded public cert 1
      - name: second-cert-name
        data: base64-encoded string of a PEM encoded public cert 2
  defaultNodeDrainTimeout: 0
```

## External Private Registry Configuration

You can configure the Tanzu Kubernetes Grid Service with custom certificates for connecting Tanzu Kubernetes clusters with an external private registry. For more information, see [Use an External Container Registry with Tanzu Kubernetes Clusters](#).

```
apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TkgServiceConfiguration
metadata:
  name: tkg-service-configuration-example
spec:
  defaultCNI: antrea
  trust:
    additionalTrustedCAs:
      - name: harbor-vm-cert
        data: <<<base64-encoded string of a PEM encoded public cert>>>>
```

## Scale a Tanzu Kubernetes Cluster Using the Tanzu Kubernetes Grid Service v1alpha2 API

You can scale a Tanzu Kubernetes cluster horizontally by changing the number of nodes or vertically by changing the virtual machine class hosting the nodes.

### Supported Scaling Operations

The table lists the supported scaling operations for Tanzu Kubernetes clusters.

**Table 13-3. Supported Scaling Operations for Tanzu Kubernetes Clusters**

Node	Horizontal Scale Out	Horizontal Scale In	Vertical Scale
Control Plane	Yes	No	Yes
Worker	Yes	Yes	Yes

Keep in mind the following considerations:

- While vertically scaling a cluster node, workloads may no longer be able to run on the node for lack of available resource. For this reason horizontal scaling may be the preferred approach.
- VM classes are not immutable. If you scale out a Tanzu Kubernetes cluster after editing a VM class used by that cluster, new cluster nodes use the updated class definition, but existing cluster nodes continue to use the initial class definition, resulting in a mismatch. See [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).

### Scaling Prerequisite: Configure Kubectl Editing

To scale a Tanzu Kubernetes cluster, you update the cluster manifest using the command `kubectl edit tanzukubernetescluster/CLUSTER-NAME`. The `kubectl edit` command opens the cluster manifest in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable. For instructions on setting up the environment variable, see [Specify a Default Text Editor for Kubectl](#).

When you save the manifest changes, `kubectl` reports that the edits were successfully recorded, and the cluster is updated with the changes.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
tanzukubernetescluster.run.tanzu.vmware.com/tkgs-cluster-1 edited
```

To cancel, simply close the editor without saving.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
Edit cancelled, no changes made.
```

### Scale Out the Control Plane

You can scale out a Tanzu Kubernetes cluster by increasing number of control plane nodes from 1 to 3. The number of control plane nodes must be odd. You cannot scale in the control plane.

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the vSphere Namespace where the Tanzu Kubernetes cluster is running.

```
kubectl config use-context tkgs-cluster-ns
```

- List the Kubernetes clusters that are running in the namespace.

```
kubectl get tanzukubernetescluster -n tkgs-cluster-ns
```

- Get the number of nodes running in the target cluster.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

For example, the following cluster has 1 control plane nodes and 3 worker nodes.

NAMESPACE	NAME	CONTROL PLANE	WORKER	TKR
tkgs-cluster-ns	test-cluster	1	3	v1.21.2---vmware.1-
tkg.1.13da849	5d12h	True		

- Load the cluster manifest for editing using the `kubectl edit` command.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
```

The cluster manifest opens in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variables.

- Locate the `spec.topology.controlPlane.count` parameter and increase the number of nodes from 1 to 3.

```
...
controlPlane:
  replicas: 1
...
```

```
...
ControlPlane:
  replicas: 3
...
```

- To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the file, `kubectl` applies the changes to the cluster. In the background, the Virtual Machine Service on the Supervisor Cluster provisions the new worker node.

- Verify that the new nodes are added.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

The scaled out control plane now has 3 nodes.

NAMESPACE	NAME	CONTROL PLANE	WORKER	TKR
NAME	AGE	READY		
tkgs-cluster-ns	test-cluster	3	3	v1.21.2---vmware.1-
tkg.1.13da849	5d12h	True		

## Scale Out Worker Nodes

You can scale out a Tanzu Kubernetes cluster by increasing the number of worker nodes using `kubectl`.

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the vSphere Namespace where the Tanzu Kubernetes cluster is running.

```
kubectl config use-context tkgs-cluster-ns
```

- 3 List the Kubernetes clusters that are running in the namespace.

```
kubectl get tanzukubernetescluster -n tkgs-cluster-ns
```

- 4 Get the number of nodes running in the target cluster.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

For example, the following cluster has 3 control plane nodes and 3 worker nodes.

NAMESPACE	NAME	CONTROL PLANE	WORKER	TKR
NAME	AGE	READY		
tkgs-cluster-ns	test-cluster	3	3	v1.21.2---vmware.1-
tkg.1.13da849	5d12h	True		

- 5 Load the cluster manifest for editing using the `kubectl edit` command.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
```

The cluster manifest opens in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variables.

- 6 Locate the `spec.topology.workers.count` parameter and increase the number of nodes.

```
...
workers:
  replicas: 3
...
```

```
...
workers:
  replicas: 4
...
```

- 7 To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the file, `kubectl` applies the changes to the cluster. In the background, the Virtual Machine Service on the Supervisor Cluster provisions the new worker node.

- 8 Verify that the new worker node is added.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

After scaling out, the cluster has 4 worker nodes.

NAMESPACE	NAME	CONTROL PLANE	WORKER	TKR
tkgs-cluster-ns	test-cluster	3	4	v1.21.2---vmware.1-
tkg.1.13da849	5d12h	True		

## Scale In Worker Nodes

You can scale in a Tanzu Kubernetes cluster by decreasing the number of worker nodes. Scaling in the control plane is not supported.

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the vSphere Namespace where the Tanzu Kubernetes cluster is running.

```
kubectl config use-context tkgs-cluster-ns
```

- 3 List the Kubernetes clusters that are running in the namespace.

```
kubectl get tanzukubernetescluster -n tkgs-cluster-ns
```

- 4 Get the number of nodes running in the target cluster.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

For example, the following cluster has 3 control plane nodes and 4 worker nodes.

```

NAMESPACE          NAME          CONTROL PLANE  WORKER  TKR
NAME                AGE          READY
tkgs-cluster-ns    test-cluster  3             4       v1.21.2---vmware.1-
tkg.1.13da849      5d12h       True

```

- 5 Load the cluster manifest for editing using the `kubectl edit` command.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
```

The cluster manifest opens in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variables.

- 6 Locate the `spec.topology.workers.count` parameter and increase the number of nodes.

```

...
workers:
  replicas: 4
...

```

```

...
workers:
  replicas: 2
...

```

- 7 To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the file, `kubectl` applies the changes to the cluster. In the background, the Virtual Machine Service on the Supervisor Cluster provisions the new worker node.

- 8 Verify that the worker nodes were removed.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

After scaling in, the cluster has 2 worker nodes.

```

NAMESPACE          NAME          CONTROL PLANE  WORKER  TKR
NAME                AGE          READY
tkgs-cluster-ns    test-cluster  3             2       v1.21.2---vmware.1-
tkg.1.13da849      5d12h       True

```

## Scale a Cluster Vertically

You can vertically scale a Tanzu Kubernetes cluster by changing the virtual machine class used to host the cluster nodes. Vertical scaling is supported for both control plane and worker nodes.

The Tanzu Kubernetes Grid Service supports scaling cluster nodes vertically through the rolling update mechanism built into the service. If you change the `VirtualMachineClass` definition, the service rolls out new nodes with that new class and spins down the old nodes. See [Update Tanzu Kubernetes Clusters](#).

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the vSphere Namespace where the Tanzu Kubernetes cluster is running.

```
kubectl config use-context tkgs-cluster-ns
```

- 3 List the Kubernetes clusters that are running in the namespace.

```
kubectl get tanzukubernetescluster -n tkgs-cluster-ns
```

- 4 Describe the target Tanzu Kubernetes cluster and check the VM class.

```
kubectl describe tanzukubernetescluster tkgs-cluster-2
```

For example, the following cluster is using the best-effort-medium VM class.

```
Spec:
  ...
  Topology:
    Control Plane:
      Class:          best-effort-medium
      ...
    nodePool-a1:
      Class:          best-effort-medium
      ...
```

- 5 List and describe the available VM classes.

```
kubectl get virtualmachineclassbinding
```

```
kubectl describe virtualmachineclassbinding
```

---

**Note** The VM class you want to use must be bound the vSphere Namespace. See [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).

---

- 6 Open for editing the target cluster manifest.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-2
```

The cluster manifest opens in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variables.

- 7 Edit the manifest by changing the VM class.



For example, edit the cluster manifest to use the `guaranteed-large` VM class for control plane and worker nodes.

```
spec:
  topology:
    controlPlane:
      class: guaranteed-large
      ...
    nodePool-a1:
      class: guaranteed-large
      ...
```

- To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the file, `kubectl` applies the changes to the cluster. In the background, the Tanzu Kubernetes Grid Service provisions the new nodes and deletes the old ones. For a description of the rolling update process, see [About Tanzu Kubernetes Cluster Updates](#).

- Verify that the cluster is updated.

```
kubectl get tanzukubernetescluster
NAMESPACE          NAME                CONTROL PLANE  WORKER  TKR
NAME                AGE                READY
tkgs-cluster-ns    test-cluster        3              3       v1.21.2---vmware.1-
tkg.1.13da849      5d12h              True
```

## Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API

This section describes how to provision Tanzu Kubernetes clusters using the Tanzu Kubernetes Grid Service v1alpha1 API.

### Workflow for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API

You provision Tanzu Kubernetes clusters by invoking the Tanzu Kubernetes Grid Service declarative API using `kubectl` and a cluster specification defined using YAML. After you provision a cluster, you operate it and deploy workloads to it using `kubectl`.

The workflow provides an end-to-end procedure for the cluster provisioning process. Each of the steps has links for more information about the specific task.

## Prerequisites

Complete the following prerequisites:

- Configure a Supervisor Cluster instance. See [Chapter 5 Configuring and Managing a Supervisor Cluster](#).
- Create a vSphere Namespace where you plan to provision Tanzu Kubernetes clusters. See [Create and Configure a vSphere Namespace](#).

The initial namespace configuration requires the following:

- Edit permissions for one or more DevOps engineers to access the namespace using vCenter Single Sign-On credentials.
- Tag-based shared storage policy for the namespace.
- Capacity and usage quotas for the namespace, verified and adjusted, as necessary.
- Create a content library for Tanzu Kubernetes releases on a shared datastore and synchronize the releases you want to use. See [Creating and Managing Content Libraries for Tanzu Kubernetes releases](#).
- Associate the content library and the virtual machine classes with the vSphere Namespace. See [Configure a vSphere Namespace for Tanzu Kubernetes releases](#).

## Procedure

- 1 Download and install the Kubernetes CLI Tools for vSphere. See [Download and Install the Kubernetes CLI Tools for vSphere](#).
- 2 Using the vSphere Plugin for kubectl, authenticate with the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

```
kubectl vsphere login --server=IP-ADDRESS --vsphere-username USERNAME
```

- 3 Using kubectl, switch context to the vSphere Namespace where you plan to provision the Tanzu Kubernetes cluster.

```
kubectl config get-contexts
```

```
kubectl config use-context SUPERVISOR-NAMESPACE
```

For example:

```
kubectl config use-context tkgs-cluster-ns
```

- 4 List the available virtual machine class bindings. See [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).

Use the following command to list all VM class bindings that are available in the vSphere Namespace where you deploy the cluster.

```
kubectl get virtualmachineclassbindings
```

---

**Note** The command `kubectl get virtualmachineclasses` lists all the VM classes present on the Supervisor Cluster. Because you must associate VM classes with the vSphere Namespace, you can only use those VM classes that are bound to the target namespace.

---

- 5 Get the available default storage class by describing the namespace.

```
kubectl describe namespace SUPERVISOR-NAMESPACE
```

- 6 List the available Tanzu Kubernetes releases.

---

**Note** Refer to the list of Tanzu Kubernetes releases for compatibility. See [List of Tanzu Kubernetes releases](#).

---

```
kubectl get tanzukubernetesreleases
```

---

**Note** The command `kubectl get virtualmachineimages` returns generic information about the virtual machines.

---

## 7 Construct the YAML file for provisioning a Tanzu Kubernetes cluster.

- a Start with one of the example YAML files. See [Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API](#).

For example, the following YAML file provisions a minimal cluster using all available defaults:

```
apiVersion: run.tanzu.vmware.com/v1alpha1 #TKGS API endpoint
kind: TanzuKubernetesCluster             #required parameter
metadata:
  name: tkgs-cluster-1                   #cluster name, user defined
  namespace: tkgs-cluster-ns            #vsphere namespace
spec:
  distribution:
    version: v1.19                       #Resolves to latest TKR 1.19 version
  topology:
    controlPlane:
      count: 1                            #number of control plane nodes
      class: best-effort-medium           #vmclass for control plane nodes
      storageClass: vwt-storage-policy    #storageclass for control plane
    workers:
      count: 3                            #number of worker nodes
      class: best-effort-medium           #vmclass for worker nodes
      storageClass: vwt-storage-policy    #storageclass for worker nodes
```

- b Use the information you gleaned from the output of the preceding commands to populate the cluster YAML, including the namespace, storage class, and virtual machine class.
- c Customize the cluster as needed by referring to the full list of cluster configuration parameters. See [Configuration Parameters for Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API](#).
- d Save the file as `tkgs-cluster-1.yaml`, or similar.

## 8 Provision the cluster by running the following kubectl command.

```
kubectl apply -f CLUSTER-NAME.yaml
```

For example:

```
kubectl apply -f tkgs-cluster-1.yaml
```

Expected result:

```
tanzukubernetescluster.run.tanzu.vmware.com/tkgs-cluster-1 created
```

## 9 Monitor the deployment of cluster nodes using kubectl. See [Monitor Tanzu Kubernetes Cluster Status Using kubectl](#).

```
kubectl get tanzukubernetesclusters
```

Sample result:

NAME	CONTROL PLANE	WORKER	DISTRIBUTION	AGE	PHASE
tkgs-cluster-2	1	3	v1.19.7+vmware.1-tkg.1.c40d30d	7m59s	running

- 10** Monitor the deployment of cluster nodes using the vSphere Client. See [Monitor Tanzu Kubernetes Cluster Status Using the vSphere Client](#).

For example, in the vSphere inventory you should see the virtual machine nodes being deployed in the namespace.

- 11** Run additional commands to verify cluster provisioning. See [Use Tanzu Kubernetes Cluster Operational Commands](#).

For example:

```
kubectl get tanzukubernetescluster,cluster-
api,virtualmachinesetresourcepolicy,virtualmachineservice,virtualmachine
```

---

**Note** For additional troubleshooting, see [Troubleshooting Tanzu Kubernetes Clusters](#).

- 12** Using the vSphere Plugin for kubectl, log in to the cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).

```
kubectl vsphere login --server=IP-ADDRESS --vsphere-username USERNAME \
--tanzu-kubernetes-cluster-name CLUSTER-NAME --tanzu-kubernetes-cluster-namespace
NAMESPACE-NAME
```

- 13** Verify cluster provisioning using the following kubectl commands.

```
kubectl cluster-info
```

```
kubectl get nodes
```

```
kubectl get namespaces
```

```
kubectl api-resources
```

- 14** Deploy an example workload and verify cluster creation. See [Deploy Workloads on Tanzu Kubernetes Clusters](#).

---

**Note** Tanzu Kubernetes clusters have pod security policy enabled. Depending on the workload and user, you might need to create an appropriate RoleBinding or custom PodSecurityPolicy. See [Using Pod Security Policies with Tanzu Kubernetes Clusters](#).

- 15** Operationalize the cluster by deploying TKG Extensions. See [Deploy TKG Extensions on Tanzu Kubernetes Clusters](#).

## Configuration Parameters for Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API

The Tanzu Kubernetes Grid Service declarative API exposes several parameters for configuring Tanzu Kubernetes clusters. Refer to the list and description of all parameters and usage guidelines to provision and customize your clusters.

### Annotated YAML for Provisioning a Tanzu Kubernetes Cluster

The annotated YAML lists all available parameters for provisioning a Tanzu Kubernetes cluster with summarized comments for each field.

**Note** The annotated YAML is not validated for provisioning a cluster. Refer to the examples for such guidance: [Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API](#).

```

apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TanzuKubernetesCluster
metadata:
  name: <tanzu kubernetes cluster name>
  namespace: <vsphere namespace where the cluster will be provisioned>
spec:
  distribution:
    version: <tanzu kubernetes release version string: full, point, short>
  topology:
    controlPlane:
      count: <integer either 1 or 3>
      class: <vm class bound to the target vsphere namespace>
      storageClass: <vsphere storage policy bound to the target vsphere namespace>
      volumes: #optional setting for high-churn control plane component (such as etcd)
        - name: <user-defined string>
          mountPath: </dir/path>
          capacity:
            storage: <size in GiB>
    workers:
      count: <integer from 0 to 150>
      class: <vm class bound to the target vsphere namespace>
      storageClass: <vsphere storage policy bound to the target vsphere namespace>
      volumes: #optional setting for high-churn worker node component (such as containerd)
        - name: <user-defined string>
          mountPath: </dir/path>
          capacity:
            storage: <size in GiB>
  settings: #all spec.settings are optional
    storage: #optional storage settings
      classes: [<array of kubernetes storage classes for dynamic pvc provisioning>]
      defaultClass: <default kubernetes storage class>
    network: #optional network settings
      cni: #override default cni set in the tkgservicesonfiguration spec
        name: <antrea or calico>
      pods: #custom pod network
        cidrBlocks: [<array of pod cidr blocks>]

```

```

services: #custom service network
  cidrBlocks: [<array of service cidr blocks>]
serviceDomain: <custom service domain>
proxy: #proxy server for outbound connections
  httpProxy: http://<IP:PORT>
  httpsProxy: http://<IP:PORT>
  noProxy: [<array of CIDRs to not proxy>]
trust: #trust fields for custom public certs for tls
  additionalTrustedCAs:
    - name: <first-cert-name>
      data: <base64-encoded string of PEM encoded public cert 1>
    - name: <second-cert-name>
      data: <base64-encoded string of PEM encoded public cert 2>

```

## Parameters for Provisioning Tanzu Kubernetes Clusters

The table lists and describes all parameters and acceptable values for provisioning a Tanzu Kubernetes cluster. For examples, see [Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API](#).

Table 13-4. Parameters for Provisioning Tanzu Kubernetes Clusters

Name	Value	Description
apiVersion	run.tanzu.vmware.com/v1alpha1	Specifies the version of the Tanzu Kubernetes Grid Service API.
kind	TanzuKubernetesCluster	Specifies the type of Kubernetes resource to create. The only allowed value is <code>TanzuKubernetesCluster</code> (case-sensitive).
metadata	Section for cluster metadata	Includes cluster metadata, such as <code>name</code> and <code>namespace</code> . This is standard Kubernetes metadata, so you can use <code>generateName</code> instead of <code>name</code> , add labels and annotations, and so on.
name	A user-defined string that accepts alphanumeric characters and dashes, for example: <code>my-tkg-cluster-1</code>	Specifies the name of the cluster to create. Current cluster naming constraints: <ul style="list-style-type: none"> <li>■ Name length must be 41 characters or less.</li> <li>■ Name must begin with a letter.</li> <li>■ Name may contain letters, numbers, and hyphens.</li> <li>■ Name must end with a letter or a number.</li> </ul>
namespace	A user-defined string that accepts alphanumeric characters and dashes, for example: <code>my-sns-1</code>	Identifies the name of the Supervisor Namespace where the cluster will be deployed. This is a reference to a Supervisor Namespace that exists on the Supervisor Cluster.

Table 13-4. Parameters for Provisioning Tanzu Kubernetes Clusters (continued)

Name	Value	Description
<code>spec</code>	Section for technical specifications for the cluster	Includes the specification, expressed in declarative fashion, for the end-state of the cluster, including the node <code>topology</code> and Kubernetes software <code>distribution</code> .
<code>distribution</code>	Section for specifying the Tanzu Kubernetes Release version	Indicates the distribution for the cluster: the Tanzu Kubernetes cluster software installed on the control plane and worker nodes, including Kubernetes itself.
<code>version</code>	Alphanumeric string with dashes representing the Kubernetes version, for example: <code>v1.20.2+vmware.1-tkg.1</code> or <code>v1.20.2</code> or <code>v1.20</code>	Specifies the software version of the Kubernetes distribution to install on cluster nodes using semantic version notation. Can specify the fully qualified version or use version shortcuts, such as "version: v1.20.2", which is resolved to the most recent image matching that patch version, or "version: v1.20", which is resolved to the most recent matching patch version. The resolved version displays as the "fullVersion" on the cluster description after you have created it.
<code>topology</code>	Section for cluster node topologies	Includes fields that describe the number, purpose, and organization of cluster nodes and the resources allocated to each. Cluster nodes are grouped into pools based on their intended purpose: either <code>control-plane</code> or <code>worker</code> . Each pool is homogeneous, having the same resource allocation and using the same storage.
<code>controlPlane</code>	Section for control plane settings	Specifies the topology of the cluster control plane, including the number of nodes ( <code>count</code> ), type of VM ( <code>class</code> ), and the storage resources allocated for each node ( <code>storageClass</code> ).
<code>count</code>	An integer that is either 1 or 3	Specifies the number of control plane nodes. The control plane must have an odd number of nodes.



Table 13-4. Parameters for Provisioning Tanzu Kubernetes Clusters (continued)

Name	Value	Description
class	A system-defined element in the form of a string from an enumerated set, for example: <code>guaranteed-small</code> or <code>best-effort-large</code>	Specifies the name of the <code>VirtualMachineClass</code> that describes the virtual hardware settings to be used each node in the pool. This controls the hardware available to the node (CPU and memory) as well as the requests and limits on those resources. See <a href="#">Virtual Machine Classes for Tanzu Kubernetes Clusters</a> .
storageClass	<code>node-storage</code> (for example)	Identifies the storage class to be used for storage of the disks which store the root file systems of the control plane nodes. Run <code>kubectl describe ns</code> on the namespace to view the available storage classes. The available storage classes for the namespace depend on the storage set by the vSphere administrator. Storage classes associated with the Supervisor Namespace are replicated in the cluster. In other words, the storage class must be available on the Supervisor Namespace to be a valid value for this field. See <a href="#">Chapter 7 Configuring and Managing vSphere Namespaces</a> .
volumes	Optional storage setting <ul style="list-style-type: none"> <li>■ volumes: <ul style="list-style-type: none"> <li>■ name: <i>string</i></li> <li>■ mountPath: <i>/dir/path</i></li> <li>■ capacity <ul style="list-style-type: none"> <li>■ storage: GiB size</li> </ul> </li> </ul> </li> </ul>	Can specify separate disk and storage parameters for etcd on control plane nodes. See the example <a href="#">Cluster with Separate Disks and Storage Parameters</a> .
workers	Section for worker node settings	Specifies the topology of the cluster worker nodes, including the number of nodes ( <code>count</code> ), type of VM ( <code>class</code> ), and the storage resources allocated for each node ( <code>storageClass</code> ).
count	An integer between 0 and 150, for example: 1 or 2 or 7	Specifies the number of worker nodes in the cluster. A cluster with zero worker nodes can be created, allowing for a cluster with only control plane nodes. There is no hard maximum for the number of worker nodes, but a reasonable limit is 150.

Table 13-4. Parameters for Provisioning Tanzu Kubernetes Clusters (continued)

Name	Value	Description
class	A system-defined element in the form of a string from an enumerated set, for example: <code>guaranteed-small</code> or <code>best-effort-large</code>	Specifies the name of the <code>VirtualMachineClass</code> that describes the virtual hardware settings to be used each node in the pool. This controls the hardware available to the node (CPU and memory) as well as the requests and limits on those resources. See <a href="#">Virtual Machine Classes for Tanzu Kubernetes Clusters</a> .
storageClass	<code>node-storage</code> (for example)	Identifies the storage class to be used for storage of the disks that store the root file systems of the worker nodes. Run <code>kubectl describe ns</code> on the namespace to list available storage classes. The available storage classes for the namespace depend on the storage set by the vSphere administrator. Storage classes associated with the Supervisor Namespace are replicated in the cluster. In other words, the storage class must be available on the Supervisor Namespace to be valid. See <a href="#">Chapter 7 Configuring and Managing vSphere Namespaces</a> .
volumes	Optional storage setting <ul style="list-style-type: none"> <li>■ volumes: <ul style="list-style-type: none"> <li>■ name: <i>string</i></li> <li>■ mountPath: <i>/dir/path</i></li> <li>■ capacity <ul style="list-style-type: none"> <li>■ storage: GiB size</li> </ul> </li> </ul> </li> </ul>	Can specify separate disk and storage parameters for container images on worker nodes. See the example <a href="#">Cluster with Separate Disks and Storage Parameters</a> .
settings	Section for cluster-specific settings; all <code>spec.settings</code> are optional	Identifies optional runtime configuration information for the cluster, including node <code>network</code> details and persistent <code>storage</code> for pods.
storage	Section for specifying storage	Identifies persistent volume (PV) storage entries for container workloads.

Table 13-4. Parameters for Provisioning Tanzu Kubernetes Clusters (continued)

Name	Value	Description
classes	Array of one or more user-defined strings, for example: ["gold", "silver"]	Specifies named persistent volume (PV) storage classes for container workloads. Storage classes associated with the Supervisor Namespace are replicated in the cluster. In other words, the storage class must be available on the Supervisor Namespace to be a valid value. See the example <a href="#">Cluster with Storage Classes and a Default Class for Persistent Volumes</a> .
defaultClass	silver (for example)	Specifies a named storage class to be annotated as the default in the cluster. If you do not specify it, there is no default. You do not have to specify one or more classes to specify a defaultClass. Some workloads may require a default class, such as Helm. See the example <a href="#">Cluster with Storage Classes and a Default Class for Persistent Volumes</a> .
network	Section marker for networking settings	Specifies network-related settings for the cluster.
cni	Section marker for specifying the CNI	Identifies the Container Networking Interface (CNI) plug-in for the cluster. The default is Antrea, which does not need to be specified for new clusters.
name	String antrea or calico	Specifies the CNI to use. Antrea and Calico are supported. System configuration sets Antrea as the default CNI. The default CNI can be changed. If using the default, this field does not need to be specified.
services	Section marker for specifying Kubernetes services subnets	Identifies network settings for Kubernetes services. Default is 10.96.0.0/12.
cidrBlocks	Array ["198.51.100.0/12"] (for example)	Specifies a range of IP addresses to use for Kubernetes services. Default is 10.96.0.0/12. Must not overlap with the settings chosen for the Supervisor Cluster. Although this field is an array, allowing for multiple ranges, currently only a single IP range is allowed. See the networking examples at <a href="#">Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API</a> .

Table 13-4. Parameters for Provisioning Tanzu Kubernetes Clusters (continued)

Name	Value	Description
pods	Section marker for specifying Kubernetes pods subnets	Specifies network settings for pods. Default is 192.168.0.0/16. Minimum block size is /24.
cidrBlocks	Array ["192.0.2.0/16"] (for example)	Specifies a range of IP addresses to use for Kubernetes pods. Default is 192.168.0.0/16. Must not overlap with the settings chosen for the Supervisor Cluster. Pods subnet size must be equal to or larger than /24. Although this field is an array, allowing for multiple ranges, currently only a single IP range is allowed. See the networking examples at <a href="#">Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API</a> .
serviceDomain	"cluster.local"	Specifies the service domain for the cluster. Default is cluster.local.
proxy	Section that specifies HTTP(s) proxy configuration for the cluster. If implemented all fields are required.	Provides fields for specified proxy settings; will be auto-populated if a global proxy is configured and individual cluster proxy is not configured. See the example <a href="#">Cluster with a Proxy Server</a> .
httpProxy	http://<user>:<pwd>@<ip>:<port>	Specifies a proxy URL to use for creating HTTP connections outside the cluster.
httpsProxy	http://<user>:<pwd>@<ip>:<port>	Specifies a proxy URL to use for creating HTTPS connections outside the cluster.

Table 13-4. Parameters for Provisioning Tanzu Kubernetes Clusters (continued)

Name	Value	Description
<code>noProxy</code>	<p>Array of CIDR blocks to not proxy, for example:  <code>[10.246.0.0/16,192.168.144.0/20,192.168.128.0/20]</code>.</p> <p>Get the required values come from the Workload Network on the Supervisor Cluster: <code>Pod</code> CIDRs, <code>Ingress</code> CIDRs, and <code>Egress</code> CIDRs.</p> <p>Refer to the image below for what values to include in the <code>noProxy</code> array field.</p>	<p>You must not proxy the subnets used by the Workload Network on the Supervisor Cluster for Pods, Ingress, and Egress.</p> <p>You do not need to include the Services CIDR from the Supervisor Cluster in the <code>noProxy</code> field. Tanzu Kubernetes clusters do not interact with such services.</p> <p>The endpoints <code>localhost</code> and <code>127.0.0.1</code> are automatically not proxied. You do not need to add them to the <code>noProxy</code> field.</p> <p>The Pod and Service CIDRs for Tanzu Kubernetes clusters are automatically not proxied. You do not need to add them to the <code>noProxy</code> field.</p> <p>See the example <a href="#">Cluster with a Proxy Server</a>.</p>
<code>trust</code>	Section marker for <code>trust</code> parameters.	Accepts no data.
<code>additionalTrustedCAs</code>	Accepts an array of certificates with <code>name</code> and <code>data</code> for each.	Accepts no data.
<code>name</code>	String	The name of the TLS certificate.
<code>data</code>	String	The base64-encoded string of a PEM encoded public certificate.

Get the required `noProxy` values from the **Workload Network** on the Supervisor Cluster as shown in the image.

The screenshot displays the configuration page for a compute cluster, specifically the Network settings. The left sidebar contains a navigation menu with categories like Services, Configuration, Licensing, Namespaces, and vSAN. The 'Network' option under Namespaces is selected. The main content area shows the 'Workload Network' section with various settings:

- Management Network (expanded)
- Workload Network (expanded)
- vSphere Distributed Switch: `wcp_vds_1`
- Edge Cluster: `EDGECLUSTER1`
- DNS Servers: `10.20.145.1` (EDIT)
- Pod CIDRs: `10.246.0.0/16` (EDIT)
- Services CIDR: `10.94.0.0/12`
- Ingress CIDRs: `192.168.144.0/20` (EDIT)
- Egress CIDRs: `192.168.128.0/20` (EDIT)

The Pod CIDRs, Ingress CIDRs, and Egress CIDRs settings are highlighted with red boxes in the original image.

## Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API

The Tanzu Kubernetes Grid Service API provides intelligent defaults and an array of options for customizing Tanzu Kubernetes clusters. Refer to the examples to provision clusters of various types with different configurations and customizations to meet your needs.

### Minimal YAML for Provisioning a Tanzu Kubernetes Cluster

The following example YAML is the minimal configuration required to invoke the Tanzu Kubernetes Grid Service and provision a Tanzu Kubernetes cluster that uses all of the default settings.

Characteristics of the minimal example YAML include:

- The Tanzu Kubernetes release version, listed as v1.19, is resolved to the most recent distribution matching that minor version, for example v1.19.7+vmware.1-tkg.1.xxxxxx. See [List of Tanzu Kubernetes releases](#).
- The VM class `best-effort-<size>` has no reservations. For more information, see [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).
- The cluster does not include persistent storage for containers. If needed this is set in `spec.settings.storage`. See the storage example below.
- Some workloads, such as Helm, may require a `spec.settings.storage.defaultClass`. See the storage example below.
- The `spec.settings.network` section is not specified. This means that the cluster uses the following default network settings:
  - Default CNI: `antrea`
  - Default Pod CIDR: `192.168.0.0/16`
  - Default Services CIDR: `10.96.0.0/12`
  - Default Service Domain: `cluster.local`

---

**Note** The default IP range for Pods is `192.168.0.0/16`. If this subnet is already in use, you must specify a different CIDR range. See the custom network examples below.

---

```
apiVersion: run.tanzu.vmware.com/v1alpha1      #TKGS API endpoint
kind: TanzuKubernetesCluster                  #required parameter
metadata:
  name: tgks-cluster-1                        #cluster name, user defined
  namespace: tgks-cluster-ns                 #vsphere namespace
spec:
  distribution:
    version: v1.20                            #Resolves to latest TKR 1.20
  topology:
    controlPlane:
```

```

count: 1                                #number of control plane nodes
class: best-effort-medium                #vmclass for control plane nodes
storageClass: vwt-storage-policy        #storageclass for control plane
workers:
count: 3                                #number of worker nodes
class: best-effort-medium                #vmclass for worker nodes
storageClass: vwt-storage-policy        #storageclass for worker nodes

```

## Cluster with Separate Disks and Storage Parameters

The following example YAML shows how to provision a cluster with separate disks and storage parameters for cluster control plane and worker nodes.

Using separating disks and storage parameters for high-churn data help to minimize read-write overhead related to the use of linked clones, among other benefits. There are two primary use cases:

- Customize storage performance on control plane nodes for the etcd database
- Customize the size of the disk for container images on the worker nodes

The example has the following characteristics:

- The `spec.topology.controlPlane.volumes` settings specify the separate volume for the etcd database.
- The `spec.topology.workers.volumes` settings specify the separate volume for the container images.
- The `mountPath: /var/lib/containerd` for container images is supported for Tanzu Kubernetes releases 1.17 and later.

```

apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TanzuKubernetesCluster
metadata:
  name: tkgs-cluster-5
  namespace: tgks-cluster-ns
spec:
  distribution:
    version: v1.20
  topology:
    controlPlane:
      count: 3
      class: best-effort-medium
      storageClass: vwt-storage-policy
      volumes:
        - name: etcd
          mountPath: /var/lib/etcd
          capacity:
            storage: 4Gi
    workers:
      count: 3
      class: best-effort-medium
      storageClass: vwt-storage-policy

```



```
volumes:
  - name: containerd
    mountPath: /var/lib/containerd
    capacity:
      storage: 16Gi
```

## Cluster with a Custom Antrea Network

The following YAML demonstrates how to provision a Tanzu Kubernetes cluster with custom network ranges for the Antrea CNI.

- Because custom network settings are applied, the `cni.name` parameter is required even though the default Antrea CNI is used.
  - CNI name: `antrea`
  - Custom Pods CIDR: `193.0.2.0/16`
  - Custom Services CIDR: `195.51.100.0/12`
  - Custom Service Domain: `managedcluster.local`
- The custom CIDR blocks cannot overlap with the Supervisor Cluster. For more information, see [Configuration Parameters for Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API](#).

```
apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TanzuKubernetesCluster
metadata:
  name: tkg-cluster-3-antrea
  namespace: tkgs-cluster-ns
spec:
  distribution:
    version: v1.20
  topology:
    controlPlane:
      class: guaranteed-medium
      count: 3
      storageClass: vwt-storage-policy
    workers:
      class: guaranteed-medium
      count: 5
      storageClass: vwt-storage-policy
  settings:
    network:
      cni:
        name: antrea #Use Antrea CNI
    pods:
      cidrBlocks:
        - 193.0.2.0/16 #Must not overlap with SVC
```

```

services:
  cidrBlocks:
    - 195.51.100.0/12          #Must not overlap with SVC
  serviceDomain: managedcluster.local

```

## Cluster with a Custom Calico Network

The following YAML demonstrates how to provision a Tanzu Kubernetes cluster with a custom Calico network.

- Calico is not the default CNI, so it is explicitly named in the manifest. To change the default CNI at the service-level, see [Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API](#).
  - CNI name: `calico`
  - Custom Pods CIDR: `198.51.100.0/12`
  - Custom Services CIDR: `192.0.2.0/16`
  - Custom Service Domain: `managedcluster.local`
- The network uses custom CIDR ranges, not the defaults. These ranges must not overlap with the Supervisor Cluster. See [Configuration Parameters for Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API](#).

```

apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TanzuKubernetesCluster
metadata:
  name: tkgs-cluster-2
  namespace: tkgs-cluster-ns
spec:
  distribution:
    version: v1.20
  topology:
    controlPlane:
      count: 3
      class: guaranteed-large
      storageClass: vwt-storage-policy
    workers:
      count: 5
      class: guaranteed-xlarge
      storageClass: vwt-storage-policy
  settings:
    network:
      cni:
        name: calico          #Use Calico CNI for this cluster
      services:
        cidrBlocks: ["198.51.100.0/12"]    #Must not overlap with SVC
      pods:
        cidrBlocks: ["192.0.2.0/16"]      #Must not overlap with SVC
      serviceDomain: managedcluster.local

```

## Cluster with Storage Classes and a Default Class for Persistent Volumes

The following example YAML demonstrates how to provision a cluster with a storage classes for dynamic PVC provisioning and a default storage class.

- The `spec.settings.storage.classes` setting specifies two storage classes for persistent storage for containers in the cluster.
- The `spec.settings.storage.defaultClass` is specified. Some applications require a default class. For example, if you want to use Helm or Kubeapps as the `defaultClass`, which is referenced by many charts.

```
apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TanzuKubernetesCluster
metadata:
  name: default-storage-spec
  namespace: tkgs-cluster-ns
spec:
  topology:
    controlPlane:
      count: 3
      class: best-effort-medium
      storageClass: vwt-storage-policy
    workers:
      count: 3
      class: best-effort-medium
      storageClass: vwt-storage-policy
  distribution:
    version: v1.20
  settings:
    network:
      cni:
        name: antrea
      services:
        cidrBlocks: ["198.51.100.0/12"]
      pods:
        cidrBlocks: ["192.0.2.0/16"]
        serviceDomain: "tanzukubernetescluster.local"
    storage:
      classes: ["gold", "silver"]           #Array of named PVC storage classes
      defaultClass: silver                 #Default PVC storage class
```

## Cluster with a Proxy Server

You can use a proxy server with an individual Tanzu Kubernetes cluster by applying the proxy server configuration to the cluster manifest.

Note the following characteristics:

- The section `spec.settings.network.proxy` specifies HTTP(s) proxy configuration for this Tanzu Kubernetes cluster.
- The syntax for both `proxy server` values is `http://<user>:<pwd>@<ip>:<port>`.

- Specific endpoints are automatically not proxied, including `localhost` and `127.0.0.1`, and the Pod and Service CIDRs for Tanzu Kubernetes clusters. You do not need to include these in the `noProxy` field.
- The `noProxy` field accepts an array of CIDRs to not proxy. Get the required values from the Workload Network on the Supervisor Cluster. Refer to the image at [Configuration Parameters for Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API](#).
- If a global proxy is configured on the `TkgServiceConfiguration`, that proxy information is propagated to the cluster manifest after the initial deployment of the cluster. The global proxy configuration is added to the cluster manifest only if there is no proxy configuration fields present when creating the cluster. In other words, per-cluster configuration takes precedence and will overwrite a global proxy configuration.

```

apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TanzuKubernetesCluster
metadata:
  name: tkgs-cluster-with-proxy
  namespace: tkgs-cluster-ns
spec:
  distribution:
    version: v1.20
  topology:
    controlPlane:
      count: 3
      class: guaranteed-medium
      storageClass: vwt-storage-policy
    workers:
      count: 5
      class: guaranteed-xlarge
      storageClass: vwt-storage-policy
  settings:
    storage:
      classes: ["gold", "silver"]
      defaultClass: silver
    network:
      cni:
        name: antrea
      pods:
        cidrBlocks:
          - 193.0.2.0/16
      services:
        cidrBlocks:
          - 195.51.100.0/12
      serviceDomain: managedcluster.local
    proxy:
      httpProxy: http://10.186.102.224:3128 #Proxy URL for HTTP connections
      httpsProxy: http://10.186.102.224:3128 #Proxy URL for HTTPS connections
      noProxy: [10.246.0.0/16,192.168.144.0/20,192.168.128.0/20] #SVC Pod, Egress, Ingress
  CIDRs

```

## Cluster with Custom Certificates for TLS

Similar to how you can specify a `trust.additionalTrustedCAs` in the `TkgServiceConfiguration` (see [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#)), you can include `trust.additionalTrustedCAs` under the `spec.settings.network` in the `TanzuKubernetesCluster` `spec`. For example:

```
apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TanzuKubernetesCluster
metadata:
  name: tkgs-cluster-with-custom-certs-tls
  namespace: tkgs-cluster-ns
spec:
  topology:
    controlPlane:
      count: 3
      class: guaranteed-medium
      storageClass: vwt-storage-profile
    workers:
      count: 3
      class: guaranteed-large
      storageClass: vwt-storage-profile
  distribution:
    version: 1.20.2
  settings:
    network:
      cni:
        name: antrea
      services:
        cidrBlocks: ["198.51.100.0/12"]
      pods:
        cidrBlocks: ["192.0.2.0/16"]
        serviceDomain: "managedcluster.local"
      trust:
        additionalTrustedCAs:
          - name: custom-selfsigned-cert-for-tkc
            data: |
              LS0aaaaaaaaaaaaaaaaabase64...
```

## Cluster that Does or Does Not Inherit Global Settings from the TkgServiceConfiguration Spec

---

**Note** The following example cluster configurations require vCenter Server version 7.0U2a or later and at least Supervisor Cluster version 1.18.10.

---

To provision a Tanzu Kubernetes cluster that inherits a global setting from the `TkgServiceConfiguration`, configure the cluster with the global setting not specified or nulled out.

For example, if you wanted to configure a cluster that would inherit the `proxy` setting you could use either of the following approaches:

Option 1: Do not include the `proxy` setting in the cluster specification:

```
...
settings:
  network:
    cni:
      name: antrea
    services:
      cidrBlocks: ["198.51.100.0/12"]
    pods:
      cidrBlocks: ["192.0.2.0/16"]
      serviceDomain: "tanzukubernetescluster.local"
```

Option 2: Include the `proxy` setting in the specification but explicitly set its value to `null`:

```
settings:
  network:
    proxy: null
```

To provision a Tanzu Kubernetes cluster that does not inherit the default value from `TkgServiceConfiguration`, configure the cluster specification with all elements included but empty values.

For example, if the `TkgServiceConfiguration` has a global `proxy` configured and you want to provision a cluster that does not inherit the global `proxy` settings, include the following syntax in your cluster specification:

```
...
settings:
  network:
    proxy:
      httpProxy: ""
      httpsProxy: ""
      noProxy: null
```

## Cluster Using a Local Content Library

To provision a Tanzu Kubernetes cluster in an air-gapped environment, create a cluster using the virtual machine image synchronized from a Local Content Library.

To provision a cluster using a local content library image, you must specify that image in the cluster spec. For the `distribution.version` value, you can enter either the full image name or, if you kept the name format from the image directory, you can shorten it to the Kubernetes version. If you want to use a fully qualified version number, replace `-----` with `+`. For example, if you have an OVA image named `photon-3-k8s-v1.20.2---vmware.1-tkg.1.1d4f79a`, the following formats are acceptable.

```
spec:
  distribution:
    version: v1.20
```

```
spec:
  distribution:
    version: v1.20.2
```

```
spec:
  distribution:
    version: v1.20.2+vmware.1-tkg.1
```

```
apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TanzuKubernetesCluster
metadata:
  name: tgks-cluster-9
  namespace: tkgs-cluster-ns
spec:
  topology:
    controlPlane:
      count: 3
      class: best-effort-medium
      storageClass: vwt-storage-policy
    workers:
      count: 3
      class: best-effort-medium
      storageClass: vwt-storage-policy
  distribution:
    version: v1.20.2
  settings:
    network:
      cni:
        name: antrea
    services:
      cidrBlocks: ["198.51.100.0/12"]
    pods:
      cidrBlocks: ["192.0.2.0/16"]
```

## Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API

You can customize the Tanzu Kubernetes Grid Service with global settings for key features, including the container network interface (CNI), proxy server, and TLS certificates. Be aware of trade-offs and considerations when implementing global versus per-cluster functionality.

Optionally you can configure the Tanzu Kubernetes Grid Service with global parameters.

**Caution** Configuring the Tanzu Kubernetes Grid Service is a global operation. This means that any change you make to the `TkgServiceConfiguration` specification applies to all Tanzu Kubernetes clusters provisioned by that service. If a rolling update is initiated, either manually or by upgrade, clusters are updated by the changed service spec.

### TkgServiceConfiguration Specification

The `TkgServiceConfiguration` specification provides fields for configuring the Tanzu Kubernetes Grid Service instance.

```
apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TkgServiceConfiguration
metadata:
  name: tkg-service-configuration-example
spec:
  defaultCNI: <antrea or calico>
  proxy:
    httpProxy: http://<user>:<pwd>@<ip>:<port>
    httpsProxy: http://<user>:<pwd>@<ip>:<port>
    noProxy: [<array of CIDRs to not proxy>]
  trust:
    additionalTrustedCAs:
      - name: <first-cert-name>
        data: <base64-encoded string of a PEM encoded public cert 1>
      - name: <second-cert-name>
        data: <base64-encoded string of a PEM encoded public cert 2>
```

### TkgServiceConfiguration Specification Parameters

The table lists and describes each of the `TkgServiceConfiguration` specification parameters. For examples, see [Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API](#).

Field	Value	Description
defaultCNI	antrea or calico	Default CNI for clusters to use. The default is antrea. The other supported CNI is calico.
proxy	Section marker for proxy parameters.	The proxy parameters are httpProxy, httpsProxy, and noProxy. All parameters are required. If any proxy parameter is missing, you cannot create Tanzu Kubernetes clusters.



Field	Value	Description
httpProxy	URI in the form <code>http://&lt;user&gt;:&lt;pwd&gt;@&lt;ip&gt;:&lt;port&gt;</code>	Does not allow the <code>https</code> protocol. If <code>https</code> is used, you cannot create Tanzu Kubernetes clusters.
httpsProxy	URI in the form <code>http://&lt;user&gt;:&lt;pwd&gt;@&lt;ip&gt;:&lt;port&gt;</code>	Does not allow the <code>https</code> protocol. If <code>https</code> is used, you cannot create Tanzu Kubernetes clusters.
noProxy	<p>Array of CIDR blocks to not proxy, for example:  <code>[10.246.0.0/16,192.168.144.0/20,192.168.128.0/20]</code>.</p> <p>Get the required values from the Workload Network on the Supervisor Cluster: Pod CIDRs, Ingress CIDRs, and Egress CIDRs.</p> <p>Refer to the image below for what values to include in the <code>noProxy</code> array field.</p>	<p>You must not proxy the subnets used by the Workload Network on the Supervisor Cluster for Pods, Ingress, and Egress.</p> <p>You do not need to include the Services CIDR from the Supervisor Cluster in the <code>noProxy</code> field. Tanzu Kubernetes clusters do not interact with such services.</p> <p>The endpoints <code>localhost</code> and <code>127.0.0.1</code> are automatically not proxied. You do not need to add them to the <code>noProxy</code> field.</p> <p>The Pod and Service CIDRs for Tanzu Kubernetes clusters are automatically not proxied. You do not need to add them to the <code>noProxy</code> field.</p>
trust	Section marker for <code>trust</code> parameters.	Accepts no data.
additionalTrustedCAs	Accepts an array of certificates with <code>name</code> and <code>data</code> for each.	Accepts no data.
name	String	The name of the TLS certificate.
data	String	The base64-encoded string of a PEM encoded public certificate.

Get the required `noProxy` values from the **Workload Network** on the Supervisor Cluster as shown in the image.

The screenshot shows the configuration page for a compute cluster, specifically the 'Network' settings. The left sidebar contains a navigation menu with categories like Services, Configuration, Licensing, Namespaces, and vSAN. The 'Network' option is selected. The main content area displays the following network settings:

Management Network	
Workload Network	
vSphere Distributed Switch	wcp_vds_1
Edge Cluster	EDGECLUSTER1
DNS Servers	10.20.145.1 <a href="#">EDIT</a>
Pod CIDRs	10.246.0.0/16 <a href="#">EDIT</a>
Services CIDR	10.94.0.0/12
Ingress CIDRs	192.168.144.0/20 <a href="#">EDIT</a>
Egress CIDRs	192.168.128.0/20 <a href="#">EDIT</a>

## When To Use Global or Per-Cluster Configuration Options

The `TkgServiceConfiguration` is a global specification that impacts all Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service instance.

Before editing the `TkgServiceConfiguration` specification, be aware of the per-cluster alternatives that might satisfy your use case instead of a global configuration.

**Table 13-5. Global vs. Per-Cluster Configuration Options**

Setting	Global Option	Per-Cluster Option
Default CNI	Edit the <code>TkgServiceConfiguration</code> spec. See <a href="#">Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API</a> .	Specify the CNI in the cluster specification. For example, Antrea is the default CNI. To use Calico, specify it in the cluster YAML. See <a href="#">Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API</a>
Proxy Server	Edit the <code>TkgServiceConfiguration</code> spec. See <a href="#">Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API</a> .	Include the proxy server configuration parameters in the cluster spec. See <a href="#">Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API</a> .
Trust Certificates	Edit the <code>TkgServiceConfiguration</code> spec. There are two use cases: configuring an external container registry and certificate-based proxy configuration. See <a href="#">Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API</a>	Yes, you can include custom certificates on a per-cluster basis or override the globally-set <code>trust</code> settings in the cluster specification. See <a href="#">Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API</a> .

---

**Note** If a global proxy is configured on the `TkgServiceConfiguration`, that proxy information is propagated to the cluster manifest after the initial deployment of the cluster. The global proxy configuration is added to the cluster manifest only if there is no proxy configuration fields present when creating the cluster. In other words, per-cluster configuration takes precedence and will overwrite a global proxy configuration. For more information, see [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#).

---

Before editing the `TkgServiceConfiguration` specification, be aware of the ramifications of applying the setting at the global level.

Field	Applied	Impact on Existing Clusters If Added/ Changed	Per-Cluster Overriding on Cluster Creation	Per-Cluster Overriding on Cluster Update
defaultCNI	Globally	None	Yes, you can override the global setting on cluster creation	No, you cannot change the CNI for an existing cluster; if you used the globally set default CNI on cluster creation, it cannot be changed
proxy	Globally	None	Yes, you can override the global setting on cluster creation	Yes, with U2+, you can override the global setting on cluster update
trust	Globally	None	Yes, you can override the global setting on cluster creation	Yes, with U2+, you can override the global setting on cluster update

## Propagating Global Configuration Changes to Existing Clusters

Settings made at the global level in the `TkgServiceConfiguration` are not automatically propagated to existing clusters. For example, if you make a changes to either the `proxy` or the `trust` settings in the `TkgServiceConfiguration`, such changes will not affect clusters that are already provisioned.

To propagate a global change to an existing cluster, you must patch the Tanzu Kubernetes cluster to make the cluster inherit the changes made to the `TkgServiceConfiguration`.

For example:

```
kubectl patch tkc <CLUSTER_NAME> -n <NAMESPACE> --type merge -p "{\"spec\":{\"settings\":{\"network\":{\"proxy\": null}}}}"
```

```
kubectl patch tkc <CLUSTER_NAME> -n <NAMESPACE> --type merge -p "{\"spec\":{\"settings\":{\"network\":{\"trust\": null}}}}"
```

## Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API

Refer to the examples to customize the Tanzu Kubernetes Grid Service with global configuration settings for the container network interface, proxy server, and TLS certificates.

## About Configuring the Tanzu Kubernetes Grid Service

You can customize the Tanzu Kubernetes Grid Service by changing the default CNI, adding a global proxy server, and adding trusted certificates. See [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#).

---

**Caution** Editing the Tanzu Kubernetes Grid Service specification results in global changes to all clusters provisioned by that service, including new clusters and existing clusters that are upgraded manually or automatically.

---

### Prerequisite: Configure Kubectl Editing

To scale a Tanzu Kubernetes cluster, you update the cluster manifest using the command `kubectl edit tanzukubernetescluster/CLUSTER-NAME`. The `kubectl edit` command opens the cluster manifest in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable. For instructions on setting up the environment variable, see [Specify a Default Text Editor for Kubectl](#).

When you save the specification changes, `kubectl` reports that the edits were successfully recorded. To cancel, simply close the editor without saving.

### Configure the Default CNI

The Tanzu Kubernetes Grid Service provides a default container network interface (CNI) for Tanzu Kubernetes clusters. The default configuration lets you create clusters without the need to specify the CNI. You can change the default CNI by editing the service specification.

The Tanzu Kubernetes Grid Service supports two CNIs: Antrea and Calico, with Antrea being the default. For more information, see [Tanzu Kubernetes Cluster Networking](#).

You can override the default CNI by explicitly specifying the CNI to use. Alternatively, you can change the default CNI by editing the TKG Service controller for CNIs.

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the target vSphere Namespace.

```
kubectl config use-context tkgs-cluster-ns
```

- 3 List the default CNI.

```
kubectl get tkgserviceconfigurations
```

Example result:

```
NAME                                DEFAULT CNI
tkg-service-configuration           antrea
```

- 4 Load for editing the Tanzu Kubernetes Grid Service specification.

```
kubectl edit tkgserviceconfigurations tkg-service-configuration
```

The system opens the `tkg-service-configuration` specification in the default text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable.

- 5 Edit the `spec.defaultCNI` value.

For example, change from:

```
spec:
  defaultCNI: antrea
```

Change to:

```
spec:
  defaultCNI: calico
```

- 6 To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the change in the text editor, `kubectl` updates the `tkg-service-configuration` service specification.

- 7 Verify that the default CNI is updated.

```
kubectl get tkgserviceconfigurations
```

The default CNI is updated. Any cluster provisioned with default network settings uses the default CNI.

NAME	DEFAULT CNI
tkg-service-configuration	calico

## Configure a Global Proxy Server

To enable a global proxy server, add the proxy server parameters to the `TkgServiceConfiguration`. For a description of the required fields, see [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#).

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the target vSphere Namespace.

```
kubectl config use-context tkgs-cluster-ns
```

### 3 Get the current configuration.

```
kubectl get tkgserviceconfigurations
```

Example result:

NAME	DEFAULT CNI
tkg-service-configuration	antrea

### 4 Load for editing the Tanzu Kubernetes Grid Service specification.

```
kubectl edit tkgserviceconfigurations tkg-service-configuration
```

The system opens the `tkg-service-configuration` specification in the default text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable.

### 5 Add the `spec.proxy` subsection with each required field, including `httpProxy`, `httpsProxy`, and `noProxy`.

```
apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TkgServiceConfiguration
metadata:
  ...
  name: tkg-service-configuration-example
  resourceVersion: "44170525"
  selfLink: /apis/run.tanzu.vmware.com/v1alpha1/tkgserviceconfigurations/tkg-service-configuration
  uid: 10347195-5f0f-490e-8ae1-a758a724c0bc
spec:
  defaultCNI: antrea
  proxy:
    httpProxy: http://<user>:<pwd>@<ip>:<port>
    httpsProxy: http://<user>:<pwd>@<ip>:<port>
    noProxy: [SVC-POD-CIDRs, SVC-EGRESS-CIDRs, SVC-INGRESS-CIDRs]
```

### 6 Populate each proxy field with the appropriate values. For a description of each field, see [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#).

The required values for the `noProxy` field come from the **Workload Network** on the Supervisor Cluster. Refer to the picture at the above topic on where to get these values.

For example:

```
apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TkgServiceConfiguration
metadata:
  ...
  name: tkg-service-configuration-example
  resourceVersion: "44170525"
  selfLink: /apis/run.tanzu.vmware.com/v1alpha1/tkgserviceconfigurations/tkg-service-
```

```

configuration
  uid: 10347195-5f0f-490e-8ae1-a758a724c0bc
spec:
  defaultCNI: antrea
  proxy:
    httpProxy: http://user:password@10.186.102.224:3128
    httpsProxy: http://user:password@10.186.102.224:3128
    noProxy: [10.246.0.0/16,192.168.144.0/20,192.168.128.0/20]

```

- 7 To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the changes in the text editor, kubectl updates Tanzu Kubernetes Grid Service with the configuration defined in the `tkg-service-configuration` service specification.

- 8 Verify that the Tanzu Kubernetes Grid Service is updated with the proxy settings.

```
kubectl get tkgserviceconfigurations -o yaml
```

- 9 To verify, provision a Tanzu Kubernetes cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).

Use the following command to confirm that the cluster is using the proxy.

```
kubectl get tkc CLUSTER-NAME -n NAMESPACE -o yaml
```

## Certificate-Based Proxy Configuration

Using a proxy server to route internet traffic is a hard requirement for some environments. For example, a company in a highly regulated industry such as a financial institution requires all internet traffic go through a corporate proxy.

You can configure the Tanzu Kubernetes Grid Service to provision Tanzu Kubernetes clusters to use a proxy server for outbound HTTP/S traffic. For more information, see [Configuration Parameters for the Tanzu Kubernetes Grid Service v1alpha1 API](#).

As shown in the example, you can add trusted certificates for the proxy server to the `TkgServiceConfiguration` specification.

```

apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TkgServiceConfiguration
metadata:
  name: tkg-service-configuration-example
spec:
  defaultCNI: antrea
  proxy:
    httpProxy: http://user:password@10.186.102.224:3128
    httpsProxy: http://user:password@10.186.102.224:3128
    noProxy: [10.246.0.0/16,192.168.144.0/20,192.168.128.0/20]
  trust:
    additionalTrustedCAs:

```



```

- name: first-cert-name
  data: base64-encoded string of a PEM encoded public cert 1
- name: second-cert-name
  data: base64-encoded string of a PEM encoded public cert 2

```

## External Private Registry Configuration

You can configure the Tanzu Kubernetes Grid Service with custom certificates for connecting Tanzu Kubernetes clusters with an external private registry. For more information, see [Use an External Container Registry with Tanzu Kubernetes Clusters](#).

```

apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TkgServiceConfiguration
metadata:
  name: tkg-service-configuration-example
spec:
  defaultCNI: antrea
  trust:
    additionalTrustedCAs:
      - name: harbor-vm-cert
        data: <<<base64-encoded string of a PEM encoded public cert>>>>

```

## Scale a Tanzu Kubernetes Cluster Using the Tanzu Kubernetes Grid Service v1alpha1 API

You can scale a Tanzu Kubernetes cluster horizontally by changing the number of nodes or vertically by changing the virtual machine class hosting the nodes.

### Supported Scaling Operations

The table lists the supported scaling operations for Tanzu Kubernetes clusters.

**Table 13-6. Supported Scaling Operations for Tanzu Kubernetes Clusters**

Node	Horizontal Scale Out	Horizontal Scale In	Vertical Scale
Control Plane	Yes	No	Yes
Worker	Yes	Yes	Yes

Keep in mind the following considerations:

- While vertically scaling a cluster node, workloads may no longer be able to run on the node for lack of available resource. For this reason horizontal scaling may be the preferred approach.
- VM classes are not immutable. If you scale out a Tanzu Kubernetes cluster after editing a VM class used by that cluster, new cluster nodes use the updated class definition, but existing cluster nodes continue to use the initial class definition, resulting in a mismatch. See [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).

## Scaling Prerequisite: Configure Kubectl Editing

To scale a Tanzu Kubernetes cluster, you update the cluster manifest using the command `kubectl edit tanzukubernetescluster/CLUSTER-NAME`. The `kubectl edit` command opens the cluster manifest in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable. For instructions on setting up the environment variable, see [Specify a Default Text Editor for Kubectl](#).

When you save the manifest changes, `kubectl` reports that the edits were successfully recorded, and the cluster is updated with the changes.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
tanzukubernetescluster.run.tanzu.vmware.com/tkgs-cluster-1 edited
```

To cancel, simply close the editor without saving.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
Edit cancelled, no changes made.
```

## Scale Out the Control Plane

You can scale out a Tanzu Kubernetes cluster by increasing number of control plane nodes from 1 to 3. The number of control plane nodes must be odd. You cannot scale in the control plane.

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the vSphere Namespace where the Tanzu Kubernetes cluster is running.

```
kubectl config use-context tkgs-cluster-ns
```

- 3 List the Kubernetes clusters that are running in the namespace.

```
kubectl get tanzukubernetescluster -n tkgs-cluster-ns
```

- 4 Get the number of nodes running in the target cluster.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

For example, the following cluster has 1 control plane nodes and 3 worker nodes.

NAME	CONTROL PLANE	WORKER	DISTRIBUTION	AGE	PHASE
tkgs-cluster-1	1	3	v1.18.5+vmware.1-tkg.1.886c781	1d	running

- 5 Load the cluster manifest for editing using the `kubectl edit` command.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
```

The cluster manifest opens in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variables.

- 6 Locate the `spec.topology.controlPlane.count` parameter and increase the number of nodes from 1 to 3.

```
...
controlPlane:
  count: 1
...
```

```
...
ControlPlane:
  count: 3
...
```

- 7 To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the file, `kubectl` applies the changes to the cluster. In the background, the Virtual Machine Service on the Supervisor Cluster provisions the new worker node.

- 8 Verify that the new nodes are added.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

The scaled out control plane now has 3 nodes.

NAME	CONTROL PLANE	WORKER	DISTRIBUTION	AGE	PHASE
tkgs-cluster-1	3	3	v1.18.5+vmware.1-tkg.1.886c781	1d	running

## Scale Out Worker Nodes

You can scale out a Tanzu Kubernetes cluster by increasing the number of worker nodes using `kubectl`.

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the vSphere Namespace where the Tanzu Kubernetes cluster is running.

```
kubectl config use-context tkgs-cluster-ns
```

- 3 List the Kubernetes clusters that are running in the namespace.

```
kubectl get tanzukubernetescluster -n tkgs-cluster-ns
```

- 4 Get the number of nodes running in the target cluster.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

For example, the following cluster has 3 control plane nodes and 3 worker nodes.

NAME	CONTROL PLANE	WORKER	DISTRIBUTION	AGE	PHASE
tkgs-cluster-1	3	3	v1.18.5+vmware.1-tkg.1.886c781	1d	running

- 5 Load the cluster manifest for editing using the `kubectl edit` command.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
```

The cluster manifest opens in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variables.

- 6 Locate the `spec.topology.workers.count` parameter and increase the number of nodes.

```
...
workers:
  count: 3
...
```

```
...
workers:
  count: 4
...
```

- 7 To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the file, `kubectl` applies the changes to the cluster. In the background, the Virtual Machine Service on the Supervisor Cluster provisions the new worker node.

- 8 Verify that the new worker node is added.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

After scaling out, the cluster has 4 worker nodes.

NAME	CONTROL PLANE	WORKER	DISTRIBUTION	AGE	PHASE
tkgs-cluster-1	3	4	v1.18.5+vmware.1-tkg.1.886c781	1d	running

## Scale In Worker Nodes

You can scale in a Tanzu Kubernetes cluster by decreasing the number of worker nodes. Scaling in the control plane is not supported.

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- Switch context to the vSphere Namespace where the Tanzu Kubernetes cluster is running.

```
kubectl config use-context tkgs-cluster-ns
```

- List the Kubernetes clusters that are running in the namespace.

```
kubectl get tanzukubernetescluster -n tkgs-cluster-ns
```

- Get the number of nodes running in the target cluster.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

For example, the following cluster has 3 control plane nodes and 3 worker nodes.

NAME	CONTROL PLANE	WORKER	DISTRIBUTION	AGE	PHASE
tkgs-cluster-1	3	4	v1.18.5+vmware.1-tkg.1.886c781	1d	running

- Load the cluster manifest for editing using the `kubectl edit` command.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
```

The cluster manifest opens in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variables.

- Locate the `spec.topology.workers.count` parameter and increase the number of nodes.

```
...
workers:
  count: 4
...
```

```
...
workers:
  count: 2
...
```

- To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the file, `kubectl` applies the changes to the cluster. In the background, the Virtual Machine Service on the Supervisor Cluster provisions the new worker node.

- Verify that the worker nodes were removed.

```
kubectl get tanzukubernetescluster tkgs-cluster-1
```

After scaling in, the cluster has 2 worker nodes.

NAME	CONTROL PLANE	WORKER	DISTRIBUTION	AGE	PHASE
tkgs-cluster-1	3	2	v1.18.5+vmware.1-tkg.1.886c781	1d	running

## Scale a Cluster Vertically

You can vertically scale a Tanzu Kubernetes cluster by changing the virtual machine class used to host the cluster nodes. Vertical scaling is supported for both control plane and worker nodes.

The Tanzu Kubernetes Grid Service supports scaling cluster nodes vertically through the rolling update mechanism built into the service. If you change the `VirtualMachineClass` definition, the service rolls out new nodes with that new class and spins down the old nodes. See [Update Tanzu Kubernetes Clusters](#).

- 1 Authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=SVC-IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the vSphere Namespace where the Tanzu Kubernetes cluster is running.

```
kubectl config use-context tkgs-cluster-ns
```

- 3 List the Kubernetes clusters that are running in the namespace.

```
kubectl get tanzukubernetescluster -n tkgs-cluster-ns
```

- 4 Describe the target Tanzu Kubernetes cluster and check the VM class.

```
kubectl describe tanzukubernetescluster tkgs-cluster-2
```

For example, the following cluster is using the best-effort-small VM class.

```
Spec:
  ...
  Topology:
    Control Plane:
      Class:          best-effort-small
      ...
    Workers:
      Class:          best-effort-small
      ...
```

- 5 List and describe the available VM classes.

```
kubectl get virtualmachineclassbinding
```

```
kubectl describe virtualmachineclassbinding
```

---

**Note** The VM class you want to use must be bound the vSphere Namespace. See [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).

---

- 6 Open for editing the target cluster manifest.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-2
```

The cluster manifest opens in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variables.

- 7 Edit the manifest by changing the VM class.

For example, edit the cluster manifest to use the `guaranteed-xlarge` VM class for control plane and worker nodes.

```
spec:
  topology:
    controlPlane:
      class: guaranteed-xlarge
      ...
    workers:
      class: guaranteed-xlarge
      ...
```

- 8 To apply the changes, save the file in the text editor. To cancel, close the editor without saving.

When you save the file, `kubectl` applies the changes to the cluster. In the background, the Tanzu Kubernetes Grid Service provisions the new nodes and deletes the old ones. For a description of the rolling update process, see [About Tanzu Kubernetes Cluster Updates](#).

- 9 Verify that the cluster is being updated.

```
kubectl get tanzukubernetescluster
NAME                CONTROL PLANE  WORKER  DISTRIBUTION                                AGE   PHASE
tkgs-cluster-1     3              3      v1.18.5+vmware.1-tkg.1.c40d30d          21h   updating
```

## Delete a Tanzu Kubernetes Cluster

Use `kubectl` to delete a Tanzu Kubernetes cluster provisioned by the Tanzu Kubernetes Grid Service.

When you delete a Tanzu Kubernetes cluster using `kubectl`, Kubernetes garbage collection ensures that all dependent resources are deleted.

---

**Note** Do not attempt to delete a Tanzu Kubernetes cluster using the vSphere Client or the vCenter Server CLI.

---

### Procedure

- 1 Authenticate with the Supervisor Cluster.

See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

- 2 Change context to the vSphere Namespace where the Tanzu Kubernetes you want to delete is provisioned.

```
kubectl config use-context CLUSTER-NAMESPACE
```

For example:

```
kubectl config use-context tkgs-ns-1
```

- 3 List the Tanzu Kubernetes clusters in the namespace.

```
kubectl get clusters
```

For example:

```
kubectl get clusters
NAME              PHASE
tkgs-cluster-1    provisioned
```

- 4 Delete the Tanzu Kubernetes cluster using the following syntax.

```
kubectl delete tanzukubernetescluster --namespace CLUSTER-NAMESPACE CLUSTER-NAME
```

For example:

```
kubectl delete tanzukubernetescluster --namespace tkgs-ns-1 tkgs-cluster-1
```

Expected result:

```
tanzukubernetescluster.run.tanzu.vmware.com "tkgs-cluster-1" deleted
```

- 5 Verify that the cluster is deleted.

```
kubectl get clusters
```

For example:

```
kubectl get clusters
No resources found in tkgs-ns-1 namespace.
```

- 6 Delete the cluster context from the kubeconfig file.

```
kubectl config delete-context CONTEXT
```

For example:

```
kubectl config get-contexts
CURRENT  NAME              CLUSTER          AUTHINFO
NAMESPACE
```



```

192.0.2.1      192.0.2.1      wcp:192.0.2.1:administrator@vsphere.local
tkgs-cluster-1 192.0.2.6      wcp:192.0.2.6:administrator@vsphere.local
*            tkgs-ns-1      192.0.2.7      wcp:192.0.2.7:administrator@vsphere.local
tkgs-ns-1

```

```

kubectl config delete-context tkgs-cluster-1
deleted context tkgs-cluster-1 from $HOME/.kube/config

```

```

kubectl config get-contexts
CURRENT  NAME              CLUSTER          AUTHINFO
NAMESPACE
          192.0.2.1         192.0.2.1        wcp:192.0.2.1:administrator@vsphere.local
*        tkgs-ns-1         192.0.2.7        wcp:192.0.2.7:administrator@vsphere.local
tkgs-ns-1

```

## Specify a Default Text Editor for Kubectl

To help you provision, operate, and maintain Tanzu Kubernetes clusters, specify a default text editor for kubectl .

### Purpose

After you provision a Tanzu Kubernetes cluster you need to maintain it. Typical maintenance tasks include upgrading the Kubernetes version and scaling cluster nodes. To perform such tasks you update the cluster manifest.

The most convenient way to update the manifest for a provisioned cluster is to use the [kubectl edit command](#). This command opens the Kubernetes manifest in a text editor of your choice. When you save the changes, Kubernetes automatically applies the changes and updates the cluster.

To use the `kubectl edit` command, create a `KUBE_EDITOR` environment variable and specify your preferred text editor as the variable value. In addition, append the watch flag (`-w`) to the value so that kubectl knows when you have committed (saved) your changes.

### Windows

On Windows, create a system environment variable named `KUBE_EDITOR` with the value set to the path of your preferred text editor. Append the watch flag (`-w`) to the value.

For example, the following environment variable sets Visual Studio Code as the default text editor for kubectl and includes the watch flag so that Kubernetes knows when you save your changes:

```
KUBE_EDITOR=code -w.
```

## Mac OS

On Mac OS, create an environment variable named `KUBE_EDITOR` with the value set to the path of your preferred text editor. Append the watch flag (`-w`) to the value so that `kubectl` knows when you have committed (saved) your changes.

For example, the following addition to the `.bash_profile` sets Sublime as the default text editor for `kubectl` and includes the watch flag so `kubectl` knows when you have saved any changes.

```
export KUBE_EDITOR="/Applications/Sublime.app/Contents/SharedSupport/bin/subl-w"
```

## Linux

On Linux (Ubuntu, for example), typically the default command-line `EDITOR` is Vim. If so, no further action is needed to use the `kubectl edit` command. If you want to use a different editor, create an environment variable named `KUBE_EDITOR` with the value set to the path of your preferred text editor.

## Monitor Tanzu Kubernetes Cluster Status Using `kubectl`

You can monitor the status of provisioned Tanzu Kubernetes clusters using `kubectl`.

### Procedure

- 1 Authenticate with the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).
- 2 Switch to the vSphere Namespace where the cluster is running.

```
kubectl config use-context SUPERVISOR-NAMESPACE
```

- 3 View a list of the Tanzu Kubernetes clusters running in the namespace.

```
kubectl get tanzukubernetesclusters
```

This command returns the status of the cluster. For a description of the status fields, see [Tanzu Kubernetes Cluster Lifecycle Status in `kubectl`](#).

- 4 View the details of the cluster.

```
kubectl describe tanzukubernetescluster <cluster-name>
```

The command returns the details of the cluster. In the Status section of the command output, you see detailed information about the cluster.

```
...
Status:
  Addons:
    Cni:
      Name:    calico
```

```

    Status:  applied
  Csi:
    Name:    pvcsi
    Status:  applied
  Psp:
    Name:    defaultpsp
    Status:  applied
  Cloudprovider:
    Name:    vmware-guest-cluster
  Cluster API Status:
  API Endpoints:
    Host:    10.161.90.22
    Port:    6443
  Phase:    provisioned
  Node Status:
    test-tanzu-cluster-control-plane-0:          ready
    test-tanzu-cluster-workers-0-749458f97c-971jv:  ready
  Phase:                                          running
  Vm Status:
    test-tanzu-cluster-control-plane-0:          ready
    test-tanzu-cluster-workers-0-749458f97c-971jv:  ready
  Events:                                        <none>

```

- 5 Run additional `kubectl` commands to view more details about the cluster. See [Use Tanzu Kubernetes Cluster Operational Commands](#).

## Monitor Tanzu Kubernetes Cluster Status Using the vSphere Client

You can monitor the status of Tanzu Kubernetes clusters using the vSphere Client.

### Procedure

- 1 Log in to the vCenter Server using the vSphere Client.
- 2 From the **Menu**, select the **Hosts and Clusters** view.
- 3 Expand the **Datacenter > Cluster** objects where the Supervisor Cluster is created.
- 4 Expand the **Namespaces** resource pool.
- 5 Select the vSphere Namespace where you have deployed the Tanzu Kubernetes cluster.

Each Tanzu Kubernetes cluster is listed as a folder within its namespace resource pool. Each Tanzu Kubernetes is graphically represented by the three hexagon icons beside its name.

- 6 Switch to the **Menu > VMs and Templates** view.

Within the cluster folder, you see the VMs that comprise the cluster nodes.

- 7 Select the vSphere Namespace, and then select the **Compute** tab.

## 8 Under **VMware Resources**, select **Tanzu Kubernetes**.

Each Tanzu Kubernetes cluster deployed in this vSphere Namespace is listed. For a description of each status field, see [Tanzu Kubernetes Cluster Lifecycle Status in vSphere](#).

## Check Tanzu Kubernetes Cluster Readiness

When the Tanzu Kubernetes Grid Service provisions a Tanzu Kubernetes cluster, several status conditions are reported that you can use to get direct insight into key aspects of machine health.

### Check TanzuKubernetesCluster Readiness

You can use the TanzuKubernetesCluster readiness conditions to determine which, if any, phase or component is not ready. See [ControlPlaneReady Condition and Reasons](#).

Once you check for cluster readiness, to diagnose further you can use capwcluster and machine conditions to look further in more detail failure. See [Check Tanzu Kubernetes Machine Health](#) and [Check Tanzu Kubernetes Cluster Health](#).

To check the readiness of a Tanzu Kubernetes cluster:

- 1 Log in to the Supervisor Cluster.
- 2 Switch context to the namespace where the target cluster is provisioned. For example:

```
kubectl config use-context tkgs-cluster-ns
```

- 3 Run the command `kubectl get tkc -o yaml`. The system displays the cluster readiness conditions. For example:

```
status:
  addons:
    authsvc:
      conditions:
        - lastTransitionTime: "2021-01-30T19:53:54Z"
          status: "True"
          type: AuthServiceProvisioned
      name: authsvc
      status: applied
      version: 0.1-66-g8b8f07f
    cloudprovider:
      conditions:
        - lastTransitionTime: "2021-01-30T19:53:53Z"
          status: "True"
          type: CPIProvisioned
      name: vmware-guest-cluster
      status: applied
      version: 0.1-77-g5875817
    cni:
      conditions:
        - lastTransitionTime: "2021-01-30T19:53:53Z"
          status: "True"
```

```

    type: CNIProvisioned
    name: calico
    status: applied
    version: 1.16.14+vmware.1-tkg.1.ada4837
csi:
  conditions:
  - lastTransitionTime: "2021-01-30T19:53:54Z"
    status: "True"
    type: CSIProvisioned
  name: pvcsi
  status: applied
  version: v0.0.1.alpha+vmware.79-7ecdcbl
dns:
  conditions:
  - lastTransitionTime: "2021-01-30T19:53:48Z"
    status: "True"
    type: CoreDNSProvisioned
  name: CoreDNS
  status: applied
  version: v1.6.2_vmware.10
proxy:
  conditions:
  - lastTransitionTime: "2021-01-30T19:53:48Z"
    status: "True"
    type: KubeProxyProvisioned
  name: kube-proxy
  status: applied
  version: 1.16.14+vmware.1
psp:
  conditions:
  - lastTransitionTime: "2021-01-30T19:53:47Z"
    status: "True"
    type: PSPProvisioned
  name: defaultpsp
  status: applied
  version: v1.16.14+vmware.1-tkg.1.ada4837
clusterApiStatus:
  apiEndpoints:
  - host: 192.168.1.2
    port: 6443
  phase: Provisioned
  conditions:
  - lastTransitionTime: "2021-01-30T19:53:54Z"
    status: "True"
    type: AddonsReady
  - lastTransitionTime: "2021-01-30T19:51:11Z"
    status: "True"
    type: ControlPlaneReady
  - lastTransitionTime: "2021-01-30T19:51:04Z"
    message: 3/3 Control Plane Node(s) healthy. 1/1 Worker Node(s) healthy
    status: "True"
    type: NodesHealthy
  - lastTransitionTime: "2021-01-31T21:22:45Z"
    status: "True"
    type: ProviderServiceAccountsReady

```

```

- lastTransitionTime: "2021-01-30T19:53:50Z"
  status: "True"
  type: RoleBindingSynced
- lastTransitionTime: "2021-01-30T19:53:58Z"
  status: "True"
  type: ServiceDiscoveryReady
- lastTransitionTime: "2021-01-30T19:53:59Z"
  status: "True"
  type: StorageClassSynced
- lastTransitionTime: "2021-01-27T11:34:53Z"
  status: "True"
  type: TanzuKubernetesReleaseCompatible
- lastTransitionTime: "2021-01-27T11:34:54Z"
  message: '[1.17.13+vmware.1-tkg.2.2c133ed]'
  severity: Info
  status: "True"
  type: UpdatesAvailable

```

## ControlPlaneReady Condition and Reasons

The table lists and describes the `ControlPlaneReady` condition.

**Table 13-7. ControlPlaneReady Condition**

Condition Type	Description
<code>ControlPlaneReady</code>	Reports if the control plane nodes are ready and functional for the cluster.

The table lists and describes the reasons why the `ControlPlaneReady` condition may be false.

**Table 13-8. ControlPlaneReady False Reasons**

Reason	Severity	Description
<code>WaitingForClusterInfrastructure</code>		Indicates that the cluster is waiting for prerequisites that are necessary for running machines, such as a load balancer. This reason is only used if the <code>InfrastructureCluster</code> is not reporting its own ready condition.
<code>WaitingForControlPlaneInitialized</code>		Indicates that the first control plane node is initializing.
<code>WaitingForControlPlane</code>		Reflects the condition of <code>KubeadmControlPlane</code> . This reason is used if the <code>KubeadmControlPlane</code> is not reporting its own ready condition.
Waiting for cluster infrastructure to be ready	Message	Indicates that the cluster is waiting for prerequisites that are necessary for running machines, such as networking and load balancers.

## NodesHealthy Condition and Reasons

The table lists and describes the `NodesHealthy` condition.

**Table 13-9. NodesHealthy Condition**

Condition Type	Description
<code>NodesHealthy</code>	Reports the status of <code>TanzuKubernetesCluster</code> nodes.

The table lists and describes the reason for the `NodesHealthy` condition not being true.

**Table 13-10. NodesHealthy False Reason**

Reason	Severity	Description
<code>WaitingForNodesHealthy</code>		Documents that not all the Nodes are healthy.

## Addons Conditions and Reasons

The table lists and describes the conditions related to cluster addon components.

**Table 13-11. Addons Conditions**

Condition Type	Description
<code>AddonsReady</code>	Summary of conditions for <code>TanzuKubernetesCluster</code> addons (CoreDNS, KubeProxy, CSP, CPI, CNI, AuthSvc) .
<code>CNIProvisioned</code>	Documents the status of <code>TanzuKubernetesCluster</code> container network interface (CNI) addon.
<code>CSIProvisioned</code>	Documents the status of <code>TanzuKubernetesCluster</code> container storage interface (CSI) addon.
<code>CPIProvisioned</code>	Documents the status of <code>TanzuKubernetesCluster</code> cloud provider interface (CPI) addon.
<code>KubeProxyProvisioned</code>	Documents the status of <code>TanzuKubernetesCluster</code> KubeProxy addon.
<code>CoreDNSProvisioned</code>	Documents the status of <code>TanzuKubernetesCluster</code> CoreDNS addon.
<code>AuthServiceProvisioned</code>	Documents the status of <code>TanzuKubernetesCluster</code> AuthService addon.
<code>PSPProvisioned</code>	Documents the status of PodSecurityPolicy.

The table lists and describes the reasons addon conditions not being true.

Table 13-12. Addons False Reasons

Reason	Severity	Description
AddonsReconciliationFailed		Summarized reason for all addons reconciliation failures.
CNIProvisioningFailed	Warning	Documents CNI addon failed to create or update.
CSIProvisioningFailed	Warning	Documents CSI addon failed to create or update.
CPIProvisioningFailed	Warning	Documents CPI addon failed to create or update.
KubeProxyProvisioningFailed	Warning	Documents KubeProxy addon failed to create or update.
CoreDNSProvisioningFailed	Warning	Documents CoreDNS addon failed to create or update.
AuthServiceProvisioningFailed	Warning	Documents AuthService addon failed to create or update.
AuthServiceUnManaged		Documents AuthService is not managed by controller.
BSPProvisioningFailed	Warning	Documents PodSecurityPolicy addons failed to create or update.

## Other Conditions and Reasons

The table lists and describes conditions for StorageClass and RoleBinding synchronization, ProviderServiceAccount resource reconciliation, ServiceDiscovery, and TanzuKubernetesCluster compatibility.

Table 13-13. Other Conditions

Condition	Description
StorageClassSynced	Documents the status of StorageClass synchronization from Supervisor Cluster to workload cluster.
RoleBindingSynced	Documents the status of RoleBinding synchronization from the Supervisor Cluster to the workload cluster.
ProviderServiceAccountsReady	Documents the status of provider service accounts and related Roles, RoleBindings and Secrets are created.
ServiceDiscoveryReady	Documents the status of service discoveries.
TanzuKubernetesReleaseCompatible	Indicates if the TanzuKubernetesCluster is compatible with the TanzuKubernetesRelease.

The table lists and describes the reasons for other conditions not being true.



Table 13-14. Other Reasons

Reason	Severity	Description
StorageClassSyncFailed		Reports the StorageClass synchronization failed.
RoleBindingSyncFailed		Reports the RoleBinding synchronization failed.
ProviderServiceAccountsReconciliationFailed		Reports that provider service accounts related resources reconciliation failed.
SupervisorHeadlessServiceSetupFailed		Documents the headless service setup for Supervisor Cluster API server failed.

## Check Tanzu Kubernetes Cluster Health

When the Tanzu Kubernetes Grid Service provisions a Tanzu Kubernetes cluster, several status conditions are reported that you can use to get direct insight into key aspects of cluster health.

### About Cluster Health Conditions

A Tanzu Kubernetes cluster provisioned by the Tanzu Kubernetes Grid Service comprises several moving parts, all operated by independent but related controllers, working together to build and maintain a set of Kubernetes nodes. The `TanzuKubernetesCluster` object provides status conditions that give you with fine-grained information about cluster and machine health.

### Check Cluster Health

To check the health of a Tanzu Kubernetes cluster:

- 1 Run the command `kubectl describe cluster`.

If the status is ready, it means that both the cluster infrastructure and the cluster control plane are ready. For example:

```
Status:
Conditions:
  Last Transition Time:   2020-11-24T21:37:32Z
  Status:                True
  Type:                 Ready
  Last Transition Time:   2020-11-24T21:37:32Z
  Status:                True
  Type:                 ControlPlaneReady
  Last Transition Time:   2020-11-24T21:31:34Z
  Status:                True
  Type:                 InfrastructureReady
```

But, if a cluster condition is false, the cluster is not ready, and a message field describes what is wrong. For example, here is the status is False and because the infrastructure is not ready:

```
Status:
  Conditions:
    Last Transition Time: 2020-11-24T21:37:32Z
    Status:              False
    Type:               Ready
    Last Transition Time: 2020-11-24T21:37:32Z
    Status:              True
    Type:               ControlPlaneReady
    Last Transition Time: 2020-11-24T21:31:34Z
    Status:              False
    Type:               InfrastructureReady
```

- 2 If the cluster is not ready, run the following command to determine what is wrong with the cluster infrastructure:

```
kubect1 describe wcpcluster
```

## List of Cluster Health Conditions

The table lists and defines the available health conditions for a Tanzu Kubernetes cluster.

Condition	Description
Ready	Summarizes the operational state of a Cluster API object.
Deleting	The Status is not True because the underlying object is currently being deleted.
DeletionFailed	The Status is not True because the underlying object encountered problems during deletion. This is a warning because the reconciler will retry deletion.
Deleted	The Status is not True because the underlying object was deleted.
InfrastructureReady	Reports a summary of current status of the infrastructure object defined for this cluster.
WaitingForInfrastructure	Reported when a cluster is waiting for the underlying infrastructure to be available. NOTE: This condition is used as a fallback when the infrastructure is not reporting a ready state.
ControlPlaneReady	Reported when the cluster control plane is ready.
WaitingForControlPlane	Reported when a cluster is waiting for the control plane to be available. NOTE: This condition is used as a fallback when the control plane is not reporting a ready state.

## Condition Fields

Each condition may contain several fields.

Type	Describes the type of condition. For example, <code>ControlPlaneReady</code> . For the <code>Ready</code> condition, it is a summary of all the other conditions.
Status	Describes the status of the type. States can be <code>True</code> , <code>False</code> , or <code>Unknown</code> .
Severity	Classification of the <code>Reason</code> . <code>Info</code> means the reconciliation is happening. <code>Warning</code> means something might wrong and retry. <code>Error</code> means an error occurred and manual action is required to resolve.
Reason	Provides a reason why the status is <code>False</code> . It can be a waiting for ready or a failure reason. Usually is thrown when the status is <code>False</code> .
Message	Human readable information that explains the <code>Reason</code> .

## Check Tanzu Kubernetes Machine Health

When the Tanzu Kubernetes Grid Service provisions a Tanzu Kubernetes cluster, several status conditions are reported that you can use to get direct insight into key aspects of machine health.

### About Machine Health Conditions

A Tanzu Kubernetes cluster provisioned by the Tanzu Kubernetes Grid Service comprises several moving parts, all operated by independent but related controllers, working together to build and maintain a set of Kubernetes nodes. The `TanzuKubernetesCluster` object provides status conditions that give you with fine-grained information about machine health.

### Check Machine Health

To check the health of a Tanzu Kubernetes machine:

- 1 Run the command `kubectl describe machine`.

If the status is `ready`, the machine is healthy. But, if a machine condition is `false`, such as `InfrastructureReady`, the machine is not ready.

- 2 If the machine is not ready, run the following command and determine what is wrong with the infrastructure:

```
kubectl describe wcpmachine
```

### List of Machine Health Conditions

The table lists and defines the available machine health conditions for a Tanzu Kubernetes cluster.

Condition	Description
ResourcePolicyReady	Reports the successful creation of a Resource Policy.
ResourcePolicyCreationFailed	Reported when any errors occur during ResourcePolicy creation.
ClusterNetworkReady	Reports the successful provision of a Cluster Network.
ClusterNetworkProvisionStarted	Reported when waiting for Cluster Network to be Ready.
ClusterNetworkProvisionFailed	Reported when any errors occur during network provisioning.
LoadBalancerReady	Reports the successful reconciliation of a static control plane endpoint.
LoadBalancerCreationFailed	Reported when load balancer related resources creation fails.
WaitingForLoadBalancerIP	Reported when waiting for load balancer IP to exist.
VMProvisioned	Reports that a Virtual Machine is created, powered on and assigned an IP.
WaitingForBootstrapData	Reported when a vSphereMachine is waiting for the bootstrap script to be ready before starting the provisioning process.
VMCreationFailed	Reports that creating VM CRD or corresponding bootstrap ConfigMap failed.
VMProvisionStarted	Reported when a virtual machine currently is in creation process.
PoweringOn	Reported when a virtual machine is currently executing the power on sequence.
WaitingForNetworkAddress	Reported when waiting for the machine network settings to become active.
WaitingForBIOSUUID	Reported when waiting for the machine to have a BIOS UUID

## Condition Fields

Each condition may contain several fields.

Type	Describes the type of condition. For example, <code>ResourcePolicyReady</code> . For the <code>Ready</code> condition, it is a summary of all the other conditions.
Status	Describes the status of the type. States can be <code>True</code> , <code>False</code> , or <code>Unknown</code> .
Severity	Classification of the Reason. <code>Info</code> means the reconciliation is happening. <code>Warning</code> means something might wrong and retry. <code>Error</code> means an error occurred and manual action is required to resolve.

Reason	Provides a reason why the status is <code>False</code> . It can be a waiting for ready or a failure reason. Usually is thrown when the status is <code>False</code> .
Message	Human readable information that explains the <code>Reason</code> .

## Get Tanzu Kubernetes Cluster Secrets

Tanzu Kubernetes clusters use secrets to store tokens, keys, and passwords for operating Tanzu Kubernetes clusters.

### List of Tanzu Kubernetes Cluster Secrets

A Kubernetes secret is an object that stores a small amount of sensitive data such as a password, a token, or an SSH key. Tanzu Kubernetes cluster administrators might use several secrets while operating clusters. The table lists and describes key secrets cluster administrators might use.

**Note** The list is not exhaustive. It includes only those secrets that might need to be manually rotated or used to access cluster nodes for troubleshooting purposes.

Secret	Description
<code>TANZU-KUBERNETES-CLUSTER-NAME-ccm-token-RANDOM</code>	A service account token used by the paravirtual cloud provider's cloud controller manager to connect to the vSphere Namespace. To trigger rotation of this credential, delete the secret.
<code>TANZU-KUBERNETES-CLUSTER-NAME-pvcsi-token-RANDOM</code>	A service account token used by the paravirtual CSI plugin to connect to the vSphere Namespace. To trigger rotation of this credential, delete the secret. See <a href="#">How vSphere with Tanzu Integrates with vSphere Storage</a> .
<code>TANZU-KUBERNETES-CLUSTER-NAME-kubeconfig</code>	A kubeconfig file that can be used to connect to the cluster control plane as the <code>kubernetes-admin</code> user. This secret can be used access a cluster and troubleshoot it when vCenter Single Sign-On authentication is not available. See <a href="#">Connect to the Tanzu Kubernetes Cluster Control Plane as the Administrator</a> .
<code>TANZU-KUBERNETES-CLUSTER-NAME-ssh</code>	An SSH private key that can be used to connect to any cluster node as the <code>vmware-system-user</code> . This secret can be used to SSH to any cluster node and troubleshoot it. See <a href="#">SSH to Tanzu Kubernetes Cluster Nodes as the System User Using a Private Key</a> .
<code>TANZU-KUBERNETES-CLUSTER-NAME-ssh-password</code>	A password that can be used to connect to any cluster node as the <code>vmware-system-user</code> . See <a href="#">SSH to Tanzu Kubernetes Cluster Nodes as the System User Using a Private Key</a> .
<code>TANZU-KUBERNETES-CLUSTER-NAME-ca</code>	The root CA certificate for the Tanzu Kubernetes cluster control plane that is used by <code>kubectl</code> to securely connect to the Kubernetes API server.

## Use Tanzu Kubernetes Cluster Networking Commands

The Tanzu Kubernetes Grid Service provisions Tanzu Kubernetes clusters with default networking for nodes, pods, and services. You can verify cluster networking using custom kubectl commands.

### Custom Commands to Verify Tanzu Kubernetes Cluster Networking

Table 13-15. Custom kubectl Commands to Verify Cluster Networking

Command	Description
<code>kubectl get tkgserviceconfigurations</code>	Returns the default CNI, which is <code>antrea</code> unless changed. The default CNI is used for cluster creation unless explicitly overridden in the cluster YAML. To change the default CNI, see <a href="#">Examples for Configuring the Tanzu Kubernetes Grid Service v1alpha1 API</a> .
<code>kubectl get virtualnetwork -n NAMESPACE</code>	Returns the virtual network for cluster nodes. Use to verify that the source network address translation (SNAT) IP address is assigned.
<code>kubectl get virtualmachines -n NAMESPACE NODE-NAME</code>	Returns the virtual network interface for cluster nodes. Use to verify that the virtual machine for each cluster node has an IP address assigned.
<code>kubectl get virtualmachineservices -n NAMESPACE cluster-1-control-plane-service</code>	Returns the virtual machine service for each cluster node. Use to verify that the status is updated and includes the load balancer virtual IP (VIP) address.
<code>kubectl get services -n NAMESPACE</code>	Returns the Kubernetes service load balancer created for Cluster API access. Use to verify that an external IP is assigned. Use <code>curl</code> to verify access to the API using the external IP address and port of the load balancer service.
<code>curl -k https://EXTERNAL-IP:PORT/healthz</code>	
<code>kubectl get endpoints -n NAMESPACE cluster-1-control-plane-service</code>	Returns the control plane nodes (endpoints) for the cluster. Use to verify that each endpoint is created and included in the endpoint pool.

## Use Tanzu Kubernetes Cluster Operational Commands

You can manage Tanzu Kubernetes clusters using custom kubectl commands. These commands are made available by custom resources created by the Tanzu Kubernetes Grid Service.

### Custom Commands to Manage Tanzu Kubernetes Clusters

The table lists and describes kubectl commands for managing Tanzu Kubernetes clusters.

Table 13-16. Custom Commands to Manage Tanzu Kubernetes Clusters

Command	Description
<code>kubectl get tanzukubernetescluster</code>	Lists the clusters in the current namespace.
<code>kubectl get tkc</code>	Short form version of the preceding command.
<code>kubectl describe tanzukubernetescluster CLUSTER-NAME</code>	Describe the specified cluster, showing the expressed state, status, and events. When provisioning is complete, this command shows the virtual IP created for the load balancer that fronts Kubernetes API endpoints.
<code>kubectl get cluster-api</code>	Lists the Cluster API resources supporting the clusters in the current namespace, including resources from the Cluster API project and from the Cluster API Provider used by the Tanzu Kubernetes Grid Service.
<code>kubectl get tanzukubernetesreleases</code>	List available Tanzu Kubernetes releases.
<code>kubectl get tkr</code>	Short form version of the preceding command.
<code>kubectl get tkr v1.17.8---vmware.1-tkg.1.5417466 -o yaml</code>	Provides details on the named Tanzu Kubernetes release.
<code>kubectl get virtualmachine</code>	Lists the virtual machine resources supporting the cluster nodes in the current namespace.
<code>kubectl get vm</code>	Short form version of the preceding command.
<code>kubectl describe virtualmachine VIRTUAL-MACHINE-NAME</code>	Describe the specified virtual machine, showing the state, current status, and events.
<code>kubectl describe virtualmachinesetresourcepolicy</code>	List the Virtual Machine Set Resource Policy resources supporting the cluster in the current namespace. This resource represents the vSphere objects resource pool and folder used for the cluster.
<code>kubectl get virtualmachineservice</code>	Lists the Virtual Machine Service resources supporting the cluster nodes in the current namespace. These resources are analogous to a service, but for virtual machines instead of pods. Virtual machine services are used both for providing a load balancer for the control plane nodes of a cluster and by the paravirtual cloud provider to support a Kubernetes Service of type LoadBalancer within a cluster. See also the command <code>kubectl loadbalancer</code> .
<code>kubectl get vmservice</code>	Short form version of the preceding command.
<code>kubectl describe virtualmachineservice VIRTUAL-MACHINE-SERVICE-NAME</code>	Describe the specified Virtual Machine Service, showing the expressed cluster state, current status, and events.

Table 13-16. Custom Commands to Manage Tanzu Kubernetes Clusters (continued)

Command	Description
<code>kubectl get loadbalancer</code>	Lists the load balancer resources in the current namespace, including those used for clusters. A load balancer is created for the Virtual Machine Service.
<code>kubectl get virtualnetwork</code>	Lists the virtual network resources in the current namespace, including resources used for clusters. A virtual network is created for each namespace where a cluster is provisioned, and for each cluster itself.
<code>kubectl get persistentvolumeclaim</code>	Lists the persistent volume claim resources in the current namespace, including resources used for clusters. See <a href="#">Chapter 10 Using Persistent Storage in vSphere with Tanzu</a> .
<code>kubectl get cnsnodevmattachment</code>	Lists the CNS node virtual machine attachment resources in the current namespace. These resources represent the attachment of a persistent volume managed by CNS to a virtual machine serving as the node of a cluster. See <a href="#">Chapter 10 Using Persistent Storage in vSphere with Tanzu</a> .
<code>kubectl get configmap</code>	Lists the configuration maps in the current namespace, including maps used for the creation of cluster nodes. Configuration maps are not intended to be user-modifiable, and any changes are overwritten.
<code>kubectl get secret</code>	Lists the secrets in the current namespace, including secrets used for the creation and management of cluster nodes. See <a href="#">Get Tanzu Kubernetes Cluster Secrets</a> .

## View Tanzu Kubernetes Cluster Lifecycle Status

You can view the lifecycle status of Tanzu Kubernetes clusters in the vSphere inventory and using `kubectl`.

### Tanzu Kubernetes Cluster Lifecycle Status in vSphere

The table lists and describes the Tanzu Kubernetes cluster status information that appears in the vSphere inventory. To view this information, see [Monitor Tanzu Kubernetes Cluster Status Using the vSphere Client](#).

Table 13-17. Tanzu Kubernetes Cluster Status in the vSphere Inventory

Field	Description	Example
Name	The user-defined name of the cluster.	<code>tkg-cluster-01</code>
Creation Time	The date and time of cluster creation.	<code>Mar 17, 2020, 11:42:46 PM</code>
Phase	The lifecycle status of the cluster. See <a href="#">Table 13-19. Cluster Lifecycle Phase Status</a> .	<code>creating</code>
Worker Count	The number of worker nodes in the cluster.	<code>1 or 2 or 5</code>



Table 13-17. Tanzu Kubernetes Cluster Status in the vSphere Inventory (continued)

Field	Description	Example
Distribution Version	The version of Kubernetes software that the cluster is running.	v1.16.6+vmware.1-tkg.1.7144628
Control Plane Address	The IP address of the cluster control plane load balancer.	192.168.123.2

## Tanzu Kubernetes Cluster Lifecycle Status in kubectI

The table lists and describes the Tanzu Kubernetes cluster status information that appears in kubectI. To view this information, see [Monitor Tanzu Kubernetes Cluster Status Using kubectI](#).

Table 13-18. Tanzu Kubernetes Cluster Status in kubectI

Field	Description	Example
NAME	Name of the cluster.	tkg-cluster-01
CONTROL PLANE	Number of control plane nodes in the cluster.	3
WORKER	Number of worker nodes in the cluster.	5
DISTRIBUTION	Kubernetes version that the cluster is running.	v1.16.6+vmware.1-tkg.1.5b5608b
AGE	Number of days the cluster has been running.	13d
PHASE	The lifecycle status of the cluster. See <a href="#">Table 13-19. Cluster Lifecycle Phase Status</a> .	running

## Cluster Lifecycle Phase Status

The table lists and describes the status for each phase of a cluster lifecycle. See [Table 13-19. Cluster Lifecycle Phase Status](#).

Table 13-19. Cluster Lifecycle Phase Status

Phase	Description
creating	Cluster provisioning can start, the control plane is being created, or the control plane is created but not initialized.
deleting	The cluster is being deleted.
failed	The creation of the cluster control plane failed and user intervention is likely required.
running	The infrastructure is created and configured, and the control plane is fully initialized.
updating	The cluster is being updated.

# View the Full Resource Hierarchy for a Tanzu Kubernetes Cluster

You can view the full resource hierarchy for a Tanzu Kubernetes cluster using kubectl. Viewing the complete list of cluster resources can help you pinpoint resources that might be causing problems.

## Prerequisites

Connect to the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

## Procedure

- 1 Switch context to use the target cluster context.

```
kubectl config use-context CLUSTER-NAME
```

- 2 Run the following command to view the Cluster API cluster resource.

```
kubectl describe clusters.cluster.x-k8s.io CLUSTER-NAME
```

This command returns the resource hierarchy for the named cluster, such as the following: Namespace, API version, Resource version.

# Deploying Workloads and Extensions on TKGS Clusters

# 14

You can deploy workloads and extensions to Tanzu Kubernetes clusters.

This chapter includes the following topics:

- [Deploy Workloads on Tanzu Kubernetes Clusters](#)
- [Deploy TKG Extensions on Tanzu Kubernetes Clusters](#)
- [Deploy AI/ML Workloads on Tanzu Kubernetes Clusters](#)

## Deploy Workloads on Tanzu Kubernetes Clusters

You can deploy application workloads to Tanzu Kubernetes clusters using pods, services, persistent volumes, and higher-level resources such as Deployments and Replica Sets.

### Deploy a Test Workload to a Tanzu Kubernetes Cluster

After you have provisioned a Tanzu Kubernetes cluster, it is good practice to deploy a test workload and validate cluster functionality.

Use the [kuard](#) demo app to verify that your Tanzu Kubernetes cluster is up and running.

#### Prerequisites

- Provision a Tanzu Kubernetes cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).
- [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#)

#### Procedure

- 1 Switch configuration context to the target Tanzu Kubernetes cluster.

```
kubectl config use-context TANZU-KUBERNETES-CLUSTER-NAME
```

For example:

```
kubectl config use-context tkgs-cluster-1  
Switched to context "tkgs-cluster-1".
```

**2** Deploy the `kuard` demo app.

```
kubectl run --restart=Never --image=gcr.io/kuar-demo/kuard-amd64:blue kuard
```

Expected result:

```
pod/kuard created
```

**3** Verify that the pod is running.

```
kubectl get pods
```

Expected result:

NAME	READY	STATUS	RESTARTS	AGE
kuard	1/1	Running	0	10d

**4** Forward the pod container port 8080 to your local host port 8080.

```
kubectl port-forward kuard 8080:8080
```

Expected result:

```
Forwarding from 127.0.0.1:8080 -> 8080
Forwarding from [::1]:8080 -> 8080
Handling connection for 8080
```

**5** Using a browser go to <http://localhost:8080>.

The `kuard` demo app web page appears which you can interact with and verify aspects of your cluster. For example, perform liveness and readiness probes.

**6** Stop port forwarding by pressing `Ctrl+C` in the `kubectl` session.**7** Delete the `kuard` pod.

```
kubectl delete pod kuard
```

Expected result:

```
pod "kuard" deleted
```

**8** Verify that the pod is deleted.

```
kubectl get pods
```

## Install and Run Octant

You can install the Octant web interface to help you visualize Tanzu Kubernetes cluster workloads, namespaces, metadata, and more.

## About Octant

[Octant](#) is an open source web interface for viewing Kubernetes clusters and their applications.

You install and run Octant on the same client where you run `kubectl`. Installation instructions for common platforms are provided below. For more information, see the [Octant site](#).

Once Octant is installed, to use it log in to your Tanzu Kubernetes cluster using `kubectl` and run the command `octant`.

## Install Octant on Windows

Install the [Chocolatey](#) package manager for Windows PowerShell.

Run a PowerShell session as Administrator.

Install Octant using the following command:

```
choco install octant --confirm
```

## Install Octant on Mac

Install the [Homebrew](#) package manager.

Install Octant with the following command:

```
brew install octant
```

## Install Octant on Ubuntu

Download the `.deb` from the [releases page](#).

Install using the `dpkg -i` command.

## Tanzu Kubernetes Service Load Balancer Example

To provision an external load balancer in a Tanzu Kubernetes cluster, you can create a Service of type `LoadBalancer`. The load balancer service exposes a public IP address. Traffic from the external load balancer can be directed at cluster pods.

You can provision an external load balancer for Kubernetes pods that are exposed as services. For example, you can deploy a Nginx container and expose it as a Kubernetes service of type `LoadBalancer`.

### Prerequisites

- Review the [Service type LoadBalancer](#) in the Kubernetes documentation.
- Provision a Tanzu Kubernetes cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).
- Connect to the target Tanzu Kubernetes cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).

## Procedure

- 1 Create an appropriate role binding to the default privileged PSP. See [Example Role Bindings for Pod Security Policy](#).
- 2 Create the following `nginx-lbsvc.yaml` YAML file.

This YAML file defines a Kubernetes service of type LoadBalancer and deploys a Nginx container as an external load balancer for the service.

```
kind: Service
apiVersion: v1
metadata:
  name: srvc1b-nginx
spec:
  selector:
    app: hello
    tier: frontend
  ports:
  - protocol: "TCP"
    port: 80
    targetPort: 80
  type: LoadBalancer
---
apiVersion: apps/v1
kind: Deployment
metadata:
  name: loadbalancer
spec:
  replicas: 2
  selector:
    matchLabels:
      app: hello
  template:
    metadata:
      labels:
        app: hello
        tier: frontend
    spec:
      containers:
      - name: nginx
        image: "nginxdemos/hello"
```

- 3 Apply the YAML.

```
kubectl apply -f nginx-lbsvc.yaml
```

- 4 Verify the deployment of the Nginx service.

```
kubectl get services
```

The `svc-lb-nginx` is up with an external and internal IP address.

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP	PORT(S)	AGE
svc-lb-nginx	LoadBalancer	10.11.12.19	10.19.15.89	80:30818/TCP	18m

- Using a browser, enter the external IP address for the Nginx LoadBalancer service.

You see the message `NGINX` banner and details of the load balancer.

## Tanzu Kubernetes Service Load Balancer with Static IP Address Example

You can configure a Kubernetes service of type `LoadBalancer` to use a static IP address. Be aware of minimum component requirements, an important security consideration and cluster hardening guidance before implementing this feature.

### Minimum Requirements

Static IP addressing for Kubernetes services of type `LoadBalancer` is supported on Tanzu Kubernetes clusters that meet the following requirements:

Component	Minimum Requirement	More Information
vCenter Server and ESXi	vSphere 7.0 Update 2	See the <a href="#">Release Notes</a> .
Supervisor Cluster	v1.19.1+vmware.2- vsc0.0.8-17610687	See <a href="#">Update the Supervisor Cluster by Performing a vSphere Namespaces Update</a> .
Load Balancer	NSX-T Data Center v3.1 Or NSX Advanced 20.1.x	See the <a href="#">Release Notes</a> .
Tanzu Kubernetes Release	One of the latest Tanzu Kubernetes releases.	See <a href="#">List of Tanzu Kubernetes releases</a> .

### Using a Static IP for a Service of Type `LoadBalancer`

Typically when you define a Kubernetes service of [Type `LoadBalancer`](#) you get an ephemeral IP address assigned by the load balancer. See [Tanzu Kubernetes Service Load Balancer Example](#).

Alternatively you can specify a static IP address for the load balancer. On creation of the service, the load balancer instance is provisioned with the static IP address you assigned.

The following example service demonstrates how to configure a supported load balancer with a static IP address. In the service specification you include the `loadBalancerIP` parameter and an IP address value, which is `10.11.12.49` in this example.

```
kind: Service
apiVersion: v1
metadata:
  name: load-balancer-service-with-static-ip
spec:
```

```

selector:
  app: hello-world
  tier: frontend
ports:
- protocol: "TCP"
  port: 80
  targetPort: 80
type: LoadBalancer
loadBalancerIP: 10.11.12.49

```

For the NSX Advanced load balancer, you use a IP address from the IPAM pool configured for the load balancer when it was installed. When the service is created and the static IP address is assigned, the load balancer marks it as allocated and manages the lifecycle of the IP address the same way it does an ephemeral IP address. That is, if the service is removed, the IP address is unassigned and made available for reallocation.

For the NSX-T load balancer, you have two options. The default mechanism is the same as the NSX Advanced load balancer: use an IP address taken from the IP pool configured for the load balancer when it was installed. When the static IP address is assigned, the load balancer automatically marks it as allocated and manages its lifecycle.

The second NSX-T option is to manually pre-allocate the static IP address. In this case you use an IP address that is not part of the external load balancer IP pool assigned to load balancer, but instead taken from a floating IP pool. In this case you manually administer the allocation and lifecycle of the IP address using the NSX Manager.

## Important Security Consideration and Hardening Requirement

There is a potential security issue to be aware of when using this feature. If a developer is able to patch the `Service.status.loadBalancerIP` value, the developer may be able to hijack the traffic in the cluster destined for the patched IP address. Specifically, if a Role or ClusterRole with the `patch` permission is bound to a service or user account on a cluster where this feature is implemented, that account owner is able to use its own credentials to issue `kubectl` commands and change the static IP address assigned to the load balancer.

To avoid the potential security implications of using static IP allocation for a load balancer service, you must harden each cluster where you are implementing this feature. To do this, the Role or ClusterRole you define for any developer must not allow the `patch` verb for `apiGroups: ""` and `resources: services/status`. The example role snippet demonstrates what not to do when implementing this feature.

### DO NOT ALLOW PATCH

```

- apiGroups:
  - ""
  resources:
  - services/status
  verbs:
  - patch

```



To check if a developer has patch permissions, run the following command as that user:

```
kubectl --kubeconfig <KUBECONFIG> auth can-i patch service/status
```

If the command returns `yes`, the user has patch permissions. See [Checking API Access](#) in the Kubernetes documentation for more information.

To grant developer access to a cluster, see [Grant Developer Access to Tanzu Kubernetes Clusters](#). For a sample Role template that you can customize, see [Example Role for Pod Security Policy](#). For an example on how to restrict cluster access, see <https://kubernetes.io/docs/reference/access-authn-authz/rbac/#role-example>.

## Tanzu Kubernetes Service Load Balancer Examples for Local Traffic Policy and Source IP Ranges

You can configure a Kubernetes service of type `LoadBalancer` to allow load balancer traffic based on the source IP address of the incoming request, and to only allow local pod traffic.

### Minimum Requirements

You can use the `externalTrafficPolicy` and `LoadBalancerSourceRanges` features with a Kubernetes service of type `LoadBalancer` on a Tanzu Kubernetes cluster that meets the following minimum requirements:

Component	Minimum Requirement	More Information
vCenter Server and ESXi	vSphere 7.0 Update 2	See the <a href="#">Release Notes</a> .
Supervisor Cluster	v1.19.1+vmware.2- vsc0.0.8-17610687	See <a href="#">Update the Supervisor Cluster by Performing a vSphere Namespaces Update</a> .
Load Balancer	NSX-T Data Center v3.1	See <a href="#">Chapter 4 Networking for vSphere with Tanzu</a> .
Tanzu Kubernetes Release	One of the latest Tanzu Kubernetes releases.	See <a href="#">List of Tanzu Kubernetes releases</a> .

### About Support for Local Traffic Policy and Source IP Ranges

If you are using NSX-T Data Center networking, you can configure a Kubernetes Service of Type `LoadBalancer` to allow external traffic policy and load balancer source IP ranges. The `externalTrafficPolicy` feature lets you restrict pod traffic to the local node. The `LoadBalancerSourceRange` feature lets you specify source IP addresses to allow or block.

## Example Service for Local Traffic Only

The following load balancer service specification configures the load balancer instance with the `externalTrafficPolicy` parameter set to `Local`. The result is that pod traffic is routed to only those nodes that have local pods running.

```
apiVersion: v1
kind: Service
metadata:
  name: local-only
spec:
  selector:
    app: testApp
  ports:
    - protocol: TCP
      port: 80
      targetPort: 80
  externalTrafficPolicy: Local
  type: LoadBalancer
```

The feature works using a NSX-T health check monitor. From an NSX-T administration perspective, it is important to be aware of the internal operations of this feature.

An NSX-T health check monitor watches the Kubernetes Health Check NodePort allocated by kube-proxy for the server pool that corresponds to the Service of Type LoadBalancer. The NSX-T health check monitor sends HTTP GET requests to the target Health Check NodePort. The kube-proxy on a node returns the HTTP status code 500 when there are no local pods running. Nodes that do not have local pods will be marked DOWN by NSX-T and appear as such in NSX Manager. Traffic will be routed to only those nodes that have local pods running.

## Example Service to Allow Traffic Based on Source IP Ranges

The following load balancer service specification configures the `loadBalancerSourceRanges` parameter with an array of allowed source IP CIDRs. Only inbound requests emanating from these source IP ranges will be allowed; all other inbound traffic will be dropped.

```
apiVersion: v1
kind: Service
metadata:
  name: allow-based-on-source-IPs
spec:
  selector:
    app: testApp
  ports:
    - protocol: TCP
      port: 80
      targetPort: 80
```

```
loadBalancerSourceRanges:  
- 10.0.0.0/24  
- 10.1.0.0/24  
type: LoadBalancer
```

## Tanzu Kubernetes Ingress Example Using Nginx

A Kubernetes ingress resource provides HTTP or HTTPS routing from outside the cluster to one or more services within the cluster. Tanzu Kubernetes clusters support ingress through third-party controllers, such as Nginx.

This tutorial demonstrates how to deploy a Kubernetes ingress service based on NGINX for routing external traffic to services in your Tanzu Kubernetes cluster. An ingress service requires an ingress controller. We install the NGINX Ingress controller using Helm. Helm is a package manager for Kubernetes.

---

**Note** There several ways to accomplish this task. The steps here provide one approach. Other approaches may be more suitable for you in your given environment.

---

### Prerequisites

- Review the [Ingress](#) resource in the Kubernetes documentation.
- Review the [Nginx](#) Ingress controller documentation.
- Provision a Tanzu Kubernetes cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).
- Enable pod security policy. See [Example Role for Pod Security Policy](#).
- Connect to the Tanzu Kubernetes cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).

### Procedure

- 1 Install Helm by referring to the [documentation](#).
- 2 Install the NGINX Ingress controller using Helm.

```
helm repo add ingress-nginx https://kubernetes.github.io/ingress-nginx  
helm install ingress-nginx ingress-nginx/ingress-nginx
```

**3** Verify that the Nginx ingress controller is deployed as a service of type LoadBalancer.

```
kubectl get services
```

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP
ingress-nginx-controller	LoadBalancer	10.16.18.20	10.19.14.76 80:30635/TCP,443:30873/TCP
ingress-nginx-controller-admission	ClusterIP	10.87.41.25	<none>

**4** Ping the load balancer using the external IP address.

```
ping 10.19.14.76
```

```
Pinging 10.19.14.76 with 32 bytes of data:
Reply from 10.19.14.76: bytes=32 time<1ms TTL=62
Reply from 10.19.14.76: bytes=32 time=1ms TTL=62
```

**5** Verify that the Nginx Ingress controller is running.

```
kubectl get pods
```

NAME	READY	STATUS	RESTARTS	AGE
ingress-nginx-controller-7c6c46898c-v6blt	1/1	Running	0	76m

**6** Create an ingress resource with an ingress rule and path named `ingress-hello.yaml`.

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-hello
spec:
  rules:
  - http:
      paths:
      - path: /hello
        backend:
          serviceName: hello
          servicePort: 80
```

**7** Deploy the `ingress-hello` resource.

```
kubectl apply -f ingress-hello.yaml
```

```
ingress.networking.k8s.io/ingress-hello created
```

**8** Verify that the ingress resource is deployed.

Note that the IP address maps to the external IP of the ingress controller.

```
kubectl get ingress
```

NAME	CLASS	HOSTS	ADDRESS	PORTS	AGE
ingress-hello	<none>	*	10.19.14.76	80	51m

**9** Create a hello test app and service named `ingress-hello-test.yaml`.

```
kind: Service
apiVersion: v1
metadata:
  name: hello
spec:
  selector:
    app: hello
    tier: backend
  ports:
  - protocol: TCP
    port: 80
    targetPort: http
---
apiVersion: apps/v1
kind: Deployment
metadata:
  name: hello
spec:
  replicas: 3
  selector:
    matchLabels:
      app: hello
      tier: backend
      track: stable
  template:
    metadata:
      labels:
        app: hello
        tier: backend
        track: stable
    spec:
      containers:
      - name: hello
        image: "gcr.io/google-samples/hello-go-gke:1.0"
        ports:
        - name: http
          containerPort: 80
```

**10** Deploy the `ingress-hello-test` resource.

```
kubectl apply -f ingress-hello-test.yaml
```

```
service/hello created
deployment.apps/hello created
```

**11** Verify that the `hello` deployment is available.

```
kubectl get deployments
```

NAME	READY	UP-TO-DATE	AVAILABLE	AGE
hello	3/3	3	3	4m59s
ingress-nginx-controller	1/1	1	1	3h39m

**12** Get the public IP address of the load balancer used by the Nginx ingress controller.

```
kubectl get ingress
```

NAME	CLASS	HOSTS	ADDRESS	PORTS	AGE
ingress-hello	<none>	*	10.19.14.76	80	13m

**13** Using a browser, navigate to the public IP and include the ingress path.

```
http://10.19.14.76/hello
```

The message "hello" is returned.

```
{"message": "Hello"}
```

**Results**

The backend app that is fronted by the service running inside the cluster is accessed externally by the browser through the ingress controller using the external IP address of the load balancer.

## Tanzu Kubernetes Storage Class Example

For workloads requiring persistence, you can use the default storage class, or define your own storage class for use with persistent volumes. Tanzu Kubernetes clusters support the Container Storage Interface (CSI) provisioner.

### Container Storage Interface (CSI) Is Supported

Tanzu Kubernetes clusters support the Container Storage Interface (CSI). In the `StorageClass` definition, this type of provisioner is identified as `csi.vsphere.vmware.com`.

The following YAML definition can be used as a template to define a storage class for a Tanzu Kubernetes cluster. Specify if you want the storage class to be the default ("true"), and provide the datastore URL for your storage environment.

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: tkgs-storage-class
  annotations:
    storageclass.kubernetes.io/is-default-class: "true" or "false"
provisioner: csi.vsphere.vmware.com
parameters:
  datastoreurl: "ds:///vmfs/volumes/vsan:52d8eb4842dbf493-41523be9cd4ff7b7/"
```

Create the storage class:

```
kubectl apply -f tkgs-storage-class.yaml

storageclass.storage.k8s.io/tkgs-storage-class created
```

Verify that the storage class is created:

```
kubectl get storageclass
```

Or, using the shortcut:

```
kubectl get sc
```

## VMware Cloud Provider (vCP) Is Not Supported

Tanzu Kubernetes clusters do not support the legacy VMware Cloud Provider (vCP) StorageClass as shown below. If you attempt to create a StorageClass using the vCP provisioner, the StorageClass is not created.

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: demo-sts-sc
provisioner: kubernetes.io/vsphere-volume
parameters:
  diskformat: thin
```

## Tanzu Kubernetes Persistent Volume Claim Examples

To run stateful workloads on Tanzu Kubernetes clusters, you can create a persistent volume claim (PVC) to request persistent storage resources without knowing the details of the underlying storage infrastructure. The storage used for the PVC is allocated out of the storage quota for the vSphere Namespace.

Containers by default are ephemeral and stateless. For stateful workloads, a common approach is to create a persistent volume claim (PVC). You can use a PVC to mount the persistent volumes and access storage. The request dynamically provisions a persistent volume object and a matching virtual disk. The claim is bound to the persistent volume. When you delete the claim, the corresponding persistent volume object and the provisioned virtual disk are also deleted.

### Procedure

- 1 Log in to the target Tanzu Kubernetes cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).
- 2 Switch to the namespace where the cluster is running.

```
kubectl config use-context NAMESPACE
```

- 3 Verify the storage class, or create one.

To verify an existing storage class:

```
kubectl get storageclass
```

To create a storage class, see [Tanzu Kubernetes Storage Class Example](#).

- 4 Create a namespace.

```
kubectl create namespace guestbook
```

- 5 Create the Guestbook PVC YAML files.

- [Redis Leader PVC](#)
- [Redis Follower PVC](#)

- 6 Apply the Guestbook PVCs to the cluster.

```
kubectl apply -f redis-leader-pvc.yaml -n guestbook
```

```
kubectl apply -f redis-follower-pvc.yaml -n guestbook
```

- 7 Verify the status of the PVCs.

```
kubectl get pvc,pv -n guestbook
```

The PVCs and persistent volumes (PVs) are listed and available for use.

NAME		STATUS			
VOLUME		CAPACITY	ACCESS MODES	STORAGECLASS	
AGE					
persistentvolumeclaim/redis-follower-pvc		Bound	pvc-37b72f35-3de2-4f84-		
be7d-50d5dd968f62	2Gi RWO		tkgs-storage-class	66s	
persistentvolumeclaim/redis-leader-pvc		Bound	pvc-2ef51f31-dd4b-4fe2-bf4c-		
f0149cb4f3da	2Gi RWO		tkgs-storage-class	66s	



NAME	POLICY	STATUS	CLAIM	STORAGECLASS	CAPACITY	ACCESS MODES	RECLAIM
persistentvolume/pvc-2ef51f31-dd4b-4fe2-bf4c		Bound	guestbook/redis-leader-pvc	tkgs-storage-class	2Gi	RWO	Delete
persistentvolume/pvc-37b72f35-3de2-4f84-be7d		Bound	guestbook/redis-follower-pvc	tkgs-storage-class	2Gi	RWO	Delete

## Tanzu Kubernetes Guestbook Tutorial

Deploy the Guestbook application to your Tanzu Kubernetes cluster to explore pod security policy for service accounts, and deployment and service creation.

Deploying the [Guestbook application](#) is a common way to explore Kubernetes. If you deploy all the Guestbook YAML files to a Tanzu Kubernetes cluster provisioned by the Tanzu Kubernetes Grid Service, the application pod is not created successfully. The following error message appears when you run the `kubectl describe pod` command:

```
"Error: container has runAsNonRoot and image will run as root"
```

The Guestbook application is using both `deployment` and `replicaset` resources to deploy privileged containers in the default namespace. Because the PodSecurityPolicy Controller is enabled for Tanzu Kubernetes clusters, when any cluster user attempts to create the Guestbook application pod, the service accounts for these controllers are checked against PodSecurityPolicy. If an appropriate PSP is not bound to these service accounts, the application is not deployed.

By default, Tanzu Kubernetes administrators can create privileged pods directly in any namespace using their user account. However, the Guestbook application deploys privileged containers using service accounts. A cluster administrator can create Deployments, StatefulSets, and DaemonSet in the `kube-system` namespace. However, the Guestbook application deploys these resources in the default namespace. In addition, non-administrative users cannot create privileged or unprivileged pods at all without the proper PSP and bindings.

One solution is to create bindings to the default privileged PSP to allow the Guestbook application to be deployed. The privileged PodSecurityPolicy permits run-as-root pods and privileged containers for bound accounts. You can create a ClusterRoleBinding that applies the `vmware-system-privileged` cluster-wide, but doing so might violate the principle of least privilege by granting more permission than is needed. A better approach is to create a RoleBinding that permits the system service accounts to use the privileged PodSecurityPolicy in the default namespace. For more information, see [Example Role Bindings for Pod Security Policy](#).

### Prerequisites

Review the following topics:

- [Guestbook application tutorial](#) in the Kubernetes documentation
- [Using Pod Security Policies with Tanzu Kubernetes Clusters](#)

- [Example Role Bindings for Pod Security Policy](#)

#### Procedure

1 Log in to the Tanzu Kubernetes cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).

2 Create the Guestbook namespace.

```
kubectl create namespace guestbook
```

Verify:

```
kubectl get ns
```

3 Create role-based access control using the default privileged PSP.

```
kubectl create clusterrolebinding default-tkg-admin-privileged-binding --
clusterrole=psp:vmware-system-privileged --group=system:authenticated
```

---

**Note** If tighter security is required, apply a RoleBinding on the Guestbook namespace. See [Example Role Bindings for Pod Security Policy](#)

---

4 Verify the storage class, or create one.

To verify an existing storage class:

```
kubectl get storageclass
```

To create a storage class, see [Tanzu Kubernetes Storage Class Example](#).

5 Create the persistent volume claims (PVCs) that use the storage class.

Use the following YAML files:

- [Redis Leader PVC](#)
- [Redis Follower PVC](#)

To create the PVCs, see [Tanzu Kubernetes Persistent Volume Claim Examples](#).

6 Create the Guestbook YAML files.

Use the following YAML files:

- [Redis Leader Deployment](#)
- [Redis Leader Service](#)
- [Redis Follower Deployment](#)
- [Redis Follower Service](#)
- [Guestbook Frontend Deployment](#)
- [Guestbook Frontend Service](#)

**7** Deploy the Guestbook application in its namespace.

```
kubectl apply -f . --namespace guestbook
```

**8** Verify creation of the Guestbook resources.

```
kubectl get all -n guestbook
```

```

NAME                                READY   STATUS
RESTARTS   AGE
pod/guestbook-frontend-deployment-56fc5b6b47-cd58r  1/1     Running
0          65s
pod/guestbook-frontend-deployment-56fc5b6b47-fh6dp  1/1     Running
0          65s
pod/guestbook-frontend-deployment-56fc5b6b47-hgd2b  1/1     Running
0          65s
pod/redis-follower-deployment-6fc9cf5759-99fgw      1/1     Running
0          65s
pod/redis-follower-deployment-6fc9cf5759-rhxf7      1/1     Running
0          65s
pod/redis-leader-deployment-7d89bbdbcf-flt4q       1/1     Running
0          65s

NAME                                TYPE                CLUSTER-IP      EXTERNAL-IP
PORT(S)          AGE
service/guestbook-frontend          LoadBalancer       10.10.89.59     10.19.15.99
80:31513/TCP    65s
service/redis-follower              ClusterIP           10.111.163.189 <none>
6379/TCP       65s
service/redis-leader                ClusterIP           10.111.70.189  <none>
6379/TCP       65s

NAME                                READY   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/guestbook-frontend  3/3     3             3           65s
deployment.apps/redis-follower      1/2     2             1           65s
deployment.apps/redis-leader        1/1     1             1           65s

NAME                                DESIRED   CURRENT   READY   AGE
replicaset.apps/guestbook-frontend-56fc5b6b47  3         3         3       65s
replicaset.apps/redis-follower-deployment-6fc9cf5759  2         2         1       65s
replicaset.apps/redis-leader-deployment-7d89bbdbcf  1         1         1       65s

```

**9** Access the Guestbook web page using the External-IP address of the `service/guestbook-frontend` load balancer, which in this example is `10.19.15.99`.

You see the Guestbook web interface, and you can enter values into the Guestbook database. If you restart the application, the data is persisted.

## Guestbook Example YAML Files

Use the example YAML files to deploy the Guestbook application with persistent data.

## Redis Leader PVC

The file `redis-leader-pvc.yaml` is an example persistent volume claim that references a named storage class. To use this example, enter the name of the storage class.

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: redis-leader-pvc
spec:
  accessModes:
    - ReadWriteOnce
  storageClassName: tkgs-storage-class-name
  resources:
    requests:
      storage: 2Gi
```

## Redis Follower PVC

The file `redis-follower-pvc.yaml` is an example persistent volume claim that references a named storage class. To use this example, enter the name of the storage class.

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: redis-follower-pvc
spec:
  accessModes:
    - ReadWriteOnce
  storageClassName: tkgs-storage-class-name
  resources:
    requests:
      storage: 2Gi
```

## Redis Leader Deployment

The file `redis-leader-deployment.yaml` is an example Redis leader deployment with a persistent volume.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: redis-leader-deployment
spec:
  selector:
    matchLabels:
      app: redis
      role: leader
      tier: backend
  replicas: 1
  template:
    metadata:
      labels:
```

```

    app: redis
    role: leader
    tier: backend
spec:
  containers:
  - name: leader
    image: redis
    resources:
      requests:
        cpu: 100m
        memory: 100Mi
    ports:
    - containerPort: 6379
    volumeMounts:
    - name: redis-leader-data
      mountPath: /data
  volumes:
  - name: redis-leader-data
    persistentVolumeClaim:
      claimName: redis-leader-pvc

```

## Redis Follower Deployment

The file `redis-follower-deployment.yaml` is an example Redis follower deployment with a persistent volume.

```

apiVersion: apps/v1
kind: Deployment
metadata:
  name: redis-follower-deployment
  labels:
    app: redis
spec:
  selector:
    matchLabels:
      app: redis
      role: follower
      tier: backend
  replicas: 1
  template:
    metadata:
      labels:
        app: redis
        role: follower
        tier: backend
    spec:
      containers:
      - name: follower
        image: gcr.io/google_samples/gb-redis-follower:v2
        resources:
          requests:
            cpu: 100m
            memory: 100Mi
        env:

```

```

- name: GET_HOSTS_FROM
  value: dns
ports:
- containerPort: 6379
volumeMounts:
- name: redis-follower-data
  mountPath: /data
volumes:
- name: redis-follower-data
  persistentVolumeClaim:
    claimName: redis-follower-pvc

```

## Redis Leader Service

The file `redis-leader-service.yaml` is an example Redis leader service.

```

apiVersion: v1
kind: Service
metadata:
  name: redis-leader
  labels:
    app: redis
    role: leader
    tier: backend
spec:
  ports:
  - port: 6379
    targetPort: 6379
  selector:
    app: redis
    role: leader
    tier: backend

```

## Redis Follower Service

The file `redis-follower-service.yaml` is an example Redis follower service.

```

apiVersion: v1
kind: Service
metadata:
  name: redis-follower
  labels:
    app: redis
    role: follower
    tier: backend
spec:
  ports:
  - port: 6379
  selector:
    app: redis
    role: follower
    tier: backend

```

## Guestbook Frontend Deployment

The file `guestbook-frontend-deployment.yaml` is an example Guestbook frontend deployment.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: guestbook-frontend-deployment
spec:
  selector:
    matchLabels:
      app: guestbook
      tier: frontend
  replicas: 3
  template:
    metadata:
      labels:
        app: guestbook
        tier: frontend
    spec:
      containers:
      - name: php-redis
        image: gcr.io/google_samples/gb-frontend:v5
        resources:
          requests:
            cpu: 100m
            memory: 100Mi
        env:
        - name: GET_HOSTS_FROM
          value: dns
        ports:
        - containerPort: 80
```

## Guestbook Frontend Service

The file `guestbook-frontend-service.yaml` is an example Guestbook frontend load balancer service.

```
apiVersion: v1
kind: Service
metadata:
  name: guestbook-frontend
  labels:
    app: guestbook
    tier: frontend
spec:
  type: LoadBalancer
  ports:
  - port: 80
  selector:
    app: guestbook
    tier: frontend
```

## Using Pod Security Policies with Tanzu Kubernetes Clusters

Tanzu Kubernetes Grid Service provisions Tanzu Kubernetes clusters with the PodSecurityPolicy Admission Controller enabled. This means that pod security policy is required to deploy workloads. Cluster administrators can deploy pods from their user account to any namespace, and from service accounts to the kube-system namespace. For all other use cases, you must explicitly bind to a PodSecurityPolicy object. Clusters include default pod security policies that you can bind to, or create your own.

### About Kubernetes Pod Security Policies

Kubernetes pod security policies (PSPs) are cluster-level resources that control the security of pods. Using PSPs gives you control over the types of pods that can be deployed and the types of accounts that can deploy them.

A PodSecurityPolicy resource defines a set of conditions that a pod must satisfy to be deployable. If the conditions are not met, the pod cannot be deployed. A single PodSecurityPolicy must validate a pod in its entirety. A pod cannot have some of its rules in one policy and some in another.

There are various ways to implement the use of pod security policies in Kubernetes. The typical approach is by using role-based access control (RBAC) objects. ClusterRole and ClusterRoleBinding apply cluster-wide; Role and RoleBinding apply to a specific namespace. If a RoleBinding is used, it only lets pods run in the same namespace as the binding.

There are two ways to create Kubernetes pods: directly or indirectly. You create a pod directly by deploying a pod spec with your user account. You create a pod indirectly by defining some higher-level resource, such as a Deployment or DaemonSet. In this case, a service account creates the underlying pod.

To use PSPs effectively, you must account for both pod creation workflows. If a user creates a pod directly, the PSP bound to the user account controls the operation. If a user creates a pod by way of a service account, the PSP must be bound to the service account used to create the pod. If no service account is specified in the pod spec, the default service account for the namespace is used.

For more information, see [Pod Security Policies](#), [RBAC](#), and [Service Accounts](#) in the Kubernetes documentation.

### Default PodSecurityPolicy for Tanzu Kubernetes Clusters

The table lists and describes the privileged and restricted default pod security policies for Tanzu Kubernetes clusters, and the default ClusterRole associated with each policy.



Table 14-1. Default PodSecurityPolicy with Associated ClusterRole

Default PSP	Permission	Description	Associated Default ClusterRole
vmware-system-privileged	<b>Run as any</b>	Permissive PSP. Equivalent to running a cluster without the PSP Admission Controller enabled.	psp:vmware-system-privileged can use this PSP
vmware-system-restricted	<b>Must run as non-root</b>	Restrictive PSP. Does not permit privileged access to pod containers, blocks possible escalations to root, and requires use of several security mechanisms.	psp:vmware-system-restricted can use this PSP

## No Default Bindings for Tanzu Kubernetes Clusters

The Tanzu Kubernetes Grid Service does not provide default RoleBinding and ClusterRoleBinding for Tanzu Kubernetes clusters.

A vCenter Single Sign-On user who is granted the **Edit** permission on a vSphere Namespace is assigned to the **cluster-admin** role for any Tanzu Kubernetes cluster deployed in that namespace. An authenticated cluster administrator can implicitly use the `vmware-system-privileged` PSP. Although not technically a ClusterRoleBinding, it has the same effect.

The cluster administrator must define any bindings to allow or restrict the types of pods users can deploy to a cluster. If a RoleBinding is used, the binding only allows pods to be run in the same namespace as the binding. This can be paired with system groups to grant access to all pods run in the namespace. Non-admin users who authenticate to the cluster are assigned to the `authenticated` role and can be bound to default PSP as such. See [Grant Developer Access to Tanzu Kubernetes Clusters](#).

## Effect of Default PodSecurityPolicy on Tanzu Kubernetes Clusters

The following behavior is enforced for any Tanzu Kubernetes cluster:

- A cluster administrator can create privileged pods directly in any namespace by using his or her user account.
- A cluster administrator can create Deployments, StatefulSets, and DaemonSet (each of which creates privileged pods) in the kube-system namespace. If you want to use a different namespace, see [Tanzu Kubernetes Guestbook Tutorial](#).
- A cluster administrator can create his or her own PSPs (in addition to the two default PSPs) and bind these PSPs to any users. If you define your own PSP, see [Policy Order](#) in the Kubernetes documentation.
- No authenticated users can create privileged or unprivileged pods until the cluster administrator binds PSPs to the authenticated users. See [Tanzu Kubernetes Guestbook Tutorial](#).

## Example Role Bindings for Pod Security Policy

Tanzu Kubernetes clusters include default PodSecurityPolicy that you can bind to for privileged and restricted workload deployment.

### About Default Pod Security Policy

This section provides YAML and CLI commands for creating role binding objects to default pod security policy, including ClusterRoleBinding and RoleBinding. For more information, see [Using Pod Security Policies with Tanzu Kubernetes Clusters](#).

A RoleBinding grants permissions within a specific namespace whereas a ClusterRoleBinding grants permissions cluster-wide. The decision to use a RoleBindings or ClusterRoleBinding depends on your use case. For example, if you use a ClusterRoleBinding and configure subjects to use `system:serviceaccounts:<namespace>`, you can bind to a PSP before the namespace is created. For more information, see [RoleBinding and ClusterRoleBinding](#) in the Kubernetes documentation.

### Example 1: ClusterRoleBinding to Run a Privileged Set of Workloads

The following kubectl command creates a ClusterRoleBinding that grants access to authenticated users run a privileged set of workloads using the default PSP `vmware-system-privileged`.

```
kubectl create clusterrolebinding default-tkg-admin-privileged-binding --
clusterrole=psp:vmware-system-privileged --group=system:authenticated
```

**Note** The above command allows the deployment of privileged workloads cluster-wide. For tighter security, consider using a RoleBinding instead.

### Example 2: RoleBinding to Run a Privileged Set of Workloads

The following kubectl command creates a RoleBinding that grants access to all service accounts within the default namespace to run a privileged set of workloads using the default PSP `vmware-system-privileged`.

```
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: rolebinding-default-privileged-sa-ns_default
  namespace: default
roleRef:
  kind: ClusterRole
  name: psp:vmware-system-privileged
  apiGroup: rbac.authorization.k8s.io
subjects:
- kind: Group
  apiGroup: rbac.authorization.k8s.io
  name: system:serviceaccounts
```

As an alternative to applying YAML, you can run the following `kubectl` command.

```
kubectl create rolebinding rolebinding-default-privileged-sa-ns_default --namespace=default --clusterrole=psp:vmware-system-privileged --group=system:serviceaccounts
```

### Example 3: ClusterRoleBinding to Run a Restricted Set of Workloads

The following YAML creates a ClusterRoleBinding that grants authenticated users cluster-wide access to run a restricted set of workloads using the default PSP `vmware-system-restricted`.

```
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: psp:authenticated
subjects:
- apiGroup: rbac.authorization.k8s.io
  kind: Group
  name: system:authenticated
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: psp:vmware-system-restricted
```

As an alternative to applying YAML, you can run the following `kubectl` command.

```
kubectl create clusterrolebinding psp:authenticated --clusterrole=psp:vmware-system-restricted --group=system:authenticated
```

### Example 4: RoleBinding to Run a Restricted Set of Workloads

The following YAML creates a RoleBinding that grants access to all service accounts within a specific namespace to run a restricted set of workloads using the default PSP `vmware-system-restricted`.

```
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: psp:serviceaccounts
  namespace: some-namespace
subjects:
- apiGroup: rbac.authorization.k8s.io
  kind: Group
  name: system:serviceaccounts
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: psp:vmware-system-restricted
```

As an alternative to applying YAML, you can run the following kubectl command.

```
kubectl create rolebinding psp:serviceaccounts --clusterrole=psp:vmware-system-restricted --group=system:serviceaccounts
```

## Example Role for Pod Security Policy

Tanzu Kubernetes clusters require pod security policy (PSP) to deploy workloads. If you define your own PSP, you must create a Role or ClusterRole that references the PSP.

### Example Role for PodSecurityPolicy

The following example demonstrates a Role bound to PodSecurityPolicy. In the role definition, the `example-role` is granted the `use` verb to a custom PSP resource that you define. Alternatively, use one of the default PSPs. Then, create a [Tanzu Kubernetes Guestbook Tutorial](#).

```
apiVersion: rbac.authorization.k8s.io/v1beta1
kind: Role
metadata:
  name: example-role
  namespace: tkgs-cluster-ns
rules:
- apiGroups:
  - ""
  resources:
  - configmaps
  verbs:
  - create
  - get
  - list
  - watch
  - update
- apiGroups:
  - ""
  resources:
  - events
  verbs:
  - create
  - update
  - patch
- apiGroups:
  - extensions
  resourceName:
  - CUSTOM-OR-DEFAULT-PSP
  resources:
  - podsecuritypolicies
  verbs:
  - use
```

# Deploy TKG Extensions on Tanzu Kubernetes Clusters

Refer to this set of instructions to deploy TKG Extensions to Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service.

## TKG 1.4 Packages

To install TKG 1.4 Packages on Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service, see [Install and Configure Packages](#).

## TKG 1.3.1 Extensions

To install TKG 1.3.1 Extensions on Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service, refer to the documentation in this section.

## Download the TKG Extensions v1.3.1 Bundle

In preparation for deploying one or more TKG Extensions, download TKG Extensions v1.3.1 Bundle from VMware.

The TKG Extensions are packaged as a separate bundle that you download from VMware.

---

**Note** vSphere with Tanzu supports TKG Extensions v1.3.1 on vSphere 7 U2 and later.

---

### Procedure

- 1 Go to <https://www.vmware.com/go/get-tkg>.
- 2 Log in with your My VMware credentials.
- 3 Select **Product Downloads > Go to Downloads**.
- 4 Scroll and locate **VMware Tanzu Kubernetes Grid Extensions Manifest 1.3.1**.
- 5 Click **Download Now** to download the file `tkg-extensions-manifests-v1.3.1-vmware.1.tar.gz` to your local system.
- 6 Copy the file `tkg-extensions-manifests-v1.3.1-vmware.1.tar.gz` to the computer where you run `kubectl` commands.
- 7 Using the `tar` command, or the extraction tool of your choice, extract the TKG Extensions files.

```
tar -xzf tkg-extensions-manifests-v1.3.1-vmware.1.tar.gz
```

- 8 Verify the TKG Extensions files by navigating to the following file path.

```
cd /tkg-extensions-v1.3.1+vmware.1/extensions
```

Downloads > tkg-extensions-v1.3.1+vmware.1 > extensions

Name	Date modified	Type
authentication	8/30/2021 12:47 PM	File folder
ingress	4/22/2021 8:52 AM	File folder
logging	4/22/2021 8:52 AM	File folder
monitoring	8/30/2021 12:47 PM	File folder
registry	4/22/2021 8:52 AM	File folder
service-discovery	8/30/2021 12:47 PM	File folder
kapp-controller.yaml	4/22/2021 8:52 AM	Yaml Source File
kapp-controller-config.yaml	4/22/2021 8:52 AM	Yaml Source File
README.md	4/22/2021 8:52 AM	Markdown Source File
UPGRADE.md	4/22/2021 8:52 AM	Markdown Source File

This is the home directory for the TKG Extensions.

## Install the TKG Extensions Prerequisites

Install the prerequisite applications on each Tanzu Kubernetes cluster where you plan to install one or more TKG Extensions v1.3.1.

TKG Extensions v1.3.1 require two prerequisite components: Kapp Controller and Cert Manager.

**Note** As an alternative to Cert Manager you can use your own TLS certificates. See [Use Your Own TLS Certificate for TKG Extensions](#).

### Prerequisites

- Provision a Tanzu Kubernetes cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).
- Connect to the Tanzu Kubernetes cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).

### Procedure

- 1 [Download the TKG Extensions v1.3.1 Bundle](#).
- 2 Install Cert Manager on the cluster.

Navigate to the root directory of the TKG Extensions bundle you downloaded and extracted.

```
cd /tkg-extensions-v1.3.1+vmware.1
```

Cert Manager includes several components. There are three YAML files in the directory named `/cert-manager`. Use `ls` to verify the presence of this directory.

Install all Cert Manager components by issuing the following single command:

```
kubectl apply -f cert-manager/
```

This operation creates the `cert-manager` namespace, components, certificates, and associated objects.

### 3 Install Kapp Controller on the cluster.

Navigate to the home directory of the TKG Extensions.

```
cd /tkg-extensions-v1.3.1+vmware.1/extensions
```

Use `ls` to verify presence of the file `kapp-controller.yaml`.

**Note** The `spec.containers.image` path points to the public VMware registry. For air-gapped installations, update this path to point to your private registry.

Run the following command to install Kapp Controller.

```
kubectl apply -f kapp-controller.yaml
```

This operation creates the `tkg-system` namespace, `kapp-controller` application, and role objects.

### 4 Verify installation of Cert Manager and Kapp Controller.

Run the command `kubectl get pods -A`. You should see each are running.

```
cert-manager      cert-manager-cainjector-...  1/1    Running    0      7h54m
cert-manager      cert-manager-...             1/1    Running    0      7h54m
cert-manager      cert-manager-webhook-...     1/1    Running    0      7h54m
tkg-system        kapp-controller-...          1/1    Running    0      16m
```

## Review Persistent Storage Requirements for TKG Extensions

Both monitoring extensions, Prometheus and Grafana, require persistent storage. To prepare for deploying these extensions, verify that the target Tanzu Kubernetes cluster is configured with a default storage class and that the vSphere Namespace has sufficient storage.

### Persistent Storage Requirements for the TKG Extensions

The Tanzu Kubernetes cluster where you deploy the Prometheus or Grafana extensions should be provisioned with a default storage class. See [Examples for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha1 API](#).

Alternatively, you can configure the extensions to use a persistent volume claim when you deploy them. The configuration for this approach is provided as part of the deployment instructions for each extension.

The storage limit for the vSphere Namespace where the cluster is provisioned on which you are installing the extension must be larger than the total persistent volume claim size.

**Table 14-2. Default Storage Requirements for the TKG Extensions**

Component	TKG Extension	Default Storage Size
Grafana	Grafana	8 Gi
Prometheus Server	Prometheus	8 Gi
Alert Manager	Prometheus	8 Gi
Harbor	Harbor Registry	Varies by PVC

### Adjust the vSphere Namespace Storage Limit

To adjust the storage limit for the vSphere Namespace where the Tanzu Kubernetes cluster is provisioned:

- 1 Using the vSphere Client, log in to the vCenter Server where vSphere with Tanzu is enabled.
- 2 Select the vSphere Namespace where the target Tanzu Kubernetes cluster is provisioned.
- 3 Select **Configure > Resource Limits**.
- 4 Click **Edit**.
- 5 Adjust the **Storage** limit so that it is larger than the total size of the persistent volume claims required for the Prometheus and Grafana extensions.

### Use Your Own TLS Certificate for TKG Extensions

TKG Extensions require TLS certificates. You can install cert-manager to satisfy this prerequisite, or you can use your own self-signed certificates. Certificates from a CA are also supported.

#### About Using Your Own TLS Certificates with TKG Extensions

Installing cert-manager is documented as part of the deployment process for each TKG Extension. Alternatively, you can use your own TLS certificates.

---

**Note** This task assumes you are using a Linux host with OpenSSL installed.

---

#### Generate a Certificate Authority Certificate

In a production environment, you should obtain a certificate from a CA. In a dev or test environment, you can generate your own self signed certificate. To generate a CA certificate, complete the following instructions.

- 1 Generate a CA certificate private key.

```
openssl genrsa -out ca.key 4096
```

- 2 Generate the CA certificate.



Use the following command as a template. Update the values in the `-subj` option based on your environment. If you use an FQDN to connect your TKG Extensions host, you must specify this FQDN as the common name (CN) attribute.

```
openssl req -x509 -new -nodes -sha512 -days 3650 \
  -subj "/C=US/ST=PA/L=PA/O=example/OU=Personal/CN=tkg-extensions.system.tanzu" \
  -key ca.key \
  -out ca.crt
```

## Generate a Server Certificate

The certificate usually contains a `.crt` file and a `.key` file, for example, `tls.crt` and `tls.key`.

- 1 Generate a private key.

```
openssl genrsa -out tls.key 4096
```

- 2 Generate a certificate signing request (CSR).

Use the following command as a template. Update the values in the `-subj` option based on your environment. If you use an FQDN to connect your TKG Extensions host, you must specify this FQDN as the common name (CN) attribute, and use the FQDN in the key and CSR file names.

```
openssl req -sha512 -new \
  -subj "/C=US/ST=PA/L=PA/O=example/OU=Personal/CN=tkg-extensions.system.tanzu" \
  -key tls.key \
  -out tls.csr
```

- 3 Generate a x509 v3 extension file.

Use the following command as a template. Create this file so that you can generate a certificate for your TKG Extensions host that complies with the Subject Alternative Name (SAN) and x509 v3 extension requirements.

```
cat > v3.ext <<-EOF
authorityKeyIdentifier=keyid,issuer
basicConstraints=CA:FALSE
keyUsage = digitalSignature, nonRepudiation, keyEncipherment, dataEncipherment
extendedKeyUsage = serverAuth
subjectAltName = @alt_names

[alt_names]
DNS.1=tkg-extensions.system.tanzu
EOF
```

#### 4 Use the x509 v3 extension file to generate a certificate for your TKG Extensions host

```
openssl x509 -req -sha512 -days 3650 \
-extfile v3.ext \
-CA ca.crt -CAkey ca.key -CAcreateserial \
-in tls.csr \
-out tls.crt
```

#### 5 Copy the content of the files `ca.crt`, `tls.crt` and `tls.key` into the `TKG-EXTENSION-data-values.yaml` file using the following format.

```
ingress:
  tlsCertificate:
    tls.crt: |
      -----BEGIN ...
```

#### 6 Proceed with deploying a supported TKG Extension as documented.

## Deploy and Manage the TKG Extension for Fluent Bit Logging

Fluent Bit is a fast, lightweight log processor and forwarder that lets you collect application data and logs from different sources, unify them, and send them to multiple destinations. Deploy the TKG Extension for Fluent Bit to collect and forward Tanzu Kubernetes cluster logs to your destination of choice.

### Extension Prerequisites

This topic describes how to deploy the TKG Extension v1.3.1 for Fluent Bit. Adhere to the following requirements before deploying the extension.

- Provision a cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).
- Connect to the cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).
- [Download the TKG Extensions v1.3.1 Bundle](#) to your client host where you run `kubectl`.
- [Install the TKG Extensions Prerequisites](#) on the target cluster.

### Deploy the Fluent Bit Extension

The TKG Extension for Fluent Bit installs a Fluent Bit container on the cluster. For more information on this container, see <https://fluentbit.io/>.

Container	Resource Type	Replicas	Description
Fluent Bit	DaemonSet	6	Log collector, aggregator, forwarder

The extension is configured to pull the containers from the VMware public registry at <https://projects.registry.vmware.com/>. If you are using a private registry, change the endpoint URL in the data values and extension configurations files to match. See [Configure the Fluent Bit Extension](#) for a description of the fields and options.

- 1 Verify that you completed each of the extension prerequisites. See [Extension Prerequisites](#).
- 2 Change directory to the Fluent Bit extension.

```
cd /tkg-extensions-v1.3.1+vmware.1/extensions/logging/fluent-bit
```

- 3 Create the `tanzu-system-logging` namespace and the Fluent Bit service account and role objects.

```
kubectl apply -f namespace-role.yaml
```

- 4 Decide which log destination to use for Fluent Bit. Supported outputs include Elasticsearch, HTTP, Kafka, Splunk, and Syslog. See <https://docs.fluentbit.io/manual/pipeline/outputs> for more information.
- 5 Create a Fluent Bit data values file for your chosen log destination by copying one of the `<LOG_BACKEND>/fluent-bit-data-values.example.yaml` files.

There is an example data values file for each supported log destination. The example provides the minimum configuration for that log destination.

```
cp elasticsearch/fluent-bit-data-values.yaml.example elasticsearch/fluent-bit-data-values.yaml
```

```
cp http/fluent-bit-data-values.yaml.example http/fluent-bit-data-values.yaml
```

```
cp kafka/fluent-bit-data-values.yaml.example kafka/fluent-bit-data-values.yaml
```

```
cp splunk/fluent-bit-data-values.yaml.example splunk/fluent-bit-data-values.yaml
```

```
cp syslog/fluent-bit-data-values.yaml.example syslog/fluent-bit-data-values.yaml
```

- 6 Configure the Fluent Bit extension by populating the `<LOG_BACKEND>/fluent-bit-data-values.yaml`. See [Configure the Fluent Bit Extension](#) for a description of the fields and options.

For example, the Fluent Bit syslog configuration requires the following values:

```
logging:
  image:
    repository: projects.registry.vmware.com/tkg # Public registry
tkg:
  instance_name: "<TKG_INSTANCE_NAME>" #mandatory but arbitrary; appears in logs
  cluster_name: "<CLUSTER_NAME>" #name of the target tkgs cluster
fluent_bit:
```

```
output_plugin: "syslog"
syslog:
  host: "<SYSLOG_HOST>"
  port: "<SYSLOG_PORT>"
  mode: "<SYSLOG_MODE>"
  format: "<SYSLOG_FORMAT>"
```

A populated data values file for Fluent Bit syslog might have the following configuration:

```
logging:
  image:
    repository: projects.registry.vmware.com/tkg
tkg:
  instance_name: "tkgs-cluster-1"
  cluster_name: "tkgs-cluster-1"
fluent_bit:
  output_plugin: "syslog"
  syslog:
    host: "10.192.175.59"
    port: "514"
    mode: "tcp"
    format: "rfc5424"
```

## 7 Create a Fluent Bit secret with data values for your log destination.

```
kubectl create secret generic fluent-bit-data-values --from-file=values.yaml=elasticsearch/
fluent-bit-data-values.yaml -n tanzu-system-logging
```

```
kubectl create secret generic fluent-bit-data-values --from-file=values.yaml=kafka/fluent-
bit-data-values.yaml -n tanzu-system-logging
```

```
kubectl create secret generic fluent-bit-data-values --from-file=values.yaml=splunk/fluent-
bit-data-values.yaml -n tanzu-system-logging
```

```
kubectl create secret generic fluent-bit-data-values --from-file=values.yaml=http/fluent-
bit-data-values.yaml -n tanzu-system-logging
```

```
kubectl create secret generic fluent-bit-data-values --from-file=values.yaml=syslog/fluent-
bit-data-values.yaml -n tanzu-system-logging
```

The `secret/fluent-bit-data-values` is created in the `tanzu-system-logging` namespace. Verify using the following command:

```
kubectl get secrets -n tanzu-system-logging
```

## 8 Deploy the Fluent Bit app.

```
kubectl apply -f fluent-bit-extension.yaml
```

On success you should see `app.kappctrl.k14s.io/fluent-bit` created.

## 9 Check the status of the Fluent Bit app.

```
kubectl get app fluent-bit -n tanzu-system-logging
```

On success the status should change from `Reconciling` to `Reconcile succeeded`. If the status is `Reconcile failed`, see [Troubleshoot Fluent Bit Deployment](#).

## 10 View detailed status on the app.

```
kubectl get app fluent-bit -n tanzu-system-logging -o yaml
```

## 11 Verify the Fluent Bit DaemonSet.

```
kubectl get daemonsets -n tanzu-system-logging
```

On success you should see the following:

NAME	DESIRED	CURRENT	READY	UP-TO-DATE	AVAILABLE	NODE SELECTOR	AGE
fluent-bit	6	6	6	6	6	<none>	105s

## Troubleshoot Fluent Bit Deployment

If the deployment or reconciliation fails, run `kubectl get pods -A` to view pod status.

The `fluent-bit` pods should be `Running`. If a pod status is `ImagePullBackOff` or `ImageCrashLoopBackOff`, the container image could not be pulled. Check the registry URL in the data values and the extension YAML files and make sure they are accurate.

Check the container logs, where `name-XXXX` is the unique pod name that you can see when you run `kubectl get pods -A`:

```
kubectl logs pod/fluent-bit-XXXXX -c fluent-bit -n tanzu-system-logging
```

## Update the Fluent Bit Extension

Update the Fluent Bit extension that is deployed to a Tanzu Kubernetes cluster.

### 1 Get Fluent Bit data values from the secret.

```
kubectl get secret fluent-bit-data-values -n tanzu-system-logging -o 'go-template={{ index .data "values.yaml" }}' | base64 -d > fluent-bit-data-values.yaml
```

### 2 Update Fluent Bit data values in `fluent-bit-data-values.yaml`. See [Configure the Fluent Bit Extension](#).

### 3 Update Fluent Bit data values secret.

```
kubectl create secret generic fluent-bit-data-values --from-file=values.yaml=fluent-bit-data-values.yaml -n tanzu-system-logging -o yaml --dry-run | kubectl replace -f-
```

The Fluent Bit extension will be reconciled again with the above data values.

---

**Note** By default, kapp-controller will sync apps every 5 minutes. The update should take effect in 5 minutes or less. If you want the update to take effect immediately, change `syncPeriod` in `fluent-bit-extension.yaml` to a lesser value and apply the Fluent Bit extension using `kubectl apply -f fluent-bit-extension.yaml`.

---

- 4 Check the status of the extension.

```
kubectl get app fluent-bit -n tanzu-system-logging
```

- 5 View detailed status and troubleshoot.

```
kubectl get app fluent-bit -n tanzu-system-logging -o yaml
```

- 6 Troubleshoot if necessary. See [Troubleshoot Fluent Bit Deployment](#).

## Delete the Fluent Bit Extension

Delete the Fluent Bit extension from a Tanzu Kubernetes cluster.

---

**Note** Complete the steps in order. Do not delete the namespace, service account, and role objects before the Fluent Bit app is fully deleted. Doing so can lead to system errors.

---

- 1 Change directory to the Fluent Bit extension.

```
cd extensions/logging/fluent-bit/
```

- 2 Delete the Fluent Bit app.

```
kubectl delete app fluent-bit -n tanzu-system-logging
```

Expected result: `app.kappctrl.k14s.io "fluent-bit" deleted`.

- 3 Verify that the Fluent Bit app is deleted.

```
kubectl get app fluent-bit -n tanzu-system-logging
```

Expected result: `apps.kappctrl.k14s.io "fluent-bit" not found`.

- 4 Delete the `tanzu-system-logging` namespace and the Fluent Bit extension service account and role objects.

```
kubectl delete -f namespace-role.yaml
```

## Upgrade the Fluent Bit Extension

If you have an existing Fluent Bit extension deployed, you can upgrade it to the latest version.

- 1 Export the Fluent Bit configmap.

```
kubectl get configmap fluent-bit -n tanzu-system-logging -o 'go-template={{ index .data "fluent-bit.yaml" }}' > fluent-bit-configmap.yaml
```

- 2 Delete the existing Fluent Bit deployment. See [Delete the Fluent Bit Extension](#).
- 3 Deploy the latest Fluent Bit extension. See [Deploy the Fluent Bit Extension](#).

## Configure the Fluent Bit Extension

The configuration values for are set in `extensions/logging/fluent-bit/<LOG_BACKEND>/fluent-bit-data-values.yaml`.

**Table 14-3. Fluent Bit Extension Configurations**

Parameter	Description	Type	Default
logging.namespace	Namespace where Fluent Bit will be deployed	string	tanzu-system-logging
logging.service_account_name	Name of Fluent Bit service account	string	fluent-bit
logging.cluster_role_name	Name of cluster role which grants get, watch and list permissions to fluent bit	string	fluent-bit-read
logging.image.name	Name of Fluent Bit image	string	fluent-bit
logging.image.tag	Fluent Bit image tag. This value may need to be updated if you are upgrading the version.	string	v1.6.9_vmware.1
logging.image.repository	Location of the repository with the Fluent Bit image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg
logging.image.pullPolicy	Fluent bit image pull policy	string	IfNotPresent
logging.update_strategy	Update strategy to be used when updating DaemonSet	string	RollingUpdate
tkg.cluster_name	Name of the Tanzu Kubernetes cluster	string	Null (Mandatory parameter)

Table 14-3. Fluent Bit Extension Configurations (continued)

Parameter	Description	Type	Default
tkg.instance_name	User-defined name of the TKG instance, shared by the Supervisor Cluster and all Tanzu Kubernetes clusters in one deployment. You can use any name related to the installation.	string	Null (Mandatory parameter)  <b>Note</b> This field is mandatory but arbitrary. It is a name that appears in the logs.
fluent_bit.log_level	Log level to use for Fluent Bit	string	info
fluent_bit.output_plugin	Set the backend to which Fluent Bit should flush the information it gathers	string	Null (Mandatory parameter)
fluent_bit.elasticsearch.host	IP address or hostname of the target Elasticsearch instance	string	Null (Mandatory parameter when output_plugin is elastic search)
fluent_bit.elasticsearch.port	TCP port of the target Elasticsearch instance	integer	Null (Mandatory parameter when output_plugin is elastic search)
fluent_bit.elasticsearch.buffer_size	Specify the buffer size used to read the response from Elasticsearch service. Sets to unlimited if False	string	False
fluent_bit.elasticsearch.tls	Specify the default setting for TLS for Elasticsearch	string	Off
fluent_bit.kafka.broker_service_name	Single or multiple list of Kafka Brokers, e.g., 192.168.1.3:9092	string	Null (Mandatory parameter when output_plugin is kafka)
fluent_bit.kafka.topic_name	Single entry or list of topics separated by (,) that Fluent Bit will use to send messages to Kafka	string	Null (Mandatory parameter when output_plugin is kafka)
fluent_bit.splunk.host	IP address or hostname of the target Splunk Server	string	Null (Mandatory parameter when output_plugin is splunk)
fluent_bit.splunk.port	TCP port of the target Splunk Server	integer	Null (Mandatory parameter when output_plugin is splunk)
fluent_bit.splunk.token	Specify the Authentication Token for the HTTP Event Collector interface	string	Null (Mandatory parameter when output_plugin is splunk)
fluent_bit.http.host	IP address or hostname of the target HTTP Server	string	Null (Mandatory parameter when output_plugin is http)
fluent_bit.http.port	TCP port of the target HTTP Server	integer	Null (Mandatory parameter when output_plugin is http)



Table 14-3. Fluent Bit Extension Configurations (continued)

Parameter	Description	Type	Default
fluent_bit.http.mode	Specify an HTTP URI for the target web server	string	Null (Mandatory parameter when output_plugin is http)
fluent_bit.http.header_key_value	HTTP header key/value pair. Multiple headers can be set	string	Null (Mandatory parameter when output_plugin is http)
fluent_bit.http.format	Specify the data format to be used in the HTTP request body	string	Null (Mandatory parameter when output_plugin is http)
fluent_bit.syslog.host	Domain or IP address of the remote Syslog server	string	Null (Mandatory parameter when output_plugin is syslog)
fluent_bit.syslog.port	TCP or UDP port of the remote Syslog server	integer	Null (Mandatory parameter when output_plugin is syslog)
fluent_bit.syslog.mode	Specify the transport type from TCP, UDP and TLS	string	Null (Mandatory parameter when output_plugin is syslog)
fluent_bit.syslog.format	Specify the data format to be used in the HTTP request body	string	Null (Mandatory parameter when output_plugin is syslog)
host_path.volume_1	Directory path from the host node's file system into the pod, for volume 1	string	/var/log
host_path.volume_2	Directory path from the host node's file system into the pod, for volume 2	string	/var/lib/docker/containers
host_path.volume_3	Directory path from the host node's file system into the pod, for volume 3	string	/run/log
systemd.path	Path to the Systemd journal directory	string	/var/log/journal

## Deploy and Manage the TKG Extension for Contour Ingress

Contour is a Kubernetes ingress controller that uses the Envoy reverse proxy. Deploy the TKG Extension for Contour Ingress to expose ingress routes to services running on Tanzu Kubernetes clusters.

### Extension Prerequisites

This topic describes how to deploy the TKG Extension v1.3.1 for Contour Ingress. Adhere to the following requirements for deploying the extension.

- Provision a cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).

- Connect to the cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).
- [Download the TKG Extensions v1.3.1 Bundle](#) to your client host where you run kubectl.
- [Install the TKG Extensions Prerequisites](#) on the target cluster.

## Deploy the Contour Extension

The TKG Extension for Contour Ingress installs two containers on the cluster: Envoy and Contour. For more information, see <https://projectcontour.io/>.

Container	Resource Type	Replicas	Description
Envoy	DaemonSet	3	High performance reverse proxy
Contour	Deployment	2	Management and configuration server for Envoy

The extension is configured to pull the containers from the VMware public registry at <https://projects.registry.vmware.com/>. If you are using a private registry, change the endpoint URL in the data values and extension configurations to match. See [Configure the Contour Extension](#).

- 1 Verify that you have completed each of the extension prerequisites. See [Extension Prerequisites](#).
- 2 Change directory to where you have downloaded the Contour extension files.

```
cd /tkg-extensions-v1.3.1+vmware.1/extensions/ingress/contour
```

- 3 Run the following command to create the `tanzu-system-ingress` namespace and the Contour service account and role objects.

```
kubectl apply -f namespace-role.yaml
```

- 4 Create a Contour data values file for vSphere.

```
cp vsphere/contour-data-values-lb.yaml.example vsphere/contour-data-values.yaml
```

- 5 Configure Contour by updating the file `vsphere/contour-data-values.yaml`.

The example data values file provides the minimum required configuration. See [Configure the Contour Extension](#) for a description of all configuration fields and options.

For example, the following Contour configuration for vSphere uses a service of type LoadBalancer.

```
infrastructure_provider: "vsphere"
contour:
  image:
    repository: projects.registry.vmware.com/tkg
envoy:
  image:
```

```

repository: projects.registry.vmware.com/tkg
tag: v1.17.3_vmware.1
service:
  type: "LoadBalancer"

```

**Note** It is recommended that you specify the Envoy image version `v1.17.3_vmware.1` so that you do not use Envoy image version `v1.16.2_vmware.1` which has a CVE. For more information, see the [Release Notes](#).

- 6 Create a secret with the data values.

```

kubectl create secret generic contour-data-values --from-file=values.yaml=vsphere/contour-
data-values.yaml -n tanzu-system-ingress

```

The `secret/contour-data-values` is created in the `tanzu-system-ingress` namespace. Verify using the following command:

```

kubectl get secrets -n tanzu-system-ingress

```

- 7 Deploy the Contour Ingress controller app.

```

kubectl apply -f contour-extension.yaml

```

On success you should see `app.kappctrl.k14s.io/contour` created.

- 8 Check the status of the Contour Ingress controller app.

```

kubectl get app contour -n tanzu-system-ingress

```

On success the status changes from `Reconciling` to `Reconcile succeeded`. If the status is `Reconcile failed`, see [Troubleshoot Contour Ingress Deployment](#).

- 9 View detailed information on the Contour Ingress controller app.

```

kubectl get app contour -n tanzu-system-ingress -o yaml

```

- 10 View the Envoy service of type LoadBalancer.

```

kubectl get service envoy -n tanzu-system-ingress -o wide

```

On success you should see the Envoy LoadBalancer details.

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP	PORT(S)	AGE
envoy	LoadBalancer	10.79.65.110	10.178.147.73	80:30437/TCP,443:30589/TCP	2m42s
app=envoy,kapp.k14s.io/app=1629916985840017976					

- 11 Verify the Envoy DaemonSet.

```

kubectl get daemonsets -n tanzu-system-ingress

```

On success you should see the 3-pod Envoy DaemonSet.

NAME	DESIRED	CURRENT	READY	UP-TO-DATE	AVAILABLE	NODE SELECTOR	AGE
envoy	3	3	3	3	3	<none>	6m10s

## 12 Verify the Contour Deployment.

```
kubectl get deployments -n tanzu-system-ingress
```

On success you should see the 2-pod Contour Deployment.

NAME	READY	UP-TO-DATE	AVAILABLE	AGE
contour	2/2	2	2	8m7s

## 13 Verify that the Contour Ingress controller is installed correctly and ready for use.

```
kubectl get pod,svc -n tanzu-system-ingress
```

The status of the Contour and Envoy pods should be `Running`, and the LoadBalancer for the Envoy Service is assigned with an `EXTERNAL-IP`.

NAME	READY	STATUS	RESTARTS	AGE
pod/contour-84bb5475cf-7h4cx	1/1	Running	0	9m52s
pod/contour-84bb5475cf-v8k9r	1/1	Running	0	9m52s
pod/envoy-4828j	2/2	Running	0	9m52s
pod/envoy-c54dw	2/2	Running	0	9m52s
pod/envoy-qpjqp	2/2	Running	0	9m52s

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP
service/contour	ClusterIP	10.105.6.207	<none>
8001/TCP		9m52s	
service/envoy	LoadBalancer	10.79.65.110	10.178.147.73
TCP,443:30589/TCP		9m52s	80:30437/

## Troubleshoot Contour Ingress Deployment

If the deployment or reconciliation fails, run `kubectl get pods -n tanzu-system-ingress` to view pod status. The `contour` and `envoy` pods should be `Running`. If a pod status is `ImagePullBackOff` or `ImageCrashLoopBackOff`, the container image could not be pulled. Check the registry URL in the data values and the extension YAML files and make sure they are accurate.

Check the container logs, where `name-XXXX` is the unique pod name when you run `kubectl get pods -A`:

```
kubectl logs pod/envoy-XXXXXX -c envoy -n tanzu-system-ingress
```

```
kubectl logs pod/contour-XXXXXX -c contour -n tanzu-system-ingress
```

If you see that a Contour pod is stuck in a `ContainerCreating` state without failing with one of the above image errors, and without progressing ("contour-xxxxx has timed out progressing"), and it likely means you have an IP address conflict. Make sure that the Nodes CIDR range you specified when you configured the Workload Network does not conflict with the pods CIDR range in the cluster spec, which by default is `192.168.0.0/16`. If there is a conflict, update the cluster with a different pods subnet, or change the nodes network.

## Update the Contour Extension

Update the Contour extension that is deployed to a Tanzu Kubernetes cluster.

- 1 Get Contour data values from the secret.

```
kubectl get secret contour-data-values -n tanzu-system-ingress -o 'go-template={{ index .data "values.yaml" }}' | base64 -d > contour-data-values.yaml
```

- 2 Update the Contour Ingress data values in `ingress/contour/values.yaml`. See [Configure the Contour Extension](#).

For example, the following Contour configuration for vSphere uses a service of type `LoadBalancer`.

```
infrastructure_provider: "vsphere"
contour:
  image:
    repository: projects.registry.vmware.com/tkg
envoy:
  image:
    repository: projects.registry.vmware.com/tkg
    tag: v1.17.3_vmware.1
  service:
    type: "LoadBalancer"
```

**Note** It is recommended that you specify the Envoy image version `v1.17.3_vmware.1` so that you do not use Envoy image version `v1.16.2_vmware.1` which has a CVE. For more information, see the [Release Notes](#).

- 3 Update the Contour data values secret.

```
kubectl create secret generic contour-data-values --from-file=values.yaml=contour-data-values.yaml -n tanzu-system-ingress -o yaml --dry-run | kubectl replace -f-
```

The Contour extension is reconciled with the new data values.

**Note** By default, kapp-controller will sync apps every 5 minutes. The update should take effect in 5 minutes or less. If you want it to take effect immediately, change `syncPeriod` in `contour-extension.yaml` to a lesser value and redeploy the extension using `kubectl apply -f contour-extension.yaml`.

- 4 Check the status of the app.

```
kubectl get app contour -n tanzu-system-ingress
```

The status should change to `Reconcile Succeeded` once Contour is updated.

- 5 View detailed status.

```
kubectl get app contour -n tanzu-system-ingress -o yaml
```

- 6 Troubleshoot if necessary. See [Troubleshoot Contour Ingress Deployment](#).

## Delete the Contour Extension

Delete the Contour extension from a Tanzu Kubernetes cluster.

---

**Note** Complete the steps in order. Do not delete the namespace, service account, and role objects before the Contour Ingress controller app is fully deleted. Doing so can lead to system errors.

---

- 1 Change directory to the Contour extension.

```
cd extensions/ingress/contour/
```

- 2 Delete the Contour Ingress controller app.

```
kubectl delete app contour -n tanzu-system-ingress
```

Expected result: `app.kappctrl.k14s.io "contour" deleted.`

- 3 Verify that the Contour Ingress controller app is deleted.

```
kubectl get app contour -n tanzu-system-ingress
```

Expected result: `apps.kappctrl.k14s.io "contour" not found.`

- 4 Delete the `tanzu-system-ingress` namespace and the Contour extension service account and role objects.

```
kubectl delete -f namespace-role.yaml
```

## Upgrade the Contour Extension

If you have an existing Contour extension deployed, you can upgrade it to the latest version.

- 1 Export the Contour configmap and save it as backup.

```
kubectl get configmap contour -n tanzu-system-ingress -o 'go-template={{ index .data "contour.yaml" }}' > contour-configmap.yaml
```

- 2 Delete the existing Contour deployment. See [Delete the Contour Extension](#).
- 3 Deploy the latest Contour extension. See [Deploy the Contour Extension](#).

## Configure the Contour Extension

The Contour Ingress controller configuration values are set in `/extensions/ingress/contour/vsphere/contour-data-values.yaml`.

**Table 14-4. Contour Ingress Configuration Parameters**

Parameter	Description	Type	Default
<code>infrastructure_provider</code>	Infrastructure Provider. Supported Values: vsphere, aws, azure	string	Mandatory parameter
<code>contour.namespace</code>	Namespace where contour will be deployed	string	tanzu-system-ingress
<code>contour.config.requestTimeout</code>	Client request timeout to be passed to Envoy	time.Duration	0s See <a href="#">Route Timeout for File Downloads</a> .
<code>contour.config.server.xdsServerType</code>	XDS Server type to use: Supported Values: contour or envoy	string	Null
<code>contour.config.tls.minimumProtocolVersion</code>	Minimum TLS version that Contour will negotiate	string	1.1
<code>contour.config.tls.fallbackCertificate.name</code>	Name of secret containing fallback certificate for requests that don't match SNI defined for a vhost	string	Null
<code>contour.config.tls.fallbackCertificate.namespace</code>	Namespace of secret containing fallback certificate	string	Null
<code>contour.config.tls.envoyClientCertificate.name</code>	Name of the secret to use as client certificate, private key for TLS connection to backend service	string	Null
<code>contour.config.tls.envoyClientCertificate.namespace</code>	Namespace of the secret to use as client certificate, private key for TLS connection to backend service	string	Null
<code>contour.config.ledelection.configmapName</code>	Name of configmap to be used for contour ledelection	string	leader-elect
<code>contour.config.ledelection.configmapNamespace</code>	Namespace of contour ledelection configmap	string	tanzu-system-ingress
<code>contour.config.disablePermitInsecure</code>	Disables ingressroute permitInsecure field	boolean	false
<code>contour.config.accesslogFormat</code>	Access log format	string	envoy

Table 14-4. Contour Ingress Configuration Parameters (continued)

Parameter	Description	Type	Default
contour.config.jsonFields	Fields that will be logged	array of strings	<a href="https://godoc.org/github.com/projectcontour/contour/internal/envoy#JSONFields">https://godoc.org/github.com/projectcontour/contour/internal/envoy#JSONFields</a>
contour.config.useProxyProtocol	<a href="https://projectcontour.io/guides/proxy-protocol/">https://projectcontour.io/guides/proxy-protocol/</a>	boolean	false
contour.config.defaultHTTPVersions	HTTP versions that Contour should program Envoy to serve	array of strings	"HTTP/1.1 HTTP2"
contour.config.timeouts.requestTimeout	The timeout for an entire request	time.Duration	Null (timeout is disabled)
contour.config.timeouts.connectionIdleTimeout	The time to wait before terminating an idle connection	time.Duration	60s
contour.config.timeouts.streamIdleTimeout	The time to wait before terminating a request or stream with no activity	time.Duration	5m
contour.config.timeouts.maxConnectionDuration	The time to wait before terminating a connection irrespective of activity or not	time.Duration	Null (timeout is disabled)
contour.config.timeouts.ConnectionShutdownGracePeriod	The time to wait between sending an initial and final GOAWAY	time.Duration	5s
contour.config.cluster.dnsLookupFamily	dns-lookup-family to use for upstream requests to externalName type services from an HTTPProxy route	string	Null (Supported Values: auto, v4, v6)
contour.config.debug	Turn on contour debugging	boolean	false
contour.config.ingressStatusAddress	The address to set on status of every Ingress resource	string	Null
contour.certificate.duration	Duration for contour certificate	time.Duration	8760h
contour.certificate.renewBefore	Duration before contour certificate should be renewed	time.Duration	360h
contour.deployment.replicas	No of contour replicas	integer	2



Table 14-4. Contour Ingress Configuration Parameters (continued)

Parameter	Description	Type	Default
contour.image.repository	Location of the repository with the Contour image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg
contour.image.name	Name of contour image	string	contour
contour.image.tag	Contour image tag. This value may need to be updated if you are upgrading the Contour version.	string	v1.11.0_vmware.1
contour.image.pullPolicy	Contour image pull policy	string	IfNotPresent
envoy.image.repository	Location of the repository with the Envoy image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg
envoy.image.name	Name of envoy image	string	envoy
envoy.image.tag	Envoy image tag. This value may need to be updated if you upgrading the Envoy version.	string	v1.17.3_vmware.1 <b>Note</b> Do not use Envoy image v1.16.2_vmware.1 due to a CVE. For more information, see the <a href="#">Release Notes</a> .
envoy.image.pullPolicy	Envoy image pull policy	string	IfNotPresent
envoy.hostPort.enable	Flag to expose envoy ports on host	boolean	true
envoy.hostPort.http	Envoy HTTP host port	integer	80
envoy.hostPort.https	Envoy HTTPS host port	integer	443
envoy.service.type	Type of service to expose envoy. Supported Values: ClusterIP, NodePort, LoadBalancer	string	Mandatory parameter for vSphere: NodePort or LoadBalancer, AWS: LoadBalancer, Azure: LoadBalancer
envoy.service.annotations	Envoy service annotations	Map (Key-values)	Empty Map
envoy.service.externalTrafficPolicy	External traffic policy of envoy service. Supported Values: Local, Cluster	string	Cluster

Table 14-4. Contour Ingress Configuration Parameters (continued)

Parameter	Description	Type	Default
envoy.service.nodePort.http	Desired nodePort for service of type NodePort used for http requests	integer	Null - Kubernetes assigns a dynamic node port
envoy.service.nodePort.https	Desired nodePort for service of type NodePort used for HTTPS requests	integer	Null - Kubernetes assigns a dynamic node port
envoy.deployment.hostNetwork	Run envoy on hostNetwork	boolean	false
envoy.service.aws.LBType	AWS LB type to be used for exposing envoy service. Supported Values: classic, nlb	string	classic
envoy.loglevel	Log level to use for envoy	string	info

## Route Timeout for File Downloads

The parameter `contour.config.requestTimeout` defines the Contour route timeout. The default value is `0s`. For most use cases, this setting is appropriate. However, if you are attempting to use Contour with Envoy for file transfer, this value requires further explanation.

According to the [Contour documentation](#), a timeout value of `0s` will be treated as if the field were not set, that is, Contour will defer to Envoy and use its default behavior. According to the [Envoy documentation](#), by default Envoy has a 15 second timeout. In addition, Envoy expects the entire request-response operation to be completed in 15 seconds. For large file transfers, this may not be enough time. To disable the Envoy timeout, set the `contour.config.requestTimeout` value to `0`.

## Deploy and Manage the TKG Extension for Prometheus Monitoring

Prometheus is a system and service monitoring system. It collects metrics from configured targets at given intervals, evaluates rule expressions, displays the results, and can trigger alerts if some condition is observed to be true. Alertmanager handles alerts generated by Prometheus and routes them to their receiving endpoints. Deploy the TKG Extension for Prometheus to collect and view metrics for Tanzu Kubernetes clusters.

### Extension Prerequisites

This topic describes how to deploy the TKG Extension v1.3.1 for Prometheus with Alertmanager for cluster monitoring. Adhere to the following requirements before deploying the extension.

- Provision a cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).

---

**Note** To install the Prometheus extension, you must deploy a cluster that uses the default `serviceDomain` (`cluster.local`).

---

- Connect to the cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).
- [Download the TKG Extensions v1.3.1 Bundle](#) to the client host where you run kubectl.
- [Install the TKG Extensions Prerequisites](#) on the target Tanzu Kubernetes cluster.

In addition to the general requirements, Prometheus monitoring requires a default persistent storage class. You can create a cluster with a default persistent storage class, or specify one in the Prometheus configuration file when deploying the extension. See [Review Persistent Storage Requirements for TKG Extensions](#).

## Deploy the Prometheus Extension

The TKG Extension for Prometheus installs several containers. For more information, see <https://prometheus.io/>.

Container	Resource Type	Replicas	Description
prometheus-alertmanager	Deployment	1	Handles alerts sent by client applications such as the Prometheus server.
prometheus-cadvisor	DaemonSet	5	Analyzes and exposes resource usage and performance data from running containers
prometheus-kube-state-metrics	Deployment	1	Monitors node status and capacity, replica-set compliance, pod, job, and cronjob status, resource requests and limits.
prometheus-node-exporter	DaemonSet	5	Exporter for hardware and OS metrics exposed by kernels.
prometheus-pushgateway	Deployment	1	Service that allows you to push metrics from jobs which cannot be scraped.
prometheus-server	Deployment	1	Provides core functionality, including scraping, rule processing, and alerting.

The extension is configured to pull the containers from the VMware public registry at <https://projects.registry.vmware.com/>. If you are using a private registry, change the endpoint URL in the data values and extension configurations to match. See [Configure the Prometheus Extension](#).

- 1 Verify that you have completed each of the extension prerequisites. See [Extension Prerequisites](#).
- 2 Change directory to the Prometheus extension.

```
cd /tkg-extensions-v1.3.1+vmware.1/extensions/monitoring/prometheus
```

- 3 Create the `tanzu-system-monitoring` namespace and Prometheus service account and role objects.

```
kubectl apply -f namespace-role.yaml
```

- 4 Create a Prometheus data values file.

The example data values file provides the minimum configuration.

```
cp prometheus-data-values.yaml.example prometheus-data-values.yaml
```

- 5 Configure the Prometheus extension by updating `prometheus-data-values.yaml`. See [Configure the Prometheus Extension](#) for a description of the fields and options.

If the cluster is not provisioned with a default persistent storage class, you can specify it in the data values file. Also, make sure the namespace has sufficient storage for the persistent volume claims.

```
monitoring:
  prometheus_server:
    image:
      repository: projects.registry.vmware.com/tkg/prometheus
    pvc:
      storage_class: vwt-storage-policy
      storage: "8Gi"
  alertmanager:
    image:
      repository: projects.registry.vmware.com/tkg/prometheus
    pvc:
      storage_class: vwt-storage-policy
      storage: "8Gi"
  ...
```

- 6 Create the Prometheus secret using the `prometheus-data-values` file.

```
kubectl create secret generic prometheus-data-values --from-file=values.yaml=prometheus-
data-values.yaml -n tanzu-system-monitoring
```

The `prometheus-data-values` secret is created in the `tanzu-system-monitoring` namespace. Verify using `kubectl get secrets -n tanzu-system-monitoring`.

- 7 Deploy the Prometheus extension.

```
kubectl apply -f prometheus-extension.yaml
```

On success the Prometheus app is created: `app.kappctrl.k14s.io/prometheus` created.

- 8 Check the status of the Prometheus app.

```
kubectl get app prometheus -n tanzu-system-monitoring
```

The status should change from `Reconciling` to `Reconcile succeeded`. If the status is `Reconcile failed`, see [Troubleshooting](#).

- 9 View detailed information on the Prometheus app.

```
kubectl get app prometheus -n tanzu-system-monitoring -o yaml
```

## 10 Verify Prometheus DaemonSets.

```
kubectl get daemonsets -n tanzu-system-monitoring
```

## 11 Verify Prometheus Deployments.

```
kubectl get deployments -n tanzu-system-monitoring
```

## Troubleshoot Prometheus Deployment

If the deployment or reconciliation fails, run `kubectl get pods -A` to view the status of the pods. Under normal conditions you should see that the pods are `Running`. If the status is `ImagePullBackOff` or `ImageCrashLoopBackOff`, the container image could not be pulled from the registry. Check the URL in the data values and the extension YAML files and make sure they are accurate.

Check the container logs, where `name-XXXX` is the unique pod name when you run `kubectl get pods -A`:

```
kubectl logs pod/prometheus-alertmanager-XXXXX -c prometheus-alertmanager -n tanzu-system-monitoring
```

```
kubectl logs pod/prometheus-server-XXXXX -c prometheus-server -n tanzu-system-monitoring
```

## Update the Prometheus Extension

Update the configuration for a Prometheus extension that is deployed to a Tanzu Kubernetes cluster.

## 1 Get Prometheus data values from the secret.

```
kubectl get secret prometheus-data-values -n tanzu-system-monitoring -o 'go-template={{ index .data "values.yaml" }}' | base64 -d > prometheus-data-values.yaml
```

## 2 Update the Prometheus data values secret.

```
kubectl create secret generic prometheus-data-values --from-file=values.yaml=prometheus-data-values.yaml -n tanzu-system-monitoring -o yaml --dry-run | kubectl replace -f-
```

The Prometheus extension will be reconciled with the updated data values.

---

**Note** By default, kapp-controller will sync apps every 5 minutes. The update should take effect in 5 minutes or less. If you want the update to take effect immediately, change `syncPeriod` in `prometheus-extension.yaml` to a lesser value and apply the Fluent Bit extension using `kubectl apply -f prometheus-extension.yaml`.

---

## 3 Check the status of the extension.

```
kubectl get app prometheus -n tanzu-system-monitoring
```

The status should change to `Reconcile Succeeded` once Prometheus is updated.

- 4 View detailed status and troubleshoot.

```
kubectl get app prometheus -n tanzu-system-monitoring -o yaml
```

## Delete the Prometheus Extension

Delete the Prometheus extension from a Tanzu Kubernetes cluster.

---

**Note** Complete the steps in order. Do not delete the namespace, service account, and role objects before the Prometheus app is fully deleted. Doing so can lead to system errors.

---

**Caution** Both Prometheus and Grafana use the same namespace. Deleting the namespace is destructive for any extension deployed there. If Grafana is deployed, do not delete the namespace before deleting Grafana.

---

- 1 Change directory to the Prometheus extension.

```
cd /extensions/monitoring/prometheus/
```

- 2 Delete the Prometheus app.

```
kubectl delete app prometheus -n tanzu-system-monitoring
```

Expected result: `app.kappctrl.k14s.io "prometheus" deleted.`

- 3 Verify that the Prometheus app is deleted.

```
kubectl get app prometheus -n tanzu-system-monitoring
```

Expected result: `apps.kappctrl.k14s.io "prometheus" not found.`

- 4 Delete the `tanzu-system-monitoring` namespace and the Prometheus service account and role objects.

---

**Warning** Do not perform this step if Grafana is deployed.

---

```
kubectl delete -f namespace-role.yaml
```

- 5 If you want to redeploy Prometheus, remove the secret `prometheus-data-values`.

```
kubectl delete secret prometheus-data-values -n tanzu-system-monitoring
```

Expected result: `secret "prometheus-data-values" deleted.`

## Upgrade the Prometheus Extension

If you have an existing Prometheus extension deployed, you can upgrade it to the latest version.

- 1 Export the Prometheus configmap and save it as backup.

```
kubectl get configmap prometheus -n tanzu-system-monitoring -o 'go-template={{ index .data "prometheus.yaml" }}' > prometheus-configmap.yaml
```

- 2 Delete the existing Prometheus deployment. See [Delete the Prometheus Extension](#).
- 3 Deploy the Prometheus extension. See [Deploy the Prometheus Extension](#).

## Configure the Prometheus Extension

The Prometheus configuration is set in `/extensions/monitoring/prometheus/prometheus-data-values.yaml`.

**Table 14-5. Prometheus Configuration Parameters**

Parameter	Description	Type	Default
monitoring.namespace	Namespace where Prometheus will be deployed	string	tanzu-system-monitoring
monitoring.create_namespace	The flag indicates whether to create the namespace specified by monitoring.namespace	boolean	false
monitoring.prometheus_server.config.prometheus_yaml	Kubernetes cluster monitor config details to be passed to Prometheus	yaml file	prometheus.yaml
monitoring.prometheus_server.config.alerting_rules_yaml	Detailed alert rules defined in Prometheus	yaml file	alerting_rules.yaml
monitoring.prometheus_server.config.recording_rules_yaml	Detailed record rules defined in Prometheus	yaml file	recording_rules.yaml
monitoring.prometheus_server.service.type	Type of service to expose Prometheus. Supported Values: ClusterIP	string	ClusterIP
monitoring.prometheus_server.enable_alerts.kubernetes_api	Enable SLO alerting for the Kubernetes API in Prometheus	boolean	true
monitoring.prometheus_server.sc.aws_type	AWS type defined for storageclass on AWS	string	gp2
monitoring.prometheus_server.sc.aws_fsType	AWS file system type defined for storageclass on AWS	string	ext4

Table 14-5. Prometheus Configuration Parameters (continued)

Parameter	Description	Type	Default
monitoring.prometheus_server.sc.allowVolumeExpansion	Define if volume expansion allowed for storageclass on AWS	boolean	true
monitoring.prometheus_server.pvc.annotations	Storage class annotations	map	{}
monitoring.prometheus_server.pvc.storage_class	Storage class to use for persistent volume claim. By default this is null and default provisioner is used	string	null
monitoring.prometheus_server.pvc.accessMode	Define access mode for persistent volume claim. Supported values: ReadWriteOnce, ReadOnlyMany, ReadWriteMany	string	ReadWriteOnce
monitoring.prometheus_server.pvc.storage	Define storage size for persistent volume claim	string	8Gi
monitoring.prometheus_server.deployment.replicas	Number of prometheus replicas	integer	1
monitoring.prometheus_server.image.repository	Location of the repository with the Prometheus image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg/prometheus
monitoring.prometheus_server.image.name	Name of Prometheus image	string	prometheus
monitoring.prometheus_server.image.tag	Prometheus image tag. This value may need to be updated if you are upgrading the version.	string	v2.17.1_vmware.1
monitoring.prometheus_server.image.pullPolicy	Prometheus image pull policy	string	IfNotPresent
monitoring.alertmanager_config.slack_demo	Slack notification configuration for Alertmanager	string	<pre> slack_demo:   name: slack_demo   slack_configs:   -     api_url: https:// hooks.slack.com   channel: '#alertmanager- test' </pre>



Table 14-5. Prometheus Configuration Parameters (continued)

Parameter	Description	Type	Default
monitoring.alertmanager.config.email_receiver	Email notification configuration for Alertmanager	string	<pre> email_receiver:   name: email-receiver   email_configs:   - to:     demo@tanzu.com     send_resolved:     false     from: from-email@tanzu.com     smarthost:     smtp.eample.com:25     require_tls:     false </pre>
monitoring.alertmanager.service.type	Type of service to expose Alertmanager. Supported Values: ClusterIP	string	ClusterIP
monitoring.alertmanager.image.repository	Location of the repository with the Alertmanager image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg/prometheus
monitoring.alertmanager.image.name	Name of Alertmanager image	string	alertmanager
monitoring.alertmanager.image.tag	Alertmanager image tag. This value may need to be updated if you are upgrading the version.	string	v0.20.0_vmware.1
monitoring.alertmanager.image.pullPolicy	Alertmanager image pull policy	string	IfNotPresent
monitoring.alertmanager.pvc.annotations	Storage class annotations	map	{}
monitoring.alertmanager.pvc.storage_class	Storage class to use for persistent volume claim. By default this is null and default provisioner is used.	string	null
monitoring.alertmanager.pvc.accessMode	Define access mode for persistent volume claim. Supported values: ReadWriteOnce, ReadOnlyMany, ReadWriteMany	string	ReadWriteOnce
monitoring.alertmanager.pvc.storage	Define storage size for persistent volume claim	string	2Gi

Table 14-5. Prometheus Configuration Parameters (continued)

Parameter	Description	Type	Default
monitoring.alertmanager.deployment.replicas	Number of alertmanager replicas	integer	1
monitoring.kube_state_metrics.image.repository	Repository containing kube-state-metrics image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg/prometheus
monitoring.kube_state_metrics.image.name	Name of kube-state-metrics image	string	kube-state-metrics
monitoring.kube_state_metrics.image.tag	kube-state-metrics image tag. This value may need to be updated if you are upgrading the version.	string	v1.9.5_vmware.1
monitoring.kube_state_metrics.image.pullPolicy	kube-state-metrics image pull policy	string	IfNotPresent
monitoring.kube_state_metrics.deployment.replicas	Number of kube-state-metrics replicas	integer	1
monitoring.node_exporter.image.repository	Repository containing node-exporter image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg/prometheus
monitoring.node_exporter.image.name	Name of node-exporter image	string	node-exporter
monitoring.node_exporter.image.tag	node-exporter image tag. This value may need to be updated if you are upgrading the version.	string	v0.18.1_vmware.1
monitoring.node_exporter.image.pullPolicy	node-exporter image pull policy	string	IfNotPresent
monitoring.node_exporter.hostNetwork	If set to <code>hostNetwork: true</code> , the pod can use the network namespace and network resources of the node.	boolean	false
monitoring.node_exporter.deployment.replicas	Number of node-exporter replicas	integer	1

Table 14-5. Prometheus Configuration Parameters (continued)

Parameter	Description	Type	Default
monitoring.pushgateway.image.repository	Repository containing pushgateway image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg/prometheus
monitoring.pushgateway.image.name	Name of pushgateway image	string	pushgateway
monitoring.pushgateway.image.tag	pushgateway image tag. This value may need to be updated if you are upgrading the version.	string	v1.2.0_vmware.1
monitoring.pushgateway.image.pullPolicy	pushgateway image pull policy	string	IfNotPresent
monitoring.pushgateway.deployment.replicas	Number of pushgateway replicas	integer	1
monitoring.cadvisor.image.repository	Repository containing cadvisor image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg/prometheus
monitoring.cadvisor.image.name	Name of cadvisor image	string	cadvisor
monitoring.cadvisor.image.tag	cadvisor image tag. This value may need to be updated if you are upgrading the version.	string	v0.36.0_vmware.1
monitoring.cadvisor.image.pullPolicy	cadvisor image pull policy	string	IfNotPresent
monitoring.cadvisor.deployment.replicas	Number of cadvisor replicas	integer	1
monitoring.ingress.enabled	Enable/disable ingress for prometheus and alertmanager	boolean	false To use ingress, set this field to <code>true</code> and deploy <a href="#">Deploy and Manage the TKG Extension for Contour Ingress</a> . To access Prometheus, update your local <code>/etc/hosts</code> with an entry that maps <code>prometheus.system.tanzu</code> to a worker node IP address.

Table 14-5. Prometheus Configuration Parameters (continued)

Parameter	Description	Type	Default
monitoring.ingress.virtual_host_fqdn	Hostname for accessing Prometheus and Alertmanager	string	prometheus.system.tanzu
monitoring.ingress.prometheus_prefix	Path prefix for prometheus	string	/
monitoring.ingress.alertmanager_prefix	Path prefix for alertmanager	string	/alertmanager/
monitoring.ingress.tlsCertificate.tls.crt	Optional cert for ingress if you want to use your own TLS cert. A self signed cert is generated by default	string	Generated cert
monitoring.ingress.tlsCertificate.tls.key	Optional cert private key for ingress if you want to use your own TLS cert.	string	Generated cert key

Table 14-6. Configurable Fields for Prometheus\_Server Configmap

Parameter	Description	Type	Default
evaluation_interval	frequency to evaluate rules	duration	1m
scrape_interval	frequency to scrape targets	duration	1m
scrape_timeout	How long until a scrape request times out	duration	10s
rule_files	Rule files specifies a list of globs. Rules and alerts are read from all matching files	yaml file	
scrape_configs	A list of scrape configurations.	list	
job_name	The job name assigned to scraped metrics by default	string	
kubernetes_sd_configs	List of Kubernetes service discovery configurations.	list	
relabel_configs	List of target relabel configurations.	list	
action	Action to perform based on regex matching.	string	
regex	Regular expression against which the extracted value is matched.	string	
source_labels	The source labels select values from existing labels.	string	
scheme	Configures the protocol scheme used for requests.	string	

Table 14-6. Configurable Fields for Prometheus\_Server Configmap (continued)

Parameter	Description	Type	Default
tls_config	Configures the scrape request's TLS settings.	string	
ca_file	CA certificate to validate API server certificate with.	filename	
insecure_skip_verify	Disable validation of the server certificate.	boolean	
bearer_token_file	Optional bearer token file authentication information.	filename	
replacement	Replacement value against which a regex replace is performed if the regular expression matches.	string	
target_label	Label to which the resulting value is written in a replace action.	string	

Table 14-7. Configurable Fields for Alertmanager Configmap

Parameter	Description	Type	Default
resolve_timeout	ResolveTimeout is the default value used by alertmanager if the alert does not include EndsAt	duration	5m
smtp_smarthost	The SMTP host through which emails are sent.	duration	1m
slack_api_url	The Slack webhook URL.	string	global.slack_api_url
pagerduty_url	The pagerduty URL to send API requests to.	string	global.pagerduty_url
templates	Files from which custom notification template definitions are read	file path	
group_by	group the alerts by label	string	
group_interval	set time to wait before sending a notification about new alerts that are added to a group	duration	5m
group_wait	How long to initially wait to send a notification for a group of alerts	duration	30s
repeat_interval	How long to wait before sending a notification again if it has already been sent successfully for an alert	duration	4h

Table 14-7. Configurable Fields for Alertmanager Configmap (continued)

Parameter	Description	Type	Default
receivers	A list of notification receivers.	list	
severity	Severity of the incident.	string	
channel	The channel or user to send notifications to.	string	
html	The HTML body of the email notification.	string	
text	The text body of the email notification.	string	
send_resolved	Whether or not to notify about resolved alerts.	filename	
email_configs	Configurations for email integration	boolean	

Annotations on pods allow a fine control of the scraping process. These annotations must be part of the pod metadata. They will have no effect if set on other objects such as Services or DaemonSets.

Table 14-8. Prometheus Pod Annotations

Pod Annotation	Description
<code>prometheus.io/scrape</code>	The default configuration will scrape all pods and, if set to false, this annotation will exclude the pod from the scraping process.
<code>prometheus.io/path</code>	If the metrics path is not <code>/metrics</code> , define it with this annotation.
<code>prometheus.io/port</code>	Scrape the pod on the indicated port instead of the pod's declared ports (default is a port-free target if none are declared).

The DaemonSet manifest below will instruct Prometheus to scrape all of its pods on port 9102.

```

apiVersion: apps/v1beta2 # for versions before 1.8.0 use extensions/v1beta1
kind: DaemonSet
metadata:
  name: fluentd-elasticsearch
  namespace: weave
  labels:
    app: fluentd-logging
spec:
  selector:
    matchLabels:
      name: fluentd-elasticsearch
  template:
    metadata:

```

```

labels:
  name: fluentd-elasticsearch
annotations:
  prometheus.io/scrape: 'true'
  prometheus.io/port: '9102'
spec:
  containers:
  - name: fluentd-elasticsearch
    image: gcr.io/google-containers/fluentd-elasticsearch:1.20

```

## Deploy and Manage the TKG Extension for Grafana Monitoring

Grafana lets you query, visualize, alert on, and explore metrics no matter where they are stored. Grafana provides tools to form graphs and visualizations from application data. Deploy the TKG Extension for Grafana to generate and view metrics for Tanzu Kubernetes clusters.

### Grafana Extension Requirements

This topic describes how to deploy and manage the TKG Extension v1.3.1 for Grafana.

Adhere to the following prerequisites to deploy the extension.

- Provision a cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).

---

**Note** You must deploy a cluster that uses the default serviceDomain (`cluster.local`).

---

- Connect to the cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).
- [Download the TKG Extensions v1.3.1 Bundle](#) to the client host where you run `kubectl` commands.
- [Install the TKG Extensions Prerequisites](#) on the target cluster.

In addition, the Grafana monitoring extension requires a default persistent storage class. You can either create a cluster with a default persistent storage class, or specify one in the Prometheus configuration file when deploying the extension. See [Review Persistent Storage Requirements for TKG Extensions](#).

### Deploy the Grafana Extension for Visualization and Analytics

The TKG Extension for Grafana deploys a single container. For more information, see <https://grafana.com/>.

Container	Resource Type	Replicas	Description
Grafana	Deployment	2	Data visualization

The extension is configured to pull the containers from the VMware public registry at <https://projects.registry.vmware.com/>. If you are using a private registry, change the endpoint URL in the data values and extension configurations to match. See [Configure the Grafana Extension](#).

- 1 Verify that you have completed each of the extension prerequisites. See [Grafana Extension Requirements](#).

## 2 Change directory to the Grafana extension.

```
cd /tkg-extensions-v1.3.1+vmware.1/extensions/monitoring/grafana
```

## 3 Create the `tanzu-system-monitoring` namespace and Grafana service account and role objects.

```
kubectl apply -f namespace-role.yaml
```

## 4 Create a Grafana data values file.

The example data values file provides the minimum required configuration.

```
cp grafana-data-values.yaml.example grafana-data-values.yaml
```

## 5 Configure the Grafana extension by updating `grafana-data-values.yaml`.

Customize the configuration as needed. See [Configure the Grafana Extension](#).

The `admin_password` should be base64 encoded, but it will not block the deployment of the extension if it is not. In the example below, the password "admin" is base64 encoded. Encode your own Grafana password here: <https://www.base64encode.org/>.

If the cluster is not provisioned with a default storage class, you can specify it in the data values file. Also, make sure the namespace has sufficient storage for the persistent volume claims.

```
monitoring:
  grafana:
    image:
      repository: "projects.registry.vmware.com/tkg/grafana"
    pvc:
      storage_class: vwt-storage-policy
      storage: "8Gi"
    secret:
      admin_password: "YWRtaW4="
  grafana_init_container:
    image:
      repository: "projects.registry.vmware.com/tkg/grafana"
  grafana_sc_dashboard:
    image:
      repository: "projects.registry.vmware.com/tkg/grafana"
```

## 6 Create the Grafana secret with `grafana-data-values` file.

```
kubectl create secret generic grafana-data-values --from-file=values.yaml=grafana-data-values.yaml -n tanzu-system-monitoring
```

The `grafana-data-values` secret is created in the `tanzu-system-monitoring` namespace. Verify using `kubectl get secrets -n tanzu-system-monitoring`.



## 7 Deploy the Grafana extension.

```
kubectl apply -f grafana-extension.yaml
```

On success the Grafana app is created: `app.kappctrl.k14s.io/grafana` created.

## 8 Check the status of the Grafana app.

```
kubectl get app grafana -n tanzu-system-monitoring
```

The status should change from `Reconciling` to `Reconcile succeeded`. If the status is `Reconcile failed`, see [Troubleshooting](#).

## 9 View detailed status on the Grafana app.

```
kubectl get app grafana -n tanzu-system-monitoring -o yaml
```

## 10 Verify the Grafana Deployment.

```
kubectl get deployments -n tanzu-system-monitoring
```

## Troubleshoot Grafana Deployment

If the deployment or reconciliation fails, run `kubectl get pods -A` to view pod status.

The `contour` and `envoy` pods should be `Running`. If a pod status is `ImagePullBackOff` or `ImageCrashLoopBackOff`, the container image could not be pulled. Check the registry URL in the data values and the extension YAML files and make sure they are accurate.

Check the container logs, where `name-XXXX` is the unique pod name when you run `kubectl get pods -A`:

```
kubectl logs pod/grafana-XXXX -c grafana -n tanzu-system-monitoring
```

## Update the Grafana Extension

Update the Grafana extension that is deployed to a Tanzu Kubernetes cluster.

### 1 Get the current Grafana data values from the `grafana-data-values` secret.

```
kubectl get secret grafana-data-values -n tanzu-system-monitoring -o 'go-template={{ index .data "values.yaml" }}' | base64 -d > grafana-data-values.yaml
```

### 2 Update the Grafana data values in `grafana-data-values.yaml`. See [Configure the Grafana Extension](#).

### 3 Update the Grafana data values secret.

```
kubectl create secret generic grafana-data-values --from-file=values.yaml=grafana-data-values.yaml -n tanzu-system-monitoring -o yaml --dry-run | kubectl replace -f-
```

The Grafana extension is reconciled with the updated data values.

---

**Note** By default, kapp-controller will sync apps every 5 minutes. The update should take effect in 5 minutes or less. If you want the update to take effect immediately, change `syncPeriod` in `grafana-extension.yaml` to a lesser value and apply the Grafana extension using `kubectl apply -f grafana-extension.yaml`.

---

- 4 Check the status of the extension.

```
kubectl get app grafana -n tanzu-system-monitoring
```

The status should change to `Reconcile Succeeded` once Grafana is updated.

- 5 View detailed status and troubleshoot if necessary.

```
kubectl get app grafana -n tanzu-system-monitoring -o yaml
```

## Delete the Grafana Extension

Delete the Grafana extension from a Tanzu Kubernetes cluster.

---

**Note** Complete the steps in order. Do not delete the namespace, service account, and role objects before the Grafana app is fully deleted. Doing so can lead to system errors.

---

**Note** The Prometheus and Grafana extensions are deployed to the same namespace: `tanzu-system-monitoring`. If you have deployed both extensions to the same cluster, delete each extension before you delete the namespace.

---

- 1 Change directory to the Grafana extension.

```
cd /tkg-extensions-v1.3.1+vmware.1/extensions/monitoring/grafana
```

- 2 Delete the Grafana app.

```
kubectl delete app grafana -n tanzu-system-monitoring
```

Expected result: `app.kappctrl.k14s.io "grafana" deleted.`

- 3 Verify that the Grafana app is deleted.

```
kubectl get app grafana -n tanzu-system-monintoring
```

Expected result: `apps.kappctrl.k14s.io "grafana" not found.`

- 4 Delete the `tanzu-system-monitoring` namespace and the Grafana service account and role objects.

---

**Warning** Do not perform this step if Prometheus is deployed.

---

```
kubectl delete -f namespace-role.yaml
```

- If you want to redeploy Grafana, remove the secret `grafana-data-values`.

```
kubectl delete secret grafana-data-values -n tanzu-system-monitoring
```

Expected result: secret "grafana-data-values" deleted.

## Upgrade the Grafana Extension

If you have an existing Grafana extension deployed, you can upgrade it to use the latest version.

- Export the Grafana configmap and save it as backup.

```
kubectl get configmap grafana -n tanzu-system-monitoring -o 'go-template={{ index .data "grafana.yaml" }}' > grafana-configmap.yaml
```

- Delete the existing Grafana extension. See [Delete the Grafana Extension](#).
- Deploy the Grafana extension. See [Deploy the Grafana Extension for Visualization and Analytics](#).

## Configure the Grafana Extension

The Grafana configuration is set in `/tkg-extensions-v1.3.1+vmware.1/extensions/monitoring/grafana/grafana-data-values.yaml`.

**Table 14-9. Grafana Configuration Parameters**

Parameter	Description	Type	Default
<code>monitoring.namespace</code>	Namespace where Prometheus will be deployed	string	<code>tanzu-system-monitoring</code>
<code>monitoring.create_namespace</code>	The flag indicates whether to create the namespace specified by <code>monitoring.namespace</code>	boolean	<code>false</code>
<code>monitoring.grafana.cluster_role.apiGroups</code>	api group defined for grafana clusterrole	list	<code>[""]</code>
<code>monitoring.grafana.cluster_role.resources</code>	resources defined for grafana clusterrole	list	<code>["configmaps", "secrets"]</code>
<code>monitoring.grafana.cluster_role.verbs</code>	access permission defined for clusterrole	list	<code>["get", "watch", "list"]</code>
<code>monitoring.grafana.config.grafana_ini</code>	Grafana configuration file details	config file	<code>grafana.ini</code> In this file, <code>grafana_net</code> URL is used to integrate with Grafana, for example, to import the dashboard directly from Grafana.com.
<code>monitoring.grafana.config.datasource.type</code>	Grafana datasource type	string	<code>prometheus</code>

Table 14-9. Grafana Configuration Parameters (continued)

Parameter	Description	Type	Default
monitoring.grafana.config.datasources.access	access mode. proxy or direct (Server or Browser in the UI)	string	proxy
monitoring.grafana.config.datasources.isDefault	mark as default Grafana datasource	boolean	true
monitoring.grafana.config.provider_yaml	Config file to define grafana dashboard provider	yaml file	provider.yaml
monitoring.grafana.service.type	Type of service to expose Grafana. Supported Values: ClusterIP, NodePort, LoadBalancer	string	vSphere: NodePort, aws/azure: LoadBalancer
monitoring.grafana.pvc.storage_class	Define access mode for persistent volume claim. Supported values: ReadWriteOnce, ReadOnlyMany, ReadWriteMany	string	ReadWriteOnce
monitoring.grafana.pvc.storage	Define storage size for persistent volume claim	string	2Gi
monitoring.grafana.deployment.replicas	Number of grafana replicas	integer	1
monitoring.grafana.image.repository	Location of the repository with the Grafana image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg/grafana
monitoring.grafana.image.name	Name of Grafana image	string	grafana
monitoring.grafana.image.tag	Grafana image tag. This value may need to be updated if you are upgrading the version.	string	v7.3.5_vmware.1
monitoring.grafana.image.pullPolicy	Grafana image pull policy	string	IfNotPresent
monitoring.grafana.secret.type	Secret type defined for Grafana dashboard	string	Opaque
monitoring.grafana.secret.admin_user	username to access Grafana dashboard	string	YWRtaW4= Value is base64 encoded; to decode: <code>echo "xxxxxx"   base64 --decode</code>

Table 14-9. Grafana Configuration Parameters (continued)

Parameter	Description	Type	Default
monitoring.grafana.secret.admin_password	password to access Grafana dashboard	string	null
monitoring.grafana.secret.ldap_toml	If using ldap auth, ldap configuration file path	string	""
monitoring.grafana_init_container.image.repository	Repository containing grafana init container image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg/grafana
monitoring.grafana_init_container.image.name	Name of grafana init container image	string	k8s-sidecar
monitoring.grafana_init_container.image.tag	Grafana init container image tag. This value may need to be updated if you are upgrading the version.	string	0.1.99
monitoring.grafana_init_container.image.pullPolicy	grafana init container image pull policy	string	IfNotPresent
monitoring.grafana_sc_dashboard.image.repository	Repository containing the Grafana dashboard image. The default is the public VMware registry. Change this value if you are using a private repository (e.g., air-gapped environment).	string	projects.registry.vmware.com/tkg/grafana
monitoring.grafana_sc_dashboard.image.name	Name of grafana dashboard image	string	k8s-sidecar
monitoring.grafana_sc_dashboard.image.tag	Grafana dashboard image tag. This value may need to be updated if you are upgrading the version.	string	0.1.99
monitoring.grafana_sc_dashboard.image.pullPolicy	grafana dashboard image pull policy	string	IfNotPresent
monitoring.grafana.ingress.enabled	Enable/disable ingress for grafana	boolean	true
monitoring.grafana.ingress.virtual_host_fqdn	Hostname for accessing grafana	string	grafana.system.tanzu
monitoring.grafana.ingress.prefix	Path prefix for grafana	string	/

Table 14-9. Grafana Configuration Parameters (continued)

Parameter	Description	Type	Default
monitoring.grafana.ingress.tlsCertificate.tls.crt	Optional cert for ingress if you want to use your own TLS cert. A self signed cert is generated by default	string	Generated cert
monitoring.grafana.ingress.tlsCertificate.tls.key	Optional cert private key for ingress if you want to use your own TLS cert.	string	Generated cert key

## Deploy and Manage the TKG Extension for Harbor Registry

Harbor is an open-source container registry. You can deploy the TKG Extension for Harbor Registry as a private registry store for the container images you want to deploy to Tanzu Kubernetes clusters.

### Harbor Extension Version Dependencies

Adhere to the following minimum version requirements for installing the TKG Extension for Harbor Registry in a Tanzu Kubernetes cluster provisioned by the Tanzu Kubernetes Grid Service.

Component	Minimum Version
vCenter Server	7.0.2.00400
vSphere Namespace	0.0.10-18245956
Supervisor Cluster	v1.20.2+vmware.1-vsc0.0.10-18245956
Tanzu Kubernetes release	v1.20.7+vmware.1-tkg.1.7fb9067

### Harbor Extension Prerequisites

Adhere to the following prerequisites before deploying the TKG Extension v1.3.1 for Harbor Registry.

- Provision a cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).
- Connect to the cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).
- [Download the TKG Extensions v1.3.1 Bundle](#) to the client host where you run kubectl commands.
- [Install the TKG Extensions Prerequisites](#) on the target cluster.

### Harbor Extension Additional Requirements

The TKG Extension v1.3.1 for Harbor Registry has additional requirements pre- and post-installation.

- The Harbor extension requires a default PVC storage class. See [Review Persistent Storage Requirements for TKG Extensions](#).

- The Harbor extension requires HTTP/S ingress. Specifically, Harbor services are exposed via an Envoy service in the Contour Extension. As a prerequisite, deploy the Contour Extension. See [Deploy and Manage the TKG Extension for Contour Ingress](#).
  - If you are using NSX-T networking for the Supervisor Cluster, create an Envoy service of type LoadBalancer.
  - If you are using vSphere vDS networking for the Supervisor Cluster, create an Envoy service of type LoadBalancer or of type NodePort, depending on your environment and requirements.
- The Harbor extension requires DNS. After installation the Harbor extension you need to configure DNS.
  - For testing and verification purposes, add the Harbor and Notary FQDNs to your local `/etc/hosts` file. The instructions below describe how to do this.
  - In production Harbor requires a DNS Zone on either a local DNS Server, such as BIND, or on a public cloud, such as AWS Route53, Azure DNS, or Google CloudDNS. Once you have set up DNS, to automatically register the Harbor FQDNs with a DNS Server, install the External DNS extension. See [Deploy and Manage the TKG Extension for External DNS Service Discovery](#).

## Deploy the Harbor Extension

The TKG Extension for Harbor Registry installs several containers on the cluster. For more information, see <https://goharbor.io/>.

Container	Resource Type	Replicas	Description
harbor-core	Deployment	1	Management and configuration server for Envoy
harbor-database	Pod	1	Postgres database
harbor-jobservice	Deployment	1	Harbor job service
harbor-notary-server	Deployment	1	Harbor notary service
harbor-notary-signer	Deployment	1	Harbor notary
harbor-portal	Deployment	1	Harbor web interface
harbor-redis	Pod	1	Harbor redis instance
harbor-registry	Deployment	2	Harbor container registry instance
harbor-trivy	Pod	1	Harbor image vulnerability scanner

To install the Harbor Registry using the TKG Extension, complete the following steps.

- 1 Verify that you have completed each of the extension prerequisites. See [Harbor Extension Prerequisites](#) and [Harbor Extension Additional Requirements](#).
- 2 Change directory to the Harbor extension.

```
cd /tkg-extensions-v1.3.1+vmware.1/extensions/registry/harbor
```

- 3 Create the `tanzu-system-registry` namespace and Harbor service account and roles.

```
kubectl apply -f namespace-role.yaml
```

- 4 Create a Harbor data values file.

```
cp harbor-data-values.yaml.example harbor-data-values.yaml
```

- 5 Specify the mandatory passwords and secrets in `harbor-data-values.yaml`.

Harbor Registry requires several passwords and secrets listed and described in the table.

Password or Secret	Description
<code>harborAdminPassword</code>	The initial password for Harbor administrator.
<code>secretKey</code>	The secret key used for encryption. Must be a string of 16 characters.
<code>database.password</code>	The initial password for the Postgres database.
<code>core.secret</code>	Secret is used when core server communicates with other component.
<code>core.xsrfKey</code>	The XSRF key. Must be a string of 32 characters.
<code>jobservice.secret</code>	Secret is used when job service communicates with other component.
<code>registry.secret</code>	Secret is used to secure the upload state from client and registry storage backend.

To automatically generate random passwords and secrets and populate the `harbor-data-values.yaml` file, run the following command:

```
bash generate-passwords.sh harbor-data-values.yaml
```

On success you should see the following message:

```
Successfully generated random passwords and secrets in harbor-data-values.yaml
```

Open the `harbor-data-values.yaml` file and verify the mandatory passwords and secrets.



- 6 Specify other Harbor configuration values in `harbor-data-values.yaml`, if necessary. Commonly updated values may include the following:

Configuration Field	Description
<code>hostname</code>	The default Harbor hostname is <code>core.harbor.domain</code> . If necessary, change this value to match your requirements.
<code>port.https</code>	The default is <code>443</code> . If you are using NSX-T networking for the Supervisor Cluster, and therefore an Envoy ingress service of type <code>LoadBalancer</code> , leave this setting as the default <code>443</code> . If you are using vDS networking for the Supervisor Cluster, and therefore an Envoy ingress service of type <code>NodePort</code> , set this value to the match the Envoy node port.
<code>clair.enabled</code>	Clair image scanner is deprecated in favor of Trivy. Both are enabled in the configuration file. Disable Clair by setting its value to <code>false</code> .
<code>persistence.persistentVolumeClaim.&lt;component&gt;.accessMode</code>	There are several instances of this setting. The default is <code>ReadWriteOnce</code> . <code>ReadWriteMany</code> is scheduled to be supported in an upcoming release.
<code>imageChartStorage.type</code>	The default is <code>filesystem</code> . Change if necessary and configure the storage you are using.
<code>proxy</code>	If desired configure a proxy for Harbor. If a proxy is configured, the default <code>noProxy</code> values are required.

- 7 Create a secret with the data values.

```
kubectl create secret generic harbor-data-values --from-file=values.yaml=harbor-data-values.yaml -n tanzu-system-registry
```

The `secret/harbor-data-values` is created in the `tanzu-system-registry` namespace. Verify this by running the following command:

```
kubectl get secrets -n tanzu-system-registry
```

- 8 Deploy the Harbor extension.

```
kubectl apply -f harbor-extension.yaml
```

On success you should see `app.kappctrl.k14s.io/harbor` created.

- 9 Check the status of the Harbor application.

```
kubectl get app harbor -n tanzu-system-registry
```

On success the status changes from `Reconciling` to `Reconcile succeeded`.

NAME	DESCRIPTION	SINCE-DEPLOY	AGE
harbor	Reconciling	96s	98s

NAME	DESCRIPTION	SINCE-DEPLOY	AGE
harbor	Reconcile succeeded	39s	2m29s

If the status is `Reconcile failed`, see [Troubleshoot Harbor Registry Deployment](#).

- 10 View detailed information on the Harbor extension.

```
kubectl get app harbor -n tanzu-system-registry -o yaml
```

- 11 View the status of the Harbor Deployment objects.

```
kubectl get deployments -n tanzu-system-registry
```

On success you should see the following Deployments:

NAME	READY	UP-TO-DATE	AVAILABLE	AGE
harbor-core	1/1	1	1	5m16s
harbor-jobservice	1/1	1	1	5m16s
harbor-notary-server	1/1	1	1	5m16s
harbor-notary-signer	1/1	1	1	5m16s
harbor-portal	1/1	1	1	5m16s
harbor-registry	1/1	1	1	5m16s

- 12 View the status of the Harbor pods:

```
kubectl get pods -n tanzu-system-registry
```

NAME	READY	STATUS	RESTARTS	AGE
harbor-core-9cbf4b79d-gxvqx	1/1	Running	0	7m11s
harbor-database-0	1/1	Running	0	7m11s
harbor-jobservice-6b656ccb95-lm47d	1/1	Running	0	7m11s
harbor-notary-server-8494c684db-gm7jf	1/1	Running	0	7m11s
harbor-notary-signer-6f96b549d4-dzcnm	1/1	Running	0	7m11s
harbor-portal-5b8f4ddbd-qdnp2	1/1	Running	0	7m11s
harbor-redis-0	1/1	Running	0	7m11s
harbor-registry-688894c58d-72txm	2/2	Running	0	7m11s
harbor-trivy-0	1/1	Running	0	7m11s

- 13 Troubleshoot Harbor installation, if necessary. See [Troubleshoot Harbor Registry Deployment](#).

## Configure DNS for Harbor Using an Envoy Service of Type LoadBalancer (NSX-T Networking)

If the prerequisite Envoy service is exposed via a LoadBalancer, obtain the external IP address of the load balancer and create DNS records for the Harbor FQDNs.

- 1 Get the `External-IP` address for the Envoy service of type LoadBalancer.

```
kubectl get service envoy -n tanzu-system-ingress
```

You should see the `External-IP` address returned, for example:

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP	PORT(S)	AGE
envoy	LoadBalancer	10.99.25.220	10.195.141.17	80:30437/TCP,443:30589/TCP	3h27m

Alternatively you can get the `External-IP` address using the following command.

```
kubectl get svc envoy -n tanzu-system-ingress -o
jsonpath='{.status.loadBalancer.ingress[0]}'
```

- 2 To verify the installation of the Harbor extension, update your local `/etc/hosts` file with the Harbor and Notary FQDNs mapped to the `External-IP` address of the load balancer, for example:

```
127.0.0.1 localhost
127.0.1.1 ubuntu
# TKGS Harbor with Envoy Load Balancer IP
10.195.141.17 core.harbor.domain
10.195.141.17 core.notary.harbor.domain
```

- 3 To verify the installation of the Harbor extension, log in to Harbor. See [Log In to the Harbor Web Interface](#).
- 4 Create two CNAME records on a DNS server that map the Envoy service Load Balancer `External-IP` address to the Harbor FQDN and the Notary FQDN.
- 5 Install the External DNS extension. See [Deploy and Manage the TKG Extension for External DNS Service Discovery](#).

## Configure DNS for Harbor Using an Envoy Service of Type NodePort (vDS Networking)

If the prerequisite Envoy service is exposed via a NodePort, obtain the virtual machine IP address of a worker node and create DNS records for the Harbor FQDNs.

**Note** To use NodePort, you must have specified the correct `port.https` value in the `harbor-data-values.yaml` file.

- 1 Switch context to the vSphere Namespace where the cluster is provisioned.

```
kubectl config use-context VSPHERE-NAMESPACE
```

- 2 List the nodes in the cluster.

```
kubectl get virtualmachines
```

You should see the cluster nodes, for example:

NAME	POWERSTATE	AGE
tkgs-cluster-X-control-plane-6dgln	poweredOn	6h7m
tkgs-cluster-X-control-plane-j6hq6	poweredOn	6h10m
tkgs-cluster-X-control-plane-xc25f	poweredOn	6h14m
tkgs-cluster-X-workers-9twdr-59bc54dc97-kt4cm	poweredOn	6h12m
tkgs-cluster-X-workers-9twdr-59bc54dc97-pjprr	poweredOn	6h12m
tkgs-cluster-X-workers-9twdr-59bc54dc97-t45mn	poweredOn	6h12m

- 3 Pick one of the worker nodes and describe it using the following command.

```
kubectl describe virtualmachines tkgs-cluster-X-workers-9twdr-59bc54dc97-kt4cm
```

- 4 Locate the IP address of the virtual machine, for example `Vm Ip: 10.115.22.43`.
- 5 To verify the installation of the Harbor extension, update your local `/etc/hosts` file with the Harbor and Notary FQDNs mapped to the worker node IP address, for example:

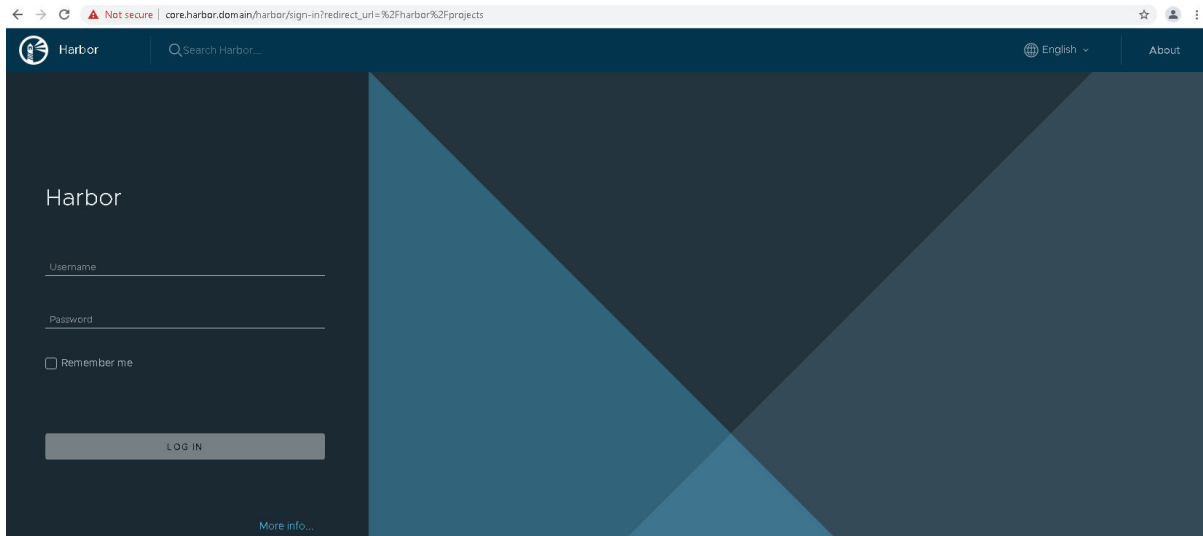
```
127.0.0.1 localhost
127.0.1.1 ubuntu
# TKGS Harbor with Envoy NodePort
10.115.22.43 core.harbor.domain
10.115.22.43 core.notary.harbor.domain
```

- 6 To verify the installation of the Harbor extension, log in to Harbor. See [Log In to the Harbor Web Interface](#).
- 7 Create two CNAME records on a DNS server that map the worker node IP address to the Harbor FQDN and the Notary FQDN.
- 8 Install the External DNS extension. See [Deploy and Manage the TKG Extension for External DNS Service Discovery](#).

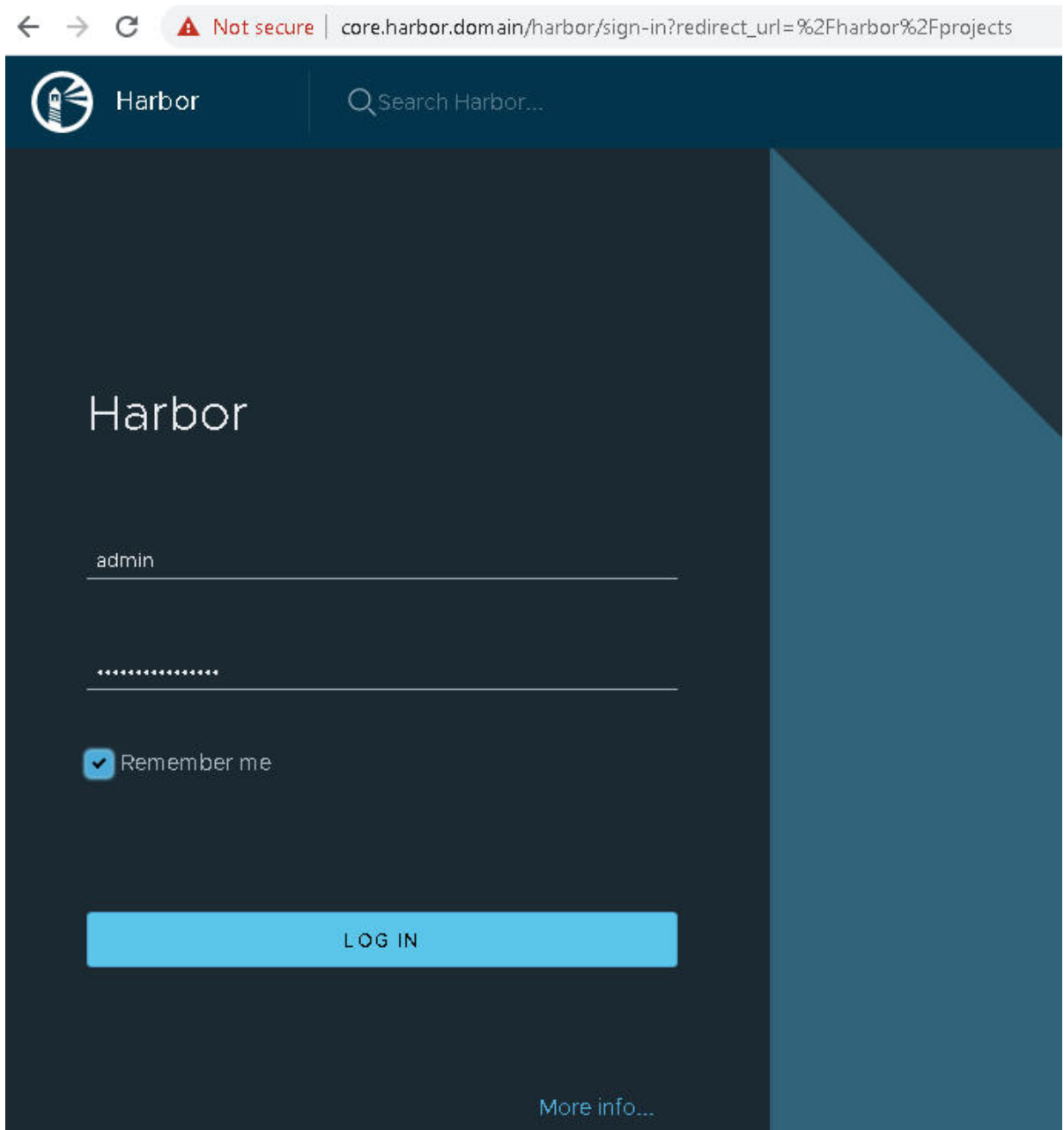
## Log In to the Harbor Web Interface

Once Harbor is installed and configured, log in and start using it.

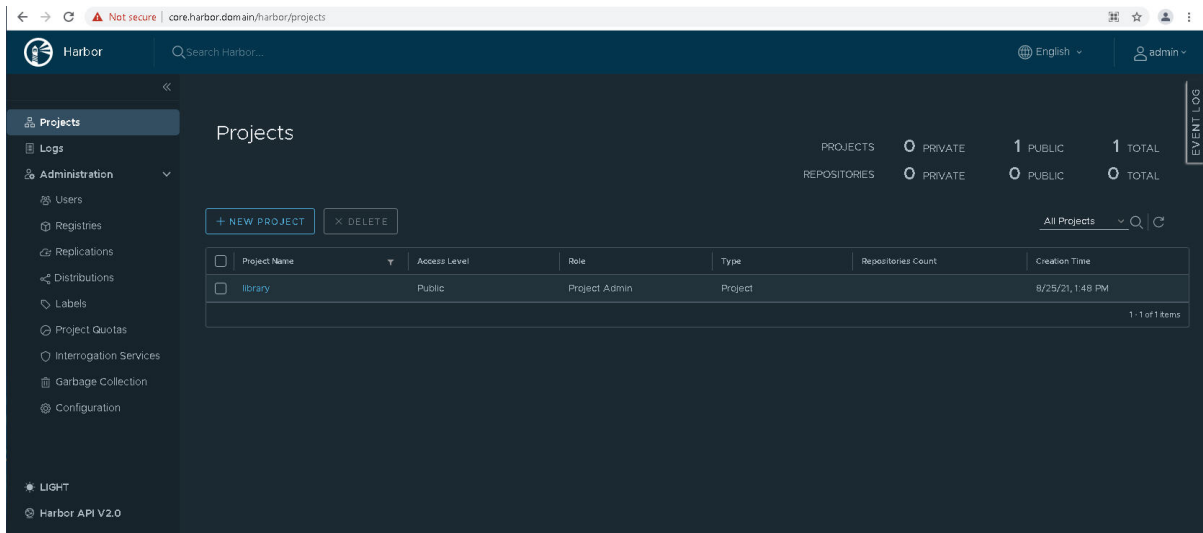
- 1 Access the Harbor Registry web interface at <https://core.harbor.domain>, or the hostname you used.



- 2 Log in to Harbor with the username **admin** and the generated password that you put in the `harbor-data-values.yaml` file.



- 3 Verify that you can access the Harbor user interface.



#### 4 Obtain the Harbor CA certificate.

In the Harbor interface, select **Projects > library**, or create a **New Project**.

Click **Registry Certificate** and download the Harbor CA certificate (`ca.crt`).

- 5 Add the Harbor CA certificate into the trust store of Docker client so you can push and pull container images to and from the Harbor Registry. See [Configure a Docker Client with the Embedded Harbor Registry Certificate](#).
- 6 Refer to the [Harbor documentation](#) for details on using Harbor.

## Troubleshoot Harbor Registry Deployment

If the deployment or reconciliation fails, run `kubectl get pods -n tanzu-system-registry` to view pod status. The harbor pods should be `Running`. If a pod status is `ImagePullBackOff` or `ImageCrashLoopBackOff`, the container image could not be pulled. Check the registry URL in the data values and the extension YAML files and make sure they are accurate.

Check the container logs, where `name-XXXX` is the unique pod name when you run `kubectl get pods -A`:

```
kubectl logs pod/harbor-XXXXX -c harbor -n tanzu-system-registry
```

## Update the Harbor Extension

Update the Contour extension that is deployed to a Tanzu Kubernetes cluster.

- 1 Get Harbor data values from the secret.

```
kubectl get secret harbor-data-values -n tanzu-system-registry -o 'go-template={{ index .data "values.yaml" }}' | base64 -d > harbor-data-values.yaml
```

- 2 Update Harbor data values in `harbor-data-values.yaml`.

### 3 Update the Harbor data values secret.

```
kubectl create secret generic harbor-data-values --from-file=values.yaml=harbor-data-values.yaml -n tanzu-system-registry -o yaml --dry-run | kubectl replace -f-
```

The Harbor extension will be reconciled with the new data values.

---

**Note** By default, kapp-controller will sync apps every 5 minutes. The update should take effect in 5 minutes or less. If you want the update to take effect immediately, change `syncPeriod` in `harbor-extension.yaml` to a lesser value and apply the Contour extension using `kubectl apply -f harbor-extension.yaml`.

---

### 4 Check the status of the extension.

```
kubectl get app harbor -n tanzu-system-registry
```

The Contour app status should change to `Reconcile Succeeded` once Contour is updated.

### 5 View detailed status and troubleshoot.

```
kubectl get app harbor -n tanzu-system-registry -o yaml
```

## Delete the Harbor Extension

Delete the Harbor extension from a Tanzu Kubernetes cluster.

---

**Note** Complete the steps in order. Do not delete the Contour namespace and role objects before the Contour extension and app are deleted. Deleting the Contour namespace and role objects deletes the service account used by kapp-controller. If this service account is deleted before the app and extension are deleted, it can lead to system errors.

---

### 1 Change directory to where you have downloaded the Harbor extension files.

```
cd /extensions/registry/harbor/
```

### 2 Delete the Harbor app.

```
kubectl delete app harbor -n tanzu-system-registry
```

Expected result:

```
app.kappctrl.k14s.io "harbor" deleted
```

### 3 Verify that the Harbor app is deleted.

```
kubectl get app Harbor -n tanzu-system-registry
```

Expected result: The app is `Not Found`.

```
apps.kappctrl.k14s.io "harbor" not found
```



#### 4 Delete the Registry namespace.

Only after you have confirmed that the Harbor extension and app are fully deleted is safe to delete the namespace and role objects.

```
kubectl delete -f namespace-role.yaml
```

Expected result: The namespace where Harbor is deployed, and the associated role-based access control objects, are deleted.

```
namespace "tanzu-system-registry" deleted
serviceaccount "harbor-extension-sa" deleted
role.rbac.authorization.k8s.io "harbor-extension-role" deleted
rolebinding.rbac.authorization.k8s.io "harbor-extension-rolebinding" deleted
clusterrole.rbac.authorization.k8s.io "harbor-extension-cluster-role" deleted
clusterrolebinding.rbac.authorization.k8s.io "harbor-extension-cluster-rolebinding" deleted
```

## Upgrade the Harbor Extension

If you have an existing Harbor extension deployed, you can upgrade it to the latest version.

#### 1 Get the Harbor configmap.

```
kubectl get configmap harbor -n tanzu-system-harbor -o 'go-template={{ index .data "harbor.yaml" }}' > harbor-configmap.yaml
```

#### 2 Delete the existing Harbor deployment. See [Delete the Harbor Extension](#).

#### 3 Deploy the Harbor extension. See [Deploy the Harbor Extension](#).

## Deploy and Manage the TKG Extension for External DNS Service Discovery

External DNS lets you dynamically configure DNS records based on Kubernetes load balanced services. You can deploy the TKG Extension for External DNS to provide dynamic service discovery for your cluster.

### Extension Prerequisites

Adhere to the following requirements before deploying the TKG Extension v1.3.1 for External DNS.

- Provision a Tanzu Kubernetes cluster. See [Workflow for Provisioning Tanzu Kubernetes Clusters](#).
- Connect to the Tanzu Kubernetes cluster. See [Connect to a Tanzu Kubernetes Cluster as a vCenter Single Sign-On User](#).
- [Download the TKG Extensions v1.3.1 Bundle](#) to your client host where you run kubectl.
- [Install the TKG Extensions Prerequisites](#) on the target Tanzu Kubernetes cluster.
- Install the Contour extension. See [Deploy and Manage the TKG Extension for Contour Ingress](#).

- Install the Harbor extension. See [Deploy and Manage the TKG Extension for Harbor Registry](#).
- Create DNS records in AWS Route 53, Azure DNS, Google DNS, or an RFC 2136-compliant Dynamic DNS provider.

## Deploy the External DNS Extension

Harbor requires a DNS Zone on either a local DNS Server, such as BIND, or on a public cloud, such as AWS Route53, Azure DNS, or Google CloudDNS. Once you have set up DNS, to automatically register the Harbor FQDNs with a DNS Server, install the External DNS extension.

- 1 Verify that you have completed the extension prerequisites. See [Extension Prerequisites](#).
- 2 Change directory to where you have downloaded the External DNS extension files.

```
cd /tkg-extensions-v1.3.1+vmware.1/extensions/service-discovery/external-dns
```

- 3 Create the namespace and several role-based access control objects for use with the External DNS extension.

```
kubectl apply -f namespace-role.yaml
```

This command creates the namespace `tanzu-system-service-discovery` and associated RBAC objects. Run `kubectl get ns` to verify.

- 4 Create a data values file. The example data values file provides the minimum required configuration.

There are example data values files for AWS, Azure, and an RFC 2136-compliant Dynamic DNS provider, each with and without Contour ingress. Choose the appropriate example file and copy it.

For example, if you are using AWS Route 53 with Contour, run the following command.

```
cp external-dns-data-values-aws-with-contour.yaml.example external-dns-data-values-aws-with-contour.yaml
```

Or, if you are using Azure with Contour, run the following command.

```
cp external-dns-data-values-azure-with-contour.yaml.example external-dns-data-values-azure-with-contour.yaml
```

- 5 Configure the External DNS data values.

For example, below is the configuration for Azure DNS. You provide the `domain-filter` and `azure-resource-group` values.

```
#@data/values
#@overlay/match-child-defaults missing_ok=True
---
externalDns:
  image:
```

```

repository: projects.registry.vmware.com/tkg
deployment:
  #@overlay/replace
  args:
    - --provider=azure
    - --source=service
    - --source=ingress
    - --domain-filter=my-zone.example.org #! zone where services are deployed
    - --azure-resource-group=my-resource-group #! Azure resource group
  #@overlay/replace
  volumeMounts:
    - name: azure-config-file
      mountPath: /etc/kubernetes
      readOnly: true
  #@overlay/replace
  volumes:
    - name: azure-config-file
      secret:
        secretName: azure-config-file

```

- 6 Create a generic secret with using the data values file you populated.

For example, the following command creates the secret using the Azure DNS data values file.

```
kubectl create secret generic external-dns-data-values --from-file=values.yaml=external-dns-data-values-azure-with-contour.yaml -n tanzu-system-service-discovery
```

You should see `secret/external-dns-data-values` created is created in the `tanzu-system-service-discovery` namespace. You can verify this using the command `kubectl get secrets -n tanzu-system-service-discovery`.

- 7 Deploy the External DNS extension.

```
kubectl apply -f external-dns-extension.yaml
```

On success you should see `app.kappctrl.k14s.io/external-dns` created.

- 8 Check the status of the extension deployment.

```
kubectl get app external-dns -n tanzu-system-service-discovery
```

The app status should change from `Reconciling` to `Reconcile succeeded` once the External DNS is deployed successfully. If the status is `Reconcile failed`, see [Troubleshoot Deployment](#).

- 9 View detailed status.

```
kubectl get app external-dns -n tanzu-system-service-discovery -o yaml
```

## Troubleshoot Deployment

If the reconciliation fails, run the command `kubectl get pods -A` to view the status of the pods. Under normal conditions you should see that the `external-dns-XXXXX` pod is `Running`. If the reconciliation fails or the pod status is `ImagePullBackOff` or `ImageCrashLoopBackOff`, this means the container image could not be pulled from the repository. Check the repository URL in the data values and the extension YAML files and make sure they are accurate.

To check the container logs, run the following commands, where `name-XXXX` is the unique pod name that you can see when you run `kubectl get pods -A`:

```
kubectl logs pod/external-dns-XXXXX -c external-dns -n tanzu-system-service-discovery
```

## Update the External DNS Extension

Update the External DNS extension that is deployed to a Tanzu Kubernetes cluster.

- 1 Get Contour data values from the secret.

```
kubectl get secret external-dns-data-values -n tanzu-system-service-discovery -o 'go-template={{ index .data "values.yaml" }}' | base64 -d > external-dns-data-values.yaml
```

- 2 Update External DNS data values in `external-dns-data-values.yaml`. See [Configure the External DNS Extension](#).
- 3 Update the Contour data values secret.

```
kubectl create secret generic external-dns-data-values --from-file=values.yaml=external-dns-data-values.yaml -n tanzu-system-service-discovery -o yaml --dry-run | kubectl replace -f-
```

The External DNS extension will be reconciled with the new data values.

---

**Note** By default, kapp-controller will sync apps every 5 minutes. The update should take effect in 5 minutes or less. If you want the update to take effect immediately, change `syncPeriod` in `external-dns-extension` to a lesser value and apply the Contour extension using `kubectl apply -f external-dns-extension`.

---

- 4 Check the status of the extension.

```
kubectl get app external-dns -n tanzu-system-service-discovery
```

The app status should change to `Reconcile Succeeded` once it is updated.

- 5 View detailed status and troubleshoot.

```
kubectl get app external-dns -n tanzu-system-service-discovery -o yaml
```

## Delete the External DNS Extension

Delete the Contour extension from a Tanzu Kubernetes cluster.

**Note** Complete the steps in order. Do not delete the target namespace and role objects before the extension and app are deleted. Deleting the namespace and role objects deletes the service account used by kapp-controller. If this service account is deleted before the app and extension are deleted, it can lead to system errors.

- 1 Change directory to where you have downloaded the extension files.

```
cd /tkg-extensions-v1.3.1+vmware.1/extensions/service-discovery/external-dns
```

- 2 Delete the External DNS extension.

```
kubectl delete -f external-dns-extension.yaml
```

- 3 Verify that the extension is deleted.

```
kubectl get app contour -n tanzu-system-ingress
```

Expected result: The app is `Not Found`.

- 4 Delete the namespace.

Only after you have confirmed that the Contour extension and app are fully deleted is safe to delete the namespace and role objects.

```
kubectl delete -f namespace-role.yaml
```

Expected result: The namespace where the extension is deployed, and the associated role-based access control objects, are deleted.

## Configure the External DNS Extension

You can configure the External DNS extension with custom settings.

Configure the deployment parameters for your External DNS provider. Refer to the Kubernetes site <https://github.com/kubernetes-sigs/external-dns#running-externaldns> for additional guidance.

**Table 14-10. Harbor Extension Configuration Parameters**

Parameter	Description	Type	Default
externalDns.namespace	Namespace where external-dns will be deployed	string	tanzu-system-service-discovery
externalDns.image.repository	Repository containing external-dns image	string	projects.registry.vmware.com/tkg
externalDns.image.name	Name of external-dns	string	external-dns

Table 14-10. Harbor Extension Configuration Parameters (continued)

Parameter	Description	Type	Default
externalDns.image.tag	ExternalDNS image tag	string	v0.7.4_vmware.1
externalDns.image.pullPolicy	ExternalDNS image pull policy	string	IfNotPresent
externalDns.deployment.annotations	Annotations on the external-dns deployment	map<string,string>	{}
externalDns.deployment.arguments	Arguments passed via command-line to external-dns	list<string>	[] ( Mandatory parameter )
externalDns.deployment.environment	Environment variables to pass to external-dns	list<string>	[]
externalDns.deployment.securityContext	Security context of the external-dns container	SecurityContext	{}
externalDns.deployment.volumeMounts	Volume mounts of the external-dns container	list<VolumeMount>	[]
externalDns.deployment.volumes	Volumes of the external-dns pod	list<Volume>	[]

## Deploy AI/ML Workloads on Tanzu Kubernetes Clusters

You can deploy AI/ML workloads on Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service. The deployment of AI/ML workloads requires some initial setup by the vSphere Administrator and some configuration by the Cluster Operator. Once the vSphere with Tanzu environment is vGPU-enabled, developers can deploy AI/ML workloads to their TKGS clusters same as they would any Kubernetes workload.

### About Deploying AI/ML Workloads on TKGS Clusters

You can deploy AI/ML workloads on TKGS clusters using vSphere with Tanzu and NVIDIA vGPU technology.

### Announcing TGKS Support for AI/ML Workloads

Beginning with the release of vSphere with Tanzu Version 7 Update 3 Monthly Patch 1, you can deploy compute intensive workloads to Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service. In this context a compute intensive workload is an artificial intelligence (AI) or machine learning (ML) application that requires the use of a GPU accelerator device.

To facilitate running AI/ML workloads in a Kubernetes environment, VMware has partnered with NVIDIA to support the NVIDIA GPU Cloud platform on vSphere with Tanzu. This means that you can deploy container images from the [NGC Catalog](#) on Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service.

To learn more about the joint NVIDIA and VMware architecture for the AI-Ready Enterprise, see [Accelerating Workloads on vSphere 7 with Tanzu - A Technical Preview of Kubernetes Clusters with GPUs](#).

## Supported vGPU Modes

Deploying AI/ML workloads on TKGS requires the use of the Ubuntu OVA that is available through the vSphere with Tanzu content delivery network. TKGS supports two modes of GPU operations: vGPU and vGPU with NIC Passthrough. The table describes the two modes in more detail.

Mode	Configuration	Description
NVIDIA + TKGS + Ubuntu + vGPU	NVIDIA vGPU	The GPU device is virtualized by the NVIDIA Host Manager Driver installed on each ESXi host. The GPU device is then shared across multiple NVIDIA virtual GPUs (vGPUs).  Each NVIDIA vGPU is defined by the amount of memory from the GPU device. For example, if the GPU device has a total amount of RAM of 32GB, you can create 8 vGPUs with approximately 4 GB of memory each.
NVIDIA + TKGS + Ubuntu + vGPU + NIC Passthrough	NVIDIA vGPU <b>and</b> Dynamic DirectPath IO	In the same VM Class where you configure the NVIDIA vGPU profile, you include support for a passthrough networking device using Dynamic DirectPath IO. In this case vSphere DRS determines VM placement.

## Getting Started

To configure NVIDIA vGPU for TKGS, refer to the following topics:

- [vSphere Administrator Workflow for Deploying AI/ML Workloads on TKGS Clusters \(vGPU\)](#)
- [Cluster Operator Workflow for Deploying AI/ML Workloads on TKGS Clusters](#)

If you are using vGPU with NIC Passthrough, also refer to the following topic: [vSphere Administrator Addendum for Deploying AI/ML Workloads on TKGS Clusters \(vGPU and Dynamic DirectPath IO\)](#).

If you are using the NVIDIA Delegated Licensing Server (DLS) for your NVAIE account, also refer to the following topic: [Cluster Operator Addendum for Deploying AI/ML Workloads on TKGS Clusters \(DLS\)](#).

## vSphere Administrator Workflow for Deploying AI/ML Workloads on TKGS Clusters (vGPU)

To enable developers to deploy AI/ML workloads on TKGS clusters, as a vSphere Administrator you set up the vSphere with Tanzu environment to support NVIDIA GPU hardware.

## vSphere Administrator Workflow for Deploying AI/ML Workloads on TKGS Clusters

The high-level workflow for vSphere Administrators to enable the deployment of AI/ML workloads on TKGS clusters is listed in the table. Detailed instructions for each step follow.

Step	Action	Link
0	Review system requirements.	See <a href="#">Admin Step 0: Review System Requirements</a> .
1	Install Supported NVIDIA GPU Device on ESXi Hosts.	See <a href="#">Admin Step 1: Install Supported NVIDIA GPU Device on ESXi Hosts</a> .
2	Configure ESXi device graphics settings for vGPU operations.	See <a href="#">Admin Step 2: Configure Each ESXi Host for vGPU Operations</a> .
3	Install the NVIDIA vGPU Manager (VIB) onto each ESXi host.	See <a href="#">Admin Step 3: Install the NVIDIA Host Manager Driver on Each ESXi Host</a> .
4	Verify NVIDIA driver operation and GPU virtualization mode.	See <a href="#">Admin Step 4: Verify ESXi Hosts Are Ready for NVIDIA vGPU Operations</a> .
5	Enable Workload Management on the GPU-configured cluster. The result is a Supervisor Cluster that is running on vGPU-enabled ESXi hosts.	See <a href="#">Admin Step 5: Enable Workload Management on the vGPU-configured vCenter Cluster</a> .
6	Create a Content Library for Tanzu Kubernetes releases and populate the library with the supported Ubuntu OVA that is required for vGPU workloads.	See <a href="#">Admin Step 6: Create a Content Library for the Tanzu Kubernetes Ubuntu Release</a> .
7	Create a custom VM Class with a certain vGPU profile selected.	See <a href="#">Admin Step 7: Create a Custom VM Class with the vGPU Profile</a>
8	Create and configure a vSphere Namespace for TKGS GPU clusters: add a user with Edit permissions and storage for persistent volumes.	See <a href="#">Admin Step 8: Create and Configure a vSphere Namespace for the TKGS GPU Cluster</a>
9	Associate the Content Library with the Ubuntu OVA and the custom VM Class for vGPU with the vSphere Namespace you created for TKGS.	See <a href="#">Admin Step 9: Associate the Content Library and VM Class with the vSphere Namespace</a>
10	Verify that the Supervisor Cluster is provisioned and accessible for the Cluster Operator.	See <a href="#">Admin Step 10: Verify that the Supervisor Cluster Is Accessible</a>

### Admin Step 0: Review System Requirements

Refer to the following system requirements to set up the environment for deploying AI/ML workloads on TKGS clusters.



Requirement	Description
vSphere infrastructure	vSphere 7 Update3 Monthly Patch 1 ESXi build 18778458 or later vCenter Server build 18644231 or later
Workload Management	vSphere Namespace version 0.0.11-18610518 or later
Supervisor Cluster	Supervisor Cluster version v1.21.0+vmware.1-vsc0.0.11-18610518 or later
TKR Ubuntu OVA	Tanzu Kubernetes release Ubuntu ob-18691651-tkgs-ova-ubuntu-2004-v1.20.8---vmware.1-tkg.2
NVIDIA vGPU Host Driver	Download the VIB from the <a href="#">NGC web site</a> . For more information, see the vGPU Software Driver <a href="#">documentation</a> . For example: NVIDIA-AIE_ESXi_7.0.2_Driver_470.51-10EM.702.0.0.17630552.vib
NVIDIA License Server for vGPU	FQDN provided by your organization

## Admin Step 1: Install Supported NVIDIA GPU Device on ESXi Hosts

To deploy AI/ML workloads on TKGS, you install one or more supported NVIDIA GPU devices on each ESXi host comprising the vCenter Cluster where **Workload Management** will be enabled.

To view compatible NVIDIA GPU devices, refer to the [VMware Compatibility Guide](#).

What are you looking for: **Shared Pass-Through Graphics** Compatibility Guides Help Current Results: 5

**Product Release Version:** All, ESXi 7.0 U2, ESXi 7.0 U1, ESXi 7.0, ESXi 6.7 U3, ESXi 6.7 U2, ESXi 6.7 U1, ESXi 6.7, ESXi 6.5 U3, ESXi 6.5 U2, ESXi 6.5 U1, ESXi 6.5, ESXi 6.0 U3

**GPU Partners:** All, NVIDIA

**GPU Device Model:** All, NVIDIA A10, NVIDIA A100 40GB PCIe, NVIDIA A40

**GPU Technology:** All, Compute, Virtual Desktop Interface (VDI)

**Guest OS:** All, Windows, Linux

**Compute:** All, AI/ML

**Features:** All, vMotion, SuspendResume, Multi-vGPU

Keyword:  Posted Date Range: All

[Update and View Results](#) [Reset](#)

[Click here to Read Important Support Information](#)

Click on the 'GPU Device Model' to view more details and to subscribe to RSS feeds.

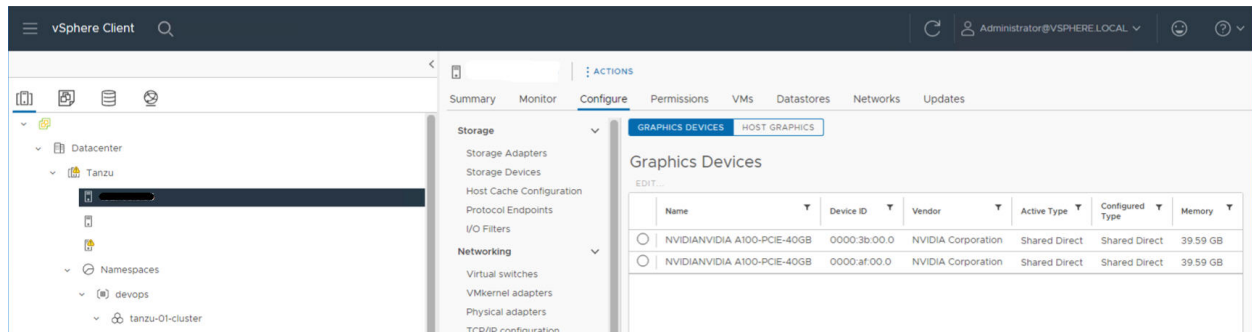
[Bookmark](#) | [Print](#) | [Export to CSV](#)

Search Results: Your search for "Shared Pass-Through Graphics" returned 5 results. [Back to Top](#) [Turn Off Auto Scroll](#) Display: 10

GPU Partner	GPU Device Model	ESX Version	Compute
NVIDIA	<a href="#">NVIDIA A10</a>	ESXi 7.0 U2	AI/ML
NVIDIA	<a href="#">NVIDIA A100 40GB PCIe</a>	ESXi 7.0 U2	AI/ML
NVIDIA	<a href="#">NVIDIA A100 80GB PCIe</a>	ESXi 7.0 U2	AI/ML
NVIDIA	<a href="#">NVIDIA A30</a>	ESXi 7.0 U2	AI/ML
NVIDIA	<a href="#">NVIDIA A40</a>	ESXi 7.0 U2	AI/ML

The NVIDIA GPU device should support the latest [NVIDIA AI Enterprise \(NVAIE\)](#) vGPU profiles. Refer to the [NVIDIA Virtual GPU Software Supported GPUs](#) documentation for guidance.

For example, the following ESXi host has two NVIDIA GPU A100 devices installed on it.



## Admin Step 2: Configure Each ESXi Host for vGPU Operations

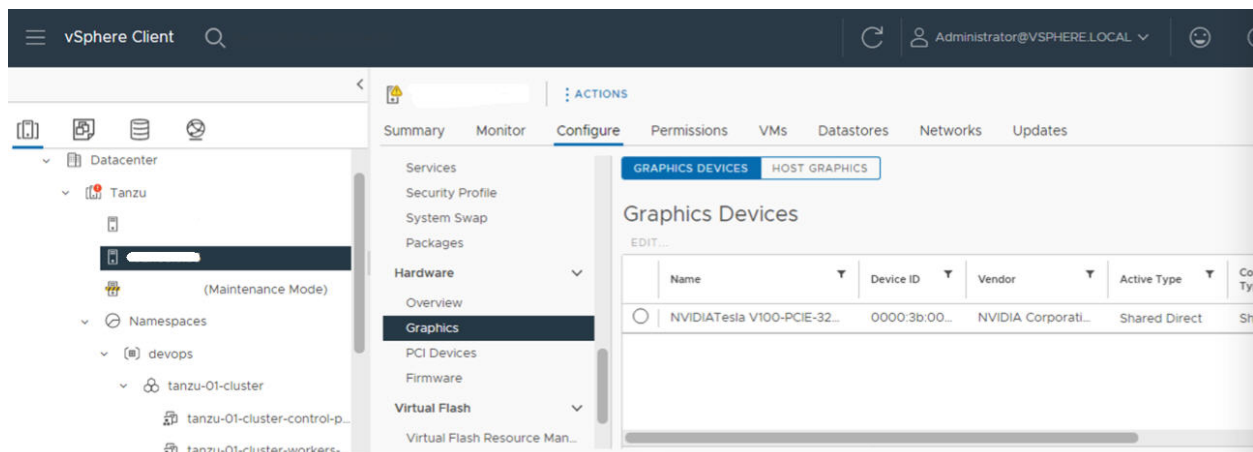
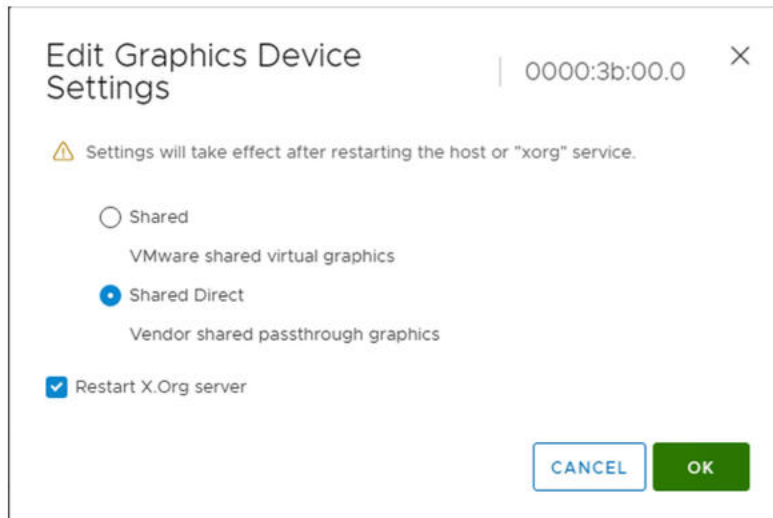
Configure each ESXi host for vGPU by enabling Shared Direct and SR-IOV.

### Enable Shared Direct on Each ESXi Host

For NVIDIA vGPU functionality to be unlocked, enable **Shared Direct** mode on each ESXi host comprising the vCenter Cluster where **Workload Management** will be enabled.

To enable **Shared Direct**, complete the following steps. For additional guidance, see [Configuring Graphics Devices](#) in the vSphere documentation.

- 1 Log on to the vCenter Server using the vSphere Client.
- 2 Select an ESXi host in the vCenter Cluster.
- 3 Select **Configure > Hardware > Graphics**.
- 4 Select the NVIDIA GPU accelerator device.
- 5 **Edit** the Graphics Device settings.
- 6 Select **Shared Direct**.
- 7 Select **Restart X.Org** server.
- 8 Click **OK** to save the configuration.
- 9 Right-click the ESXi host and put it into maintenance mode.
- 10 Reboot the host.
- 11 When the host is running again, take it out of maintenance mode.
- 12 Repeat this process for each ESXi host in the vCenter cluster where **Workload Management** will be enabled.



### Turn On SR-IOV BIOS for NVIDIA GPU A30 and A100 Devices

If you are using the NVIDIA [A30](#) or [A100](#) GPU devices, which are required for Multi-Instance GPU (MIG mode), you must enable SR-IOV on the ESXi host. If SR-IOV is not enabled, Tanzu Kubernetes cluster node VMs cannot start. If this occurs, you see the following error message in the **Recent Tasks** pane of the vCenter Server where **Workload Management** is enabled.

```
Could not initialize plugin libnvidia-vgx.so for vGPU nvidia_aXXX-xx. Failed to start the virtual machine. Module DevicePowerOn power on failed.
```

To enable SR-IOV, log in to the ESXi host using the web console. Select **Manage > Hardware**. Select the NVIDIA GPU device and click **Configure SR-IOV**. From here you can turn on SR-IOV. For additional guidance, see [Single Root I/O Virtualization \(SR-IOV\)](#) in the vSphere documentation.

**Note** If you are using vGPU with NIC Passthrough, refer to the following topic for an additional ESXi configuration step: [vSphere Administrator Addendum for Deploying AI/ML Workloads on TKG S Clusters \(vGPU and Dynamic DirectPath IO\)](#).

### Admin Step 3: Install the NVIDIA Host Manager Driver on Each ESXi Host

To run Tanzu Kubernetes cluster node VMs with NVIDIA vGPU graphics acceleration, you install the NVIDIA host manager driver on each ESXi host comprising the vCenter Cluster where **Workload Management** will be enabled.

The NVIDIA vGPU host manager driver components are packaged in a vSphere installation bundle (VIB). The NVAIE VIB is provided to you by your organization through its NVIDIA GRID licensing program. VMware does not provide NVAIE VIBs or make them available for download. As part of the NVIDIA licensing program your organization sets up a licensing server. Refer to the NVIDIA [Virtual GPU Software Quick Start Guide](#) for more information.

Once the NVIDIA environment is set up, run the following command on each ESXi host, replace the NVIDIA license server address and the NVAIE VIB version and with the appropriate values for your environment. For additional guidance, see [Installing and configuring the NVIDIA VIB on ESXi](#) at the VMware Support Knowledge Base.

---

**Note** The NVAIE VIB version installed on ESXi hosts must match the vGPU software version installed the node VMs. The version below is only an example.

---

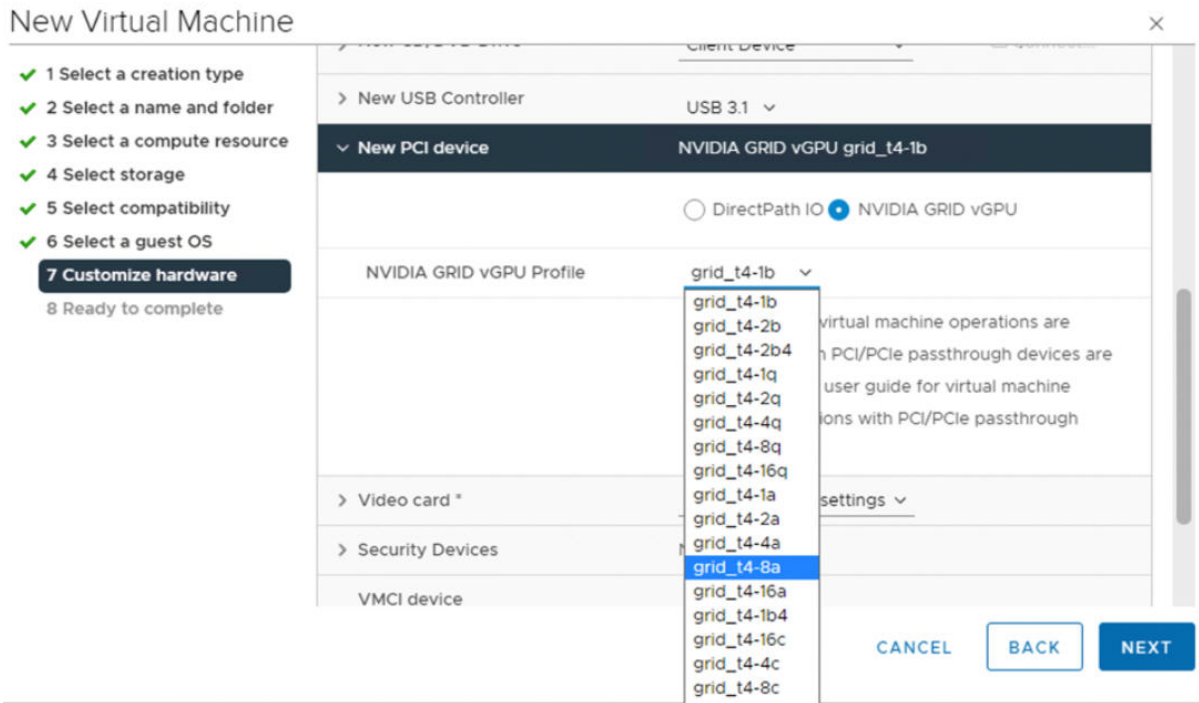
```
esxcli system maintenanceMode set --enable true
esxcli software vib install -v ftp://server.domain.example.com/nvidia/signed/
NVIDIA_bootbank_NVIDIA-VMware_ESXi_7.0_Host_Driver_460.73.02-10EM.700.0.0.15525992.vib
esxcli system maintenanceMode set --enable false
/etc/init.d/xorg restart
```

### Admin Step 4: Verify ESXi Hosts Are Ready for NVIDIA vGPU Operations

To verify that each ESXi host is ready for NVIDIA vGPU operations, perform the following checks on each ESXi host in the vCenter Cluster where **Workload Management** will be enabled:

- SSH into the ESXi host, enter shell mode and run the command `nvidia-smi`. The NVIDIA System Management Interface is a command line utility provided by the NVIDIA vGPU host manager. Running this command returns the GPUs and drivers on the host.
- Run the following command to verify that the NVIDIA driver is properly installed: `esxcli software vib list | grep NVIDIA`.
- Verify that host is configured with GPU shared direct and that SR-IOV is turned on (if you are using NVIDIA A30 or A100 devices).

- Using the vSphere Client, on the ESXi host that is configured for GPU, create a new virtual machine with a PCI device included. The NVIDIA vGPU profile should appear and be selectable.



## Admin Step 5: Enable Workload Management on the vGPU-configured vCenter Cluster

Now that ESXi hosts are configured to support NVIDIA vGPU, create a vCenter Cluster comprising these hosts. To support **Workload Management**, the vCenter Cluster must meet specific requirements, including shared storage, high-availability, fully-automated DRS.

Enabling **Workload Management** also requires the selection of a networking stack, either native vSphere vDS networking or NSX-T Data Center networking. If you use vDS networking, you need to install a load balancer, either NSX Advanced or HAProxy.

The result of enabling **Workload Management** is a Supervisor Cluster that is running on vGPU-enabled ESXi hosts. Refer to the following tasks and documentation to enable **Workload Management**.

**Note** Skip this step if you already have a vCenter Cluster with **Workload Management** enabled, assuming that cluster is using the ESXi hosts you have configured for vGPU.

Task	Instructions
Create a vCenter Cluster that meets the requirements for enabling <b>Workload Management</b>	<a href="#">Prerequisites for Configuring vSphere with Tanzu on a Cluster</a>
Configure the networking for the Supervisor Cluster, either NSX-T or vDS with a load balancer.	<a href="#">Configuring NSX-T Data Center for vSphere with Tanzu.</a> <a href="#">Configuring vSphere Networking and NSX Advanced Load Balancer for vSphere with Tanzu.</a> <a href="#">Configuring vSphere Networking and HA Proxy Load Balancer for vSphere with Tanzu.</a>
Enable <b>Workload Management</b>	<a href="#">Enable Workload Management with NSX-T Data Center Networking.</a> <a href="#">Enable Workload Management with vSphere Networking.</a>

## Admin Step 6: Create a Content Library for the Tanzu Kubernetes Ubuntu Release

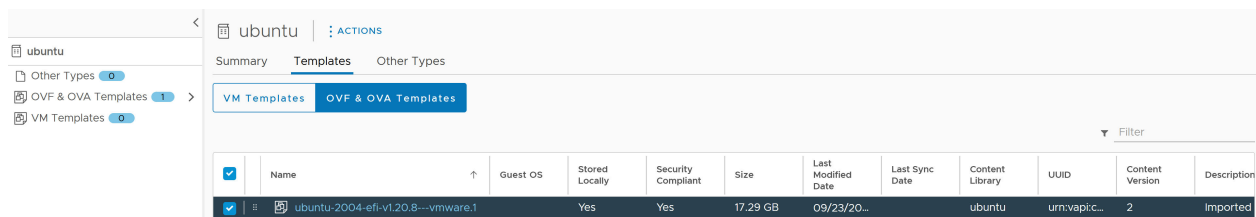
Once **Workload Management** is enabled on a GPU-configured vCenter Cluster, the next step is to create a Content Library for the Tanzu Kubernetes release OVA image.

NVIDIA vGPU requires the Ubuntu operating system. VMware provides an Ubuntu OVA for such purposes. You cannot use the PhotonOS Tanzu Kubernetes release for vGPU clusters.

To import this image into your vSphere with Tanzu environment, choose one of the methods listed in the table and follow the corresponding instructions.

Content Library Type	Description
Create a <b>Subscribed Content Library</b> and automatically synchronize the Ubuntu OVA with your environment.	<a href="#">Create, Secure, and Synchronize a Subscribed Content Library for Tanzu Kubernetes releases</a>
Create a <b>Local Content Library</b> and manually upload the Ubuntu OVA to your environment.	<a href="#">Create, Secure, and Synchronize a Local Content Library for Tanzu Kubernetes releases</a>

When you have completed this task, you should see the Ubuntu OVA available in your content library.



## Admin Step 7: Create a Custom VM Class with the vGPU Profile

To next step is to create a custom VM Class with a vGPU profile. The system will use this class definition when it creates the Tanzu Kubernetes cluster nodes.

Follow the instructions below to create a custom VM Class with a vGPU profile. For additional guidance, see [Add PCI Devices to a VM Class in vSphere with Tanzu](#).

**Note** If you are using vGPU with NIC Passthrough, refer to the following topic for an additional step: [vSphere Administrator Addendum for Deploying AI/ML Workloads on TKGS Clusters \(vGPU and Dynamic DirectPath IO\)](#).

- 1 Log on to the vCenter Server using the vSphere Client.
- 2 Select **Workload Management**.
- 3 Select **Services**.
- 4 Select **VM Classes**.
- 5 Click **Create VM Class**.
- 6 At the **Configuration** tab, configure the custom VM Class.

Configuration Field	Description
<b>Name</b>	Enter a self-descriptive name for the custom VM class, such as <code>vmclass-vgpu-1</code> .
<b>vCPU Count</b>	2
<b>CPU Resource Reservation</b>	Optional, OK to leave blank
<b>Memory</b>	80 GB, for example
<b>Memory Resource Reservation</b>	100% (mandatory when PCI devices are configured in a VM Class)
<b>PCI Devices</b>	<p><b>Yes</b></p> <p><b>Note</b> Selecting Yes for PCI Devices tells the system you are using a GPU device and changes the VM Class configuration to support vGPU configuration.</p>

For example:

### Create VM Class

- 1 Configuration
- 2 PCI Devices
- 3 Review and Confirm

### Configuration

below.

i Memory Resource Reservation must be set to 100% when PCI devices are configured in a VM Class.

Name <span style="color: #0070c0;">i</span>	vmclass-vgpu-01 <span style="float: right;">📄</span>	
vCPU Count	2	
CPU Resource Reservation <span style="color: #0070c0;">i</span>	Optional	%
Memory	80	GB <span style="font-size: small;">v</span>
Memory Resource Reservation <span style="color: #0070c0;">i</span>	100	%
PCI Devices <span style="color: #0070c0;">i</span>	Yes <span style="font-size: small;">v</span>	

CANCEL
NEXT

- 7 Click **Next**.
- 8 At the **PCI Devices tab**, select the **Add PCI Device > NVIDIA vGPU** option.
- 9 Configure the NVIDIA vGPU model.

NVIDIA vGPU Field	Description
<b>Model</b>	Select the NVIDIA GPU hardware device model from those available in the <b>NVIDIA vGPU &gt; Model</b> menu. If the system does not show any profiles, none of the hosts in the cluster have supported PCI devices.
<b>GPU Sharing</b>	<p>This setting defines how the GPU device is shared across GPU-enabled VMs. There are two types of vGPU implementations: <b>Time Sharing</b> and <b>Multi-Instance GPU Sharing</b>.</p> <p>In Time Sharing mode, the vGPU scheduler instructs the GPU to perform the work for each vGPU-enabled VM <i>serially</i> for a duration of time with the best effort goal of balancing performance across vGPUs.</p> <p>MIG mode allows multiple vGPU-enabled VMs to run <i>in parallel</i> on a single GPU device. MIG mode is based on a newer GPU architecture and is only supported on NVIDIA A100 and A30 devices. If you do not see the MIG option, the PCI device you selected does not support it.</p>
<b>GPU Mode</b>	<b>Compute</b>
<b>GPU Memory</b>	<b>8 GB</b> , for example
<b>Number of vGPUs</b>	<b>1</b> , for example



For example, here is a NVIDIA vGPU profile configured in Time Sharing mode:

The screenshot displays the 'Create VM Class' wizard on the left, with three steps: 1 Configuration, 2 PCI Devices (selected), and 3 Review and Confirm. The main area shows the 'PCI Devices' configuration for a class. It includes an 'ADD PCI DEVICE' button and a list of devices. The selected device is an NVIDIA vGPU with the following settings:

Property	Value	Limit
Model	NVIDIATesla T4	
GPU Sharing	Time Sharing	
GPU Mode	Compute	
GPU Memory	16 GB	Max. 16 GB
Number of vGPUs	1	Max. 4 GPUs

At the bottom of the configuration panel are three buttons: CANCEL, BACK, and NEXT.

For example, here is a NVIDIA vGPU profile configured in MIG mode with supported GPU device:

The screenshot shows the 'Edit VM Class' interface. On the left, a sidebar lists three steps: '1 Configuration', '2 PCI Devices' (which is highlighted), and '3 Review and Confirm'. The main area is titled 'PCI Devices' and contains the following elements:

- A note: "Adding PCI devices to the VM class will make them available to VMs created with this class."
- An 'ADD PCI DEVICE' button.
- A configuration card for 'NVIDIA vGPU' with a 'REMOVE' button in the top right corner.
- Fields for configuring the vGPU:
  - Model:** NVIDIA A100-PCIE-40GB (with an info icon).
  - GPU Sharing:** A dropdown menu is open, showing options: 'Select sharing mode', 'Time Sharing', and 'Multi-Instance GPU Sharing' (which is selected with a checkmark).
  - GPU Mode:** Compute (with an info icon).
  - GPU Memory:** 20 GB (with an info icon). Below the input is the text 'Max. 40 GB'.
  - Number of vGPUs:** 1 (with an info icon). Below the input is the text 'Max. 4 GPUs'.
- At the bottom right, there are three buttons: 'CANCEL', 'BACK', and 'NEXT'.

- 10 Click **Next**.
- 11 Review and confirm your selections.
- 12 Click **Finish**.
- 13 Verify that the new custom VM Class is available in the list of VM Classes.

## Admin Step 8: Create and Configure a vSphere Namespace for the TKGS GPU Cluster

Create a vSphere Namespace for each TKGS GPU cluster you plan to provision. Configure the namespace by adding a vSphere SSO user with Edit permissions, and attach a storage policy for persistent volumes.

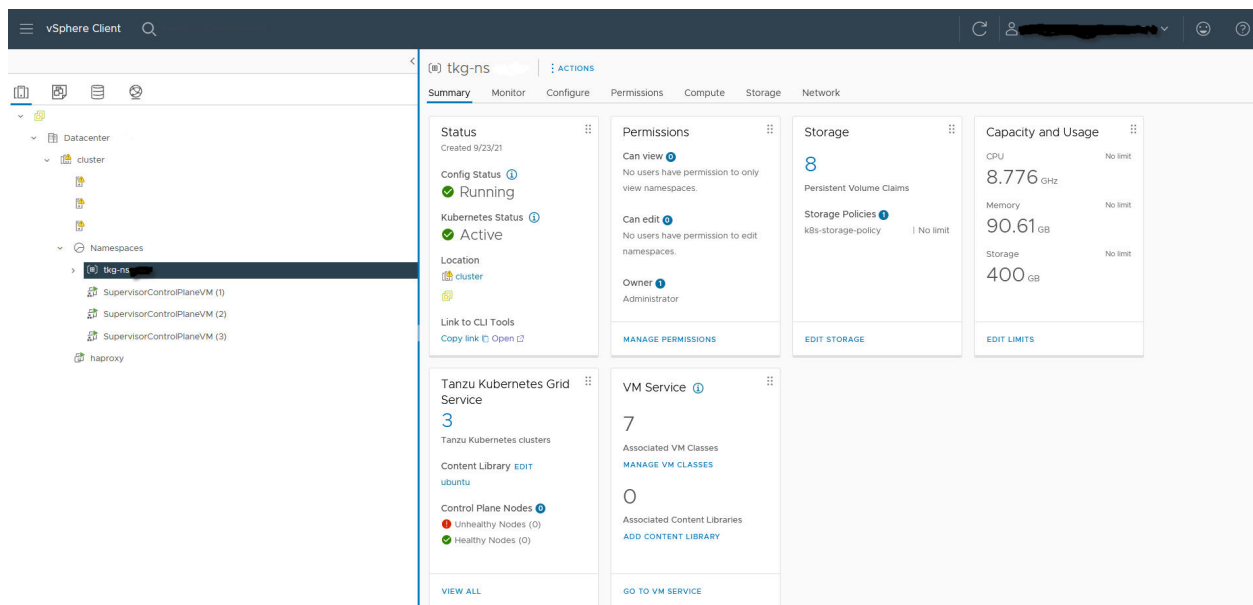
To do this, see [Create and Configure a vSphere Namespace](#).

## Admin Step 9: Associate the Content Library and VM Class with the vSphere Namespace

After you have created and configured the vSphere Namespace, associate the Content Library that includes the Ubuntu OVA with the vSphere Namespace, and associate the custom VM Class with the vGPU profile with the same vSphere Namespace.

Task	Description
Associate the Content Library with the Ubuntu OVA for vGPU with the vSphere Namespace where you will provision the TKGS cluster.	See <a href="#">Configure a vSphere Namespace for Tanzu Kubernetes releases</a> .
Associate the custom VM Class with the vGPU profile with the vSphere Namespace where you will provision the TKGS cluster.	See <a href="#">Associate a VM Class with a Namespace in vSphere with Tanzu</a> .

The following example shows a configured vSphere Namespace with an associated Content Library and custom VM Class for use with vGPU clusters.



## Admin Step 10: Verify that the Supervisor Cluster Is Accessible

The last administration task is to verify that the Supervisor Cluster is provisioned and available for use by the Cluster Operator to provision a TKGS cluster for AI/ML workloads.

- Download and install the Kubernetes CLI Tools for vSphere.  
See [Download and Install the Kubernetes CLI Tools for vSphere](#).
- Connect to the Supervisor Cluster.  
See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).
- Provide the Cluster Operator with the link to download the Kubernetes CLI Tools for vSphere and the name of the vSphere Namespace.  
See [Cluster Operator Workflow for Deploying AI/ML Workloads on TKGS Clusters](#).

## Cluster Operator Workflow for Deploying AI/ML Workloads on TKGS Clusters

To enable developers to deploy AI/ML workloads on TKGS clusters, as a Cluster Operator you configure the Kubernetes environment to support NVIDIA vGPU operations.

### Cluster Operator Workflow for Deploying AI/ML Workloads on TKGS Clusters

The high-level steps to deploy AI/ML workloads on TKGS clusters are as follows:

Step	Action	Link
0	Review system requirements.	See <a href="#">Operator Step 0: Review System Requirements</a> .
1	Download kubectl and vSphere Plugin for Kubectl to local workstation.	See <a href="#">Operator Step 1: Install the Kubernetes CLI Tools for vSphere on Your Workstation</a> .
2	Use kubectl to log in to the Supervisor Cluster, which populates .kube/config with the context for the new Supervisor Cluster.	See <a href="#">Operator Step 2: Log in to the Supervisor Cluster</a> .
3	Use kubectl to switch context to the vSphere Namespace.	See <a href="#">Operator Step 3: Switch Context to the vSphere Namespace</a> .
4	Use kubectl to list VM classes and verify that the NVIDIA vGPU-enabled class is present.	See <a href="#">Operator Step 4: Get the Custom VM Class for vGPU Workloads</a> .
5	Use kubectl to list the available Tanzu Kubernetes releases and verify that the Ubuntu image is present.	See <a href="#">Operator Step 5: Get the Ubuntu Tanzu Kubernetes Release for GPU Nodes</a> .
6	Craft the YAML specification for provisioning the GPU-enabled TKGS cluster; specify the TKR version and the VM class.	See <a href="#">Operator Step 6: Craft the YAML for Provisioning the vGPU-enabled TKGS Cluster</a> .
7	Provision the TKGS cluster.	See <a href="#">Operator Step 7: Provision the TKGS Cluster</a> .
8	Log in to the cluster and verify provisioning.	See <a href="#">Operator Step 8: Log In to the TKGS Cluster and Verify Provisioning</a> .
9	Prepare to install the NVAIE GPU Operator by creating some prerequisite objects in the TKGS cluster, including a namespace, role bindings, image secret, and license configmap.	See <a href="#">Operator Step 9: Prepare to Install the NVAIE GPU Operator</a> .
10	Install the NVAIE GPU Operator in the cluster.	See <a href="#">Operator Step 10: Install the NVIDIA GPU Operator in the Cluster</a> .
11	Deploy AI/ML workloads to the vGPU-enabled TKGS cluster.	See <a href="#">Operator Step 11: Deploy an AI/ML Workload</a> .

### Operator Step 0: Review System Requirements

Refer to the following system requirements to set up the environment for deploying AI/ML workloads on TKGS clusters.

Requirement	Description
vSphere Administrator has set up the environment for NVIDIA vGPU	See <a href="#">vSphere Administrator Workflow for Deploying AI/ML Workloads on TKGS Clusters (vGPU)</a>
TKR Ubuntu OVA	Tanzu Kubernetes release Ubuntu ob-18691651-tkgs-ova-ubuntu-2004-v1.20.8---vmware.1-tkg.2
TKG Cluster Provisioner	Tanzu Kubernetes Grid Service API version: <code>run.tanzu.vmware.com/v1alpha2</code>
NVIDIA GPU Operator	GPU Operator v1.8.0
NVIDIA GPU Driver Container	<code>nvcr.io/nvstating/cnt-ea/driver:470.51-ubuntu20.04</code>

## Operator Step 1: Install the Kubernetes CLI Tools for vSphere on Your Workstation

Download and install the Kubernetes CLI Tools for vSphere.

If you are using Linux you can run the following command to download the tools.

```
curl -LOk https://${SC_IP}/wcp/plugin/linux-amd64/vsphere-plugin.zip
unzip vsphere-plugin.zip
mv -v bin/* /usr/local/bin/
```

For additional guidance, see [Download and Install the Kubernetes CLI Tools for vSphere](#).

## Operator Step 2: Log in to the Supervisor Cluster

Using the vSphere Plugin for kubectl, authenticate with the Supervisor Cluster.

```
kubectl vsphere login --server=IP-ADDRESS --vsphere-username USERNAME
```

## Operator Step 3: Switch Context to the vSphere Namespace

Using kubectl, switch context to the vSphere Namespace that the vSphere administrator created for the TKGS GPU cluster.

```
kubectl config get-contexts
```

```
kubectl config use-context TKGS-GPU-CLUSTER-NAMESPACE
```

## Operator Step 4: Get the Custom VM Class for vGPU Workloads

Verify that the custom VM Class with the vGPU profile that the vSphere Administrator created is available in the target vSphere Namespace.

```
kubectl get virtualmachineclassbindings
```

**Note** The VM class must be bound to the target vSphere Namespace. If you do not see the custom VM class for vGPU workloads, check with the vSphere Administrator.

## Operator Step 5: Get the Ubuntu Tanzu Kubernetes Release for GPU Nodes

Verify that the required Ubuntu Tanzu Kubernetes release that the vSphere Administrator synchronized from the Content Library is available in the vSphere Namespace.

```
kubectl get tanzukubernetesreleases
```

Or, using the shortcut:

```
kubectl get tkr
```

## Operator Step 6: Craft the YAML for Provisioning the vGPU-enabled TKGS Cluster

Construct the YAML file for provisioning a Tanzu Kubernetes cluster.

Start with one of the of the examples below. Use the information you gleaned from the output of the preceding commands to customize the cluster specification. Refer to the full list of configuration parameters: [Configuration Parameters for Provisioning Tanzu Kubernetes Clusters Using the Tanzu Kubernetes Grid Service v1alpha2 API](#).

Example 1 specifies two worker node pools.

```
apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
metadata:
  #cluster name
  name: tkgs-cluster-gpu-a100
  #target vsphere namespace
  namespace: tkgs-gpu-operator
spec:
  topology:
    controlPlane:
      replicas: 3
      #storage class for control plane nodes
      #use `kubectl describe storageclasses`
      #to get available pvcs
      storageClass: vwt-storage-policy
      vmClass: guaranteed-medium
      #TKR NAME for Ubuntu ova supporting GPU
      tkr:
        reference:
          name: 1.20.8---vmware.1-tkg.1
    nodePools:
      - name: nodepool-a100-primary
        replicas: 3
        storageClass: vwt-storage-policy
        #custom VM class for vGPU
        vmClass: class-vgpu-a100
        #TKR NAME for Ubuntu ova supporting GPU
        tkr:
          reference:
            name: 1.20.8---vmware.1-tkg.1
      - name: nodepool-a100-secondary
```

```

replicas: 3
vmClass: class-vgpu-a100
storageClass: vwt-storage-policy
#TKR NAME for Ubuntu ova supporting GPU
tkr:
  reference:
    name: 1.20.8---vmware.1-tkg.1
settings:
  storage:
    defaultClass: vwt-storage-policy
  network:
    cni:
      name: antrea
    services:
      cidrBlocks: ["198.51.100.0/12"]
    pods:
      cidrBlocks: ["192.0.2.0/16"]
  serviceDomain: managedcluster.local

```

Example 2 specifies a separate volume on worker nodes for the containerd runtime with a capacity of 50 GiB. This setting is configurable. Providing a separate volume of good size is recommended for container-based AI/ML workloads.

```

apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
metadata:
  name: tkc
  namespace: tkg-ns-auto
spec:
  distribution:
    fullVersion: v1.20.8+vmware.1-tkg.1
  topology:
    controlPlane:
      replicas: 3
      storageClass: vwt-storage-policy
      tkr:
        reference:
          name: v1.20.8---vmware.1-tkg.1
        vmClass: best-effort-medium
    nodePools:
      - name: workers
        replicas: 3
        storageClass: k8s-storage-policy
        tkr:
          reference:
            name: v1.20.8---vmware.1-tkg.1
          vmClass: vmclass-vgpu
        volumes:
          - capacity:
              storage: 50Gi
              mountPath: /var/lib/containerd
              name: containerd
          - capacity:
              storage: 50Gi

```

```

    mountPath: /var/lib/kubelet
    name: kubelet
  - name: nodepool-1
    replicas: 1
    storageClass: vwt-storage-policy
    vmClass: best-effort-medium

```

Example 3 includes cluster additional metadata such as a label.

```

apiVersion: run.tanzu.vmware.com/v1alpha2
kind: TanzuKubernetesCluster
metadata:
  annotations:
  labels:
    run.tanzu.vmware.com/tkr: v1.20.8---vmware.1-tkg.1
  name: tkgs-gpu-direct-rdma
  namespace: tkgs-ns
spec:
  settings:
    network:
      cni:
        name: antrea
      pods:
        cidrBlocks:
          - 192.168.0.0/16
        serviceDomain: cluster.local
      services:
        cidrBlocks:
          - 10.96.0.0/12
    topology:
      controlPlane:
        replicas: 3
        storageClass: tkgs-storage-policy
        vmClass: guaranteed-medium
        tkr:
          reference:
            name: v1.20.8---vmware.1-tkg.1
      nodePools:
        - name: workers
          replicas: 5
          storageClass: tkgs-storage-policy
          vmClass: claire-gpu-direct-rdma
          volumes:
            - capacity:
                storage: 50Gi
              mountPath: /var/lib/containerd
              name: containerd
            - capacity:
                storage: 50Gi
              mountPath: /var/lib/kubelet
              name: kubelet
        tkr:
          reference:
            name: v1.20.8---vmware.1-tkg.1

```



## Operator Step 7: Provision the TKGS Cluster

Provision the cluster by running the following kubectl command.

```
kubectl apply -f CLUSTER-NAME.yaml
```

For example:

```
kubectl apply -f tkgs-gpu-cluster-1.yaml
```

Monitor the deployment of cluster nodes using kubectl.

```
kubectl get tanzukubernetesclusters -n NAMESPACE
```

## Operator Step 8: Log In to the TKGS Cluster and Verify Provisioning

Using the vSphere Plugin for kubectl, log in to the TKGS cluster.

```
kubectl vsphere login --server=IP-ADDRESS --vsphere-username USERNAME \
--tanzu-kubernetes-cluster-name CLUSTER-NAME --tanzu-kubernetes-cluster-namespace NAMESPACE-
NAME
```

Use the following commands to verify the cluster:

```
kubectl cluster-info
```

```
kubectl get nodes
```

```
kubectl get namespaces
```

```
kubectl api-resources
```

## Operator Step 9: Prepare to Install the NVAIE GPU Operator

Prior to installing the GPU Operator with NVIDIA AI Enterprise, complete the following tasks for the TKGS cluster you provisioned. For additional guidance, see [Prerequisite Tasks](#) in the NVAIE documentation.

---

**Note** If you are using the NVIDIA Delegated Licensing Server (DLS), refer to the following topic for instructions: [Cluster Operator Addendum for Deploying AI/ML Workloads on TKGS Clusters \(DLS\)](#)

---

- 1 Create the Kubernetes namespace `gpu-operator-resources`. As a best practice, always deploy everything in this namespace.

```
kubectl create ns gpu-operator-resources
```

- 2 Create role bindings.

Tanzu Kubernetes clusters have pod security policy enabled.

Create `rolebindings.yaml`.

```
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: psp:vmware-system-privileged:default
  namespace: default
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: psp:vmware-system-privileged
subjects:
- apiGroup: rbac.authorization.k8s.io
  kind: Group
  name: system:nodes
- apiGroup: rbac.authorization.k8s.io
  kind: Group
  name: system:serviceaccounts
```

Apply the role binding.

```
kubectl apply -f rolebindings.yaml
```

Create `post-rolebindings.yaml`.

```
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: psp:vmware-system-privileged:gpu-operator-resources
  namespace: gpu-operator-resources
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: psp:vmware-system-privileged
subjects:
- kind: Group
  apiGroup: rbac.authorization.k8s.io
  name: system:serviceaccounts
```

Apply the role binding:

```
kubectl apply -f post-rolebindings.yaml
```

- 3 Create an image secret with NGC credentials that can be used by Docker to pull container images from the [NVIDIA GPU Cloud Catalog](#).

```
kubectl create secret docker-registry registry-secret \
  --docker-server=server-name --docker-username='$oauthtoken' \
  --docker-password=<place_holder> \
  --docker-email=email-name -n gpu-operator-resources
```

#### 4 Create a configmap for the NVIDIA license server.

```
kubectl create configmap licensing-config -n gpu-operator-resources --from-file=gridd.conf
```

The `gridd.conf` reference the NVIDIA license server address, for example:

```
# Description: Set License Server Address
# Data type: string
# Format: "<address>"
ServerAddress=<place_holder>
```

### Operator Step 10: Install the NVIDIA GPU Operator in the Cluster

Install the [NVAIE GPU Operator](#) version 1.8.0 in the TKGS cluster. For additional guidance, refer to the GPU Operator [documentation](#).

**Note** If you are using the NVIDIA Delegated Licensing Server (DLS), refer to the following topic for instructions: [Cluster Operator Addendum for Deploying AI/ML Workloads on TKGS Clusters \(DLS\)](#)

- 1 Install Helm by referring to the [Helm documentation](#).
- 2 Add the `gpu-operator` Helm repository.

```
helm repo add nvidia https://nvidia.github.io/gpu-operator
```

- 3 Install the NVAIE GPU Operator by running the following command.

Where necessary, substitute environment variable values with those that match your environment.

```
export PRIVATE_REGISTRY="private/registry/path"
export OS_TAG=ubuntu20.04
export VERSION=460.73.01
export VGPU_DRIVER_VERSION=460.73.01-grid
export NGC_API_KEY=ZmJjMHZya...LWExNTRi
export REGISTRY_SECRET_NAME=registry-secret

helm install nvidia/gpu-operator \
  --set driver.repository=$PRIVATE_REGISTRY \
  --set driver.version=$VERSION \
  --set driver.imagePullSecrets=${REGISTRY_SECRET_NAME} \
  --set operator.defaultRuntime=containerd \
  --set driver.licensingConfig.configMapName=licensing-config
```

### Operator Step 11: Deploy an AI/ML Workload

The [NVIDIA GPU Cloud Catalog](#) offers several off-the-shelf container images you can use to run AI/ML workloads on your vGPU-enabled Tanzu Kubernetes clusters. For more information on the images available, see the [NGC documentation](#).

## vSphere Administrator Addendum for Deploying AI/ML Workloads on TKGS Clusters (vGPU and Dynamic DirectPath IO)

Refer to this delta topic if you are configuring TKGS to support AI/ML workloads using vGPU and Dynamic DirectPath IO.

### vSphere Administrator Workflow Adjustments for vGPU with Dynamic DirectPath IO

To use vGPU and Dynamic DirectPath IO, follow the same [vSphere Administrator Workflow for Deploying AI/ML Workloads on TKGS Clusters \(vGPU\)](#) with the following changes.

#### Admin Step 2: Enable Passthrough for the PCI Device

To use vGPU and Dynamic DirectPath IO, configure each ESXi host for vGPU as described here: [Admin Step 2: Configure Each ESXi Host for vGPU Operations](#).

In addition, configure the GPU device as follows.

- 1 Log on to the vCenter Server using the vSphere Client.
- 2 Select the target ESXi host in the vCenter Cluster.
- 3 Select **Configure > Hardware > PCI Devices**.
- 4 Select the **All PCI Devices** tab.
- 5 Select the target NVIDIA GPU accelerator device.
- 6 Click **Toggle Passthrough**.
- 7 Right-click the ESXi host and put it into maintenance mode.
- 8 Reboot the host.
- 9 When the host is running again, take it out of maintenance mode.

#### Admin Step 7: Create a Custom VM Class with a vGPU and Dynamic DirectPath IO

To use vGPU and Dynamic DirectPath IO, first configure a custom VM Class with a **NVIDIA vGPU** profile as described here: [Admin Step 7: Create a Custom VM Class with the vGPU Profile](#).

Then, to this VM Class you add a second PCI Device configuration with **Dynamic DirectPath IO** specified and the supported PCI Device selected. When a VM Class of this type is instantiated, the vSphere Distributed Resource Scheduler (DRS) determines VM placement.

Refer to the following instructions to create a custom VM Class supporting vGPU and Dynamic DirectPath IO. For additional guidance, see [Add PCI Devices to a VM Class in vSphere with Tanzu](#).

- 1 Log on to the vCenter Server using the vSphere Client.
- 2 Select **Workload Management**.
- 3 Select **Services**.
- 4 Select **VM Classes**.

- 5 Edit the custom VM Class that is already configured with a **NVIDIA vGPU** profile.
- 6 Select the **PCI Devices** tab.
- 7 Click **Add PCI Device**.
- 8 Select the **Dynamic DirectPath IO** option.



- 9 Select the **PCI Device**.

For example:



- 10 Click **Next**.
- 11 Review and confirm your selections.
- 12 Click **Finish**.
- 13 Verify that the new custom VM Class is available in the list of VM Classes.

## Cluster Operator Addendum for Deploying AI/ML Workloads on TKGS Clusters (DLS)

Refer to this delta topic if you are using the NVIDIA Delegated Licensing Server (DLS) for your NVIDIA AI Enterprise account.

## Cluster Operator Addendum for Deploying AI/ML Workloads on TKGS Clusters

NVIDIA provides a new NVIDIA Licensing Server (NLS) system called DLS which stands for Delegated Licensing Server. For more information, refer to the NVIDIA [documentation](#).

If you are using DLS for your NVAIE account, the steps for preparing to and deploying the NVAIE GPU Operator are different than what is documented here: [Cluster Operator Workflow for Deploying AI/ML Workloads on TKGS Clusters](#). Specifically, Steps 9 and 10 are modified as follows.

### Operator Step 9: Prepare to Install the NVAIE GPU Operator

Complete the following steps to prepare to install the GPU Operator using a DLS.

- 1 Create a Secret.

```
kubectl create secret docker-registry registry-secret \
  --docker-server=<users private NGC registry name>
  --docker-username='$oauthtoken' \
  --docker-password=ZmJj.....Ri \
  --docker-email=<user-email-address> -n gpu-operator-resources
```

---

**Note** The password is the user API Key that was previously created on the NVIDIA GPU Cloud (NGC) Portal.

---

- 2 Get a Client Token from the DLS Server.

A user who wishes to use a vGPU license will need to get a token from that DLS license server called a “Client token. The mechanism for doing this is in the NVIDIA [documentation](#).

- 3 Create a ConfigMap object in the TKGS cluster using the Client Token.

Place the Client Token file into a file at <path>/client\_configuration\_token.tok.

Then, run the following command:

```
kubectl delete configmap licensing-config -n gpu-operator-resources; > gridd.conf
kubectl create configmap licensing-config \
  -n gpu-operator-resources --from-file=./gridd.conf --from-file=./
client_configuration_token.tok
```

---

**Note** The grid.conf file used by the DLS is empty. However, both the “--from-file” parameters are required.

---

### Operator Step 10: Install the NVAIE GPU Operator

Complete the following steps to install the NVAIE GPU Operator using a DLS. For additional guidance, refer to the GPU Operator [documentation](#).

- 1 Install the [NVAIE GPU Operator](#) in the TKGS cluster.
  - Install Helm by referring to the [Helm documentation](#).

- Add the `gpu-operator` Helm repository.

```
helm repo add nvidia https://nvidia.github.io/gpu-operator
```

- Install the GPU Operator using Helm.

```
export PRIVATE_REGISTRY="<user's private registry name>"
export OS_TAG=ubuntu20.04
export VERSION=470.63.01
export VGPU_DRIVER_VERSION=470.63.01-grid
export NGC_API_KEY=Zm.....Ri <- The user's NGC AP Key
export REGISTRY_SECRET_NAME=registry-secret

helm show chart .
kubectl delete crd clusterpolicies.nvidia.com
helm install gpu-operator . -n gpu-operator-resources \
  --set psp.enabled=true \
  --set driver.licensingConfig.configMapName=licensing-config \
  --set operator.defaultRuntime=containerd \
  --set driver.imagePullSecrets={REGISTRY_SECRET_NAME} \
  --set driver.version=$VERSION \
  --set driver.repository=$PRIVATE_REGISTRY \
  --set driver.licensingConfig.nlsEnabled=true
```

## 2 Verify that DLS has worked.

From within a NVIDIA Driver DaemonSet pod that was deployed by the GPU Operator, execute the `nvidia-smi` command to verify that DLS is working.

First, run the following command to get into the pod and bring up a shell session:

```
kubectl exec -it nvidia-driver-daemonset-cvxx6 nvidia-driver-ctr -n gpu-operator-resources
- bash
```

Now you can run the command to verify the DLS setup.

```
nvidia-smi
```

If DLS is setup correctly, this command should return "Licensed" in the output.

# Using a Container Registry for vSphere with Tanzu Workloads

# 15

Container registries provide Kubernetes operators with a convenient repository for storing and sharing container images. vSphere with Tanzu includes an embedded Harbor Registry that you can enable on the Supervisor Cluster. You can also use an external private container registry with Tanzu Kubernetes clusters.

You can enable the embedded Harbor Registry on the Supervisor Cluster to serve as the private container registry for the deployment of vSphere Pods and Tanzu Kubernetes cluster workloads. You provide the registry URL to developers who can use the vSphere Docker Credential Helper to securely access the registry and push and pull container images.

---

**Note** The embedded Harbor Registry requires that the Supervisor Cluster is configured to use NSX-T networking.

---

As an alternative to the embedded Harbor Registry, or in addition to, you can configure Tanzu Kubernetes clusters to use an external private container registry.

This chapter includes the following topics:

- [Enable the Embedded Harbor Registry on the Supervisor Cluster](#)
- [Log In to the Embedded Harbor Registry Console](#)
- [Download and Install the Embedded Harbor Registry Certificate](#)
- [Configure a Docker Client with the Embedded Harbor Registry Certificate](#)
- [Install the vSphere Docker Credential Helper and Connect to the Registry](#)
- [Push Images to the Embedded Harbor Registry](#)
- [Purge Images from the Embedded Harbor Registry](#)
- [Use the Embedded Harbor Registry with Tanzu Kubernetes Clusters](#)
- [Use an External Container Registry with Tanzu Kubernetes Clusters](#)



# Enable the Embedded Harbor Registry on the Supervisor Cluster

As a vSphere administrator, you can enable the Harbor Registry that is embedded with vSphere with Tanzu. You can push and pull container images from the registry as well as deploy containers using these images.

Once the Harbor Registry is enabled, every namespace on the Supervisor Cluster has a matching project with the same name as the private image registry. Every user or group that has edit or view permission to a namespace becomes a corresponding role member on the matching project with the same name in the private image registry. The lifecycle of projects and members of the private image registry is automatically managed and is linked to the lifecycle of namespaces and user or group permissions in namespaces.

## Prerequisites

To enable the embedded Harbor Registry, you must have enabled **Workload Management** and deployed a Supervisor Cluster. In addition, create a storage policy for placement of container images. This storage policy is used to provision persistent volumes to use as the backing store for the container images in the registry.

---

**Note** To use the embedded Harbor Registry, you must deploy the Supervisor Cluster with NSX-T Data Center as the networking solution. See [Configuring NSX-T Data Center for vSphere with Tanzu](#).

---

## Procedure

- 1 In the vSphere Client, browse to the vCenter cluster where **Workload Management** is enabled.
- 2 Select **Configure**.
- 3 Under **Namespaces**, select **Image Registry**.
- 4 Click **Enable Harbor**.
- 5 Select the storage policy for placement of container images.

## Results

A private image registry becomes enabled after a few minutes. A special namespace is created for that instance of the private image registry. You cannot perform any operations on that namespace, it is read only for vSphere users.

## What to do next

[Log In to the Embedded Harbor Registry Console](#).

# Log In to the Embedded Harbor Registry Console

Use the embedded Harbor Registry Admin Console to manage and operate the private registry.

As a vSphere Administrator, you can use the embedded Harbor Registry Admin Console to create and manage projects, view logs, and explore the Harbor API.

### Prerequisites

[Enable the Embedded Harbor Registry on the Supervisor Cluster](#)

### Procedure

- 1 In the vSphere Client, browse to the vCenter cluster where **Workload Management** is enabled.
- 2 Select **Configure**.
- 3 Under **Namespaces**, select **Image Registry**.
- 4 Click the **Link to Harbor UI**.  
The embedded Harbor Registry Console log in page appears.
- 5 Log in using your vSphere administrator credentials.

## Download and Install the Embedded Harbor Registry Certificate

Download the embedded Harbor Registry root CA certificate so you can use it to connect clients to the registry.

To log in to the embedded Harbor Registry using a Docker client, you must install the root CA certificate on that client.

### Prerequisites

This task assumes that you have installed and configured Docker on a client host machine. In addition, the embedded Harbor Registry must be enabled. See [Enable the Embedded Harbor Registry on the Supervisor Cluster](#).

### Procedure

- 1 Download the embedded Harbor Registry certificate. There are two ways to do this.
  - Using the embedded Harbor Registry Console interface.
    - Log in to the embedded Harbor Registry Console using the URL. See [Log In to the Embedded Harbor Registry Console](#).
    - Click the project link at the **Projects > Project Name** page.
    - Select the **Repositories** tab.
    - Click **Registry Certificate**.
    - Save the `ca.crt` certificate file to your local machine.

- Using the vSphere Client.
    - Select the vCenter cluster where **Workload Management** and the embedded Harbor Registry are enabled.
    - Select **Configure > Namespaces > Image Registry**.
    - In the **Root certificate** field, click the link **Download SSL Root Certificate**.
    - Save the `root-certificate.txt` file to your local machine.
    - Rename the file to be `ca.crt`.
- 2 Copy the embedded Harbor Registry `ca.crt` file that you downloaded to the appropriate directory on a host where Docker is installed. The default certificate location differs depending on the type of OS that the Docker client is running.

- Linux

```
/etc/docker/certs.d/ca.crt
```

- Mac OS

```
security add-trusted-cert -d -r trustRoot -k ~/Library/Keychains/login.keychain ca.crt
```

---

**Note** If you do not install the `ca.crt` in the default location, you can pass the `--tlscacert /path/to/ca.crt` flag when you log in using the vSphere Docker Credential Helper.

---

- 3 Once the import is complete, restart the Docker daemon.

- Linux

```
sudo systemctl restart docker.service
```

- Mac

Use the Docker Desktop menu option **Restart Docker**, or the `command R` keyboard shortcut.

### What to do next

[Install the vSphere Docker Credential Helper and Connect to the Registry](#)

## Configure a Docker Client with the Embedded Harbor Registry Certificate

To work with container images in the embedded Harbor Registry using Docker, you must add the registry certificate to your Docker client. The certificate is used to authenticate to Docker during login.

Configure your Docker client to interact with the embedded Harbor Registry. This task is required in preparation for using the Docker Credential Helper that vSphere provides to connect and interact with the embedded Harbor Registry.

### Prerequisites

This task assumes that the embedded Harbor Registry is enabled and that you can log in:

- [Enable the Embedded Harbor Registry on the Supervisor Cluster](#)
- [Log In to the Embedded Harbor Registry Console](#)

In addition, the instructions assume that you are using a Linux host (Ubuntu) on which the Docker daemon is installed. To verify that Docker is installed and that you can pull images from the Docker hub, run the following command:

```
docker run hello-world
```

Expected result:

```
Hello from Docker!  
This message shows that your installation appears to be working correctly.
```

---

**Note** These instructions are verified using Ubuntu 20.04 and Docker 19.03.

---

### Procedure

- 1 Download the embedded Harbor Registry certificate `root-certificate.txt`. See [Download and Install the Embedded Harbor Registry Certificate](#).
- 2 Change the name of the certificate to `ca.crt`.
- 3 Securely copy the `ca.crt` file to your Docker host.
- 4 On the Docker host, create a directory path for the private registry using the Harbor IP address.

```
/etc/docker/certs.d/IP-address-of-harbor/
```

For example:

```
mkdir /etc/docker/certs.d/10.179.145.77
```

- 5 Move the `ca.crt` to this directory.

For example:

```
mv ca.crt /etc/docker/certs.d/10.179.145.77/ca.crt
```

- 6 Restart the Docker daemon.

```
sudo systemctl restart docker.service
```

## 7 Log in to the embedded Harbor Registry using your Docker client.

```
docker login https://10.179.145.77
```

You should see the following message:

```
WARNING! Your password will be stored unencrypted in /home/ubuntu/.docker/config.json.
Configure a credential helper to remove this warning. See
https://docs.docker.com/engine/reference/commandline/login/#credentials-store

Login Succeeded
```

### What to do next

As indicated by the message, for security purposes, download and install the vSphere Docker Credential Helper. See [Install the vSphere Docker Credential Helper and Connect to the Registry](#).

## Install the vSphere Docker Credential Helper and Connect to the Registry

Use the vSphere Docker Credential Helper CLI to securely push container images to and pull container images from the embedded Harbor Registry.

The Kubernetes CLI Tools download page includes a link to download the vSphere Docker Credential Helper. Use the vSphere Docker Credential Helper to securely connect your Docker client to the embedded Harbor Registry.

### Prerequisites

- [Enable the Embedded Harbor Registry on the Supervisor Cluster](#)
- 
- Get the link to the Kubernetes CLI Tools for vSphere download page from your vSphere administrator.
- Alternatively, if you have access to the vCenter Server, get the link as follows:
  - Log in to the vCenter Server using the vSphere Client.
  - Navigate to **vSphere Cluster > Namespaces** and select the vSphere Namespace where you are working.
  - Select the **Summary** tab and locate the **Status** tile.
  - Select **Open** beneath the **Link to CLI Tools** heading to open the download page. Or, you can **Copy** the link.
- Configure a Docker client. See [Configure a Docker Client with the Embedded Harbor Registry Certificate](#).

**Procedure**

- 1 Using a browser, navigate to the **Kubernetes CLI Tools** download URL for your environment.
- 2 Scroll down to the vSphere Docker Credential Helper section.
- 3 Select the operating system.
- 4 Download the `vsphere-docker-credential-helper.zip` file.
- 5 Extract the contents of the ZIP file to a working directory.

The `docker-credential-vsphere` binary executable is available.

- 6 Copy the `docker-credential-vsphere` binary to your Docker client host.
- 7 Add the location of the binary to your system PATH.

For example, on Linux:

```
mv docker-credential-vsphere /usr/local/bin/docker-credential-vsphere
```

- 8 Verify the installation of the vSphere Docker Credential Helper by running the command `docker-credential-vsphere` in a shell or terminal session.

You see the banner message, and the list of command-line options for the CLI.

```
vSphere login manager is responsible for vSphere authentication.
It allows vSphere users to securely login and logout to access Harbor images.

Usage:
  docker-credential-vsphere [command]

Available Commands:
  help          Help about any command
  login         Login into specific harbor server and get authentication
  logout        Logout from Harbor server and erase user token

Flags:
  -h, --help    help for docker-credential-vsphere

Use "docker-credential-vsphere [command] --help" for more information about a command.
```

- 9 Log in to the embedded Harbor Registry.

First, check the usage:

```
docker-credential-vsphere login -help
Usage:
  docker-credential-vsphere login [harbor-registry] [flags]

Flags:
```

```
-h, --help          help for login
-s, --service string credential store service
  --tlscacert string location to CA certificate (default "/etc/docker/certs.d/*.crt")
-u, --user string   vSphere username and password
```

Then, log in using the following command:

```
docker-credential-vsphere login <container-registry-IP>
```

The authentication token is fetched and saved, and you are logged in.

```
docker-credential-vsphere login 10.179.145.77
Username: administrator@vsphere.local
Password: INFO[0017] Fetched username and password
INFO[0017] Fetched auth token
INFO[0017] Saved auth token
```

## 10 Log out of the embedded Harbor Registry.

```
docker-credential-vsphere logout 10.179.145.77
```

### What to do next

[Push Images to the Embedded Harbor Registry](#) .

## Push Images to the Embedded Harbor Registry

You can push images from Docker to a project on the embedded Harbor Registry. Projects in the embedded Harbor Registry correspond to vSphere namespaces on a Supervisor Cluster.

### Prerequisites

It is assumed that the following tasks are completed:

- [Enable the Embedded Harbor Registry on the Supervisor Cluster](#)
- [Install the vSphere Docker Credential Helper and Connect to the Registry](#)

In addition, obtain your user account for which you have write permissions on the namespace that corresponds to the project on Harbor Registry where you want to push images.

Lastly, you need a local image that you can push to the registry. The following command pulls the hello-world image from Docker Hub. You will need an account there to pull the image.

```
docker run hello-world
```

Expected result:

```
Hello from Docker!
This message shows that your installation appears to be working correctly.
```

Verify the image using the `docker images` command.

```
docker images
REPOSITORY          TAG                 IMAGE ID            CREATED             SIZE
hello-world         latest             bf756fb1ae65       10 months ago      13.3kB
```

## Procedure

- 1 Login to Harbor Registry with the vSphere Docker Credential Helper.

```
docker-credential-vsphere login <container-registry-IP> --user username@domain.com
```

**Note** While providing `--user username` is acceptable for login, you should use the UserPrincipalName (UPN) syntax (`--user username@domain.com`) to login and use `docker push` commands.

- 2 Tag the image that you want to push to the project in Harbor Registry with same name as the namespace, where you want to use it:

```
docker tag <image-name>[:TAG] <container-registry-IP>/<project-name>/<image-name>[:TAG]
```

For example:

```
docker tag hello-world:latest 10.179.145.77/tkgs-cluster-ns/hello-world:latest
```

```
docker images
REPOSITORY          TAG                 IMAGE ID            CREATED             SIZE
10.179.145.77/tkgs-cluster-ns/hello-world  latest             bf756fb1ae65       10 months ago      13.3kB
hello-world         latest             bf756fb1ae65       10 months ago      13.3kB
```

- 3 To push an image to a project in Harbor, run the following command:

Syntax:

```
docker push <container-registry-IP>/<namespace-name>/<image_name>
```

For example:

```
docker push 10.179.145.77/tkgs-cluster-ns/hello-world:latest
```



Expected result.

```
The push refers to repository [10.179.145.77/tkgs-cluster-ns/hello-world]
9c27e219663c: Pushed
latest: digest: sha256:90659bf80b44ce6be8234e6ff90a1ac34acbeb826903b02cfa0da11c82cbc042
size: 525
```

- 4 Verify that the image is now available in the embedded Harbor Registry.
  - [Log In to the Embedded Harbor Registry Console](#)
  - Click the project link at the **Projects > Project Name**.
  - Select the **Repositories** tab.
  - You should see the image that you pushed to the registry is present, in the form namespace/image-name, such as tkgs-cluster-ns/hello-world.
  - Select this image and you see the `latest` tag and other metadata.
- 5 Navigate back to the **Repositories** tab.
- 6 Select the **Push Image Docker Command** drop down menu. The commands to tag and push images to this repository are provided to you.

### Example

Here is another example image push to the embedded Harbor Registry:

```
docker tag busybox:latest <container-registry-IP>/<namespace-name>/busybox:latest
docker push <container-registry-IP>/busybox/busybox:latest
```

### What to do next

Deploy vSphere Pods by using images from the Harbor registry. See [Deploy an Application to a vSphere Pod Using the Embedded Harbor Registry](#).

## Purge Images from the Embedded Harbor Registry

As a vSphere administrator, you can purge the images for a project in the private image registry by request from DevOps engineers. Purging images from the private image registry deletes all references to the images made by pods, but it does not remove the images from the image registry.

In case DevOps engineers report that too many images are stored for a project, as a vSphere administrator you can purge the images for that project in the private image registry. Purging the images from a project deletes all references to these images, but does not delete them from the vSphere datastore. Every Saturday at 2 AM, the garbage collector service deletes all images from the entire private image registry that are not referenced by applications.

**Procedure**

- 1 In the vSphere Client, navigate to the namespace.
- 2 Select **Configure** and select **General**.
- 3 Next to **Embedded Registry**, click **Purge**.

## Use the Embedded Harbor Registry with Tanzu Kubernetes Clusters

You can use the embedded Harbor Registry to serve as the private container registry for images that you deploy to Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service.

vSphere with Tanzu embeds a Harbor Registry instance that you can enable on the Supervisor Cluster and use to deploy container-based workloads to Tanzu Kubernetes clusters.

Once the embedded Harbor Registry is enabled on the Supervisor Cluster, the Tanzu Kubernetes Grid Service will install onto the Tanzu Kubernetes cluster nodes the root CA certificate for the registry instance. This certificate is installed on both new clusters and on existing clusters (by way of a reconciliation loop). From there you can run images on the cluster by specifying the private registry in the workload YAML.

### Workflow

Use the following workflow to securely access the private registry from Tanzu Kubernetes cluster nodes and pull container images.

Step	Action	Instructions
0	Review the workflow for using the embedded Harbor Registry with Tanzu Kubernetes clusters.	See <a href="#">Chapter 15 Using a Container Registry for vSphere with Tanzu Workloads</a> .
1	Enable the embedded Harbor Registry on the Supervisor Cluster.	See <a href="#">Enable the Embedded Harbor Registry on the Supervisor Cluster</a> .
2	Configure the kubeconfig for each cluster with the Registry Service Secret.	See the instructions below: Configure a Tanzu Kubernetes cluster with the image pull secret for the embedded Harbor Registry.
3	Configure the workload YAML to specify the private container registry.	See the instructions below: Configure a Tanzu Kubernetes cluster with the image pull secret for the embedded Harbor Registry.
4	To push images to the embedded Harbor Registry, configure a Docker client and install the vSphere Docker Credential Helper.	See <a href="#">Configure a Docker Client with the Embedded Harbor Registry Certificate</a> and <a href="#">Push Images to the Embedded Harbor Registry</a> .

## Configure a Tanzu Kubernetes Cluster with the Image Pull Secret for the Embedded Harbor Registry

Configure your kubeconfig with the image pull secret to connect a Tanzu Kubernetes cluster to a private container registry, either the embedded Harbor Registry or an external private registry.

- 1 Connect to the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).
- 2 Switch context to the vSphere Namespace where the target Tanzu Kubernetes cluster is provisioned.

```
kubectl config use-context tkgs-cluster-ns
```

- 3 Get the image pull secret for the vSphere Namespace and store it in a file.

```
kubectl get secret -n <vsphere-namespace> <vsphere-namespace>-default-image-pull-secret -o yml > <path>/image-pull-secret.yaml
```

For example:

```
kubectl get secret -n tkgs-cluster-ns tkgs-cluster-ns-default-image-pull-secret -o yml > tanzu/image-pull-secret.yaml
```

- 4 Open `image-pull-secret.yaml` with a text editor. At a minimum make the required change and save the file when you are done.

```
apiVersion: v1
data:
  .dockerconfigjson: ewoJCQkJImFldGhzJUV2s1ZVZwWVFuWmp...
kind: Secret
metadata:
  creationTimestamp: "2020-11-12T02:41:08Z"
  managedFields:
  - apiVersion: v1
    ...
  name: harbor-registry-secret #OPTIONAL: Change if desired
  namespace: default #REQUIRED: Enter the Kubernetes namespace
  ownerReferences:
  - apiVersion: registryagent.vmware.com/v1alpha1
    ...
  resourceVersion: "675868"
```

```
selfLink: /api/v1/namespaces/tkgs-cluster-ns/secrets/tkgs-cluster-ns-default-image-pull-secret
uid: 66606b41-7363-4b74-a3f2-4436f83f
type: kubernetes.io/dockerconfigjson
```

- **REQUIRED:** Change the value for `namespace` to match an appropriate Kubernetes namespace in the cluster, such as **default**.

---

**Note** To configure the image pull secret, specify a Kubernetes namespace. If the Tanzu Kubernetes cluster already exists, switch context to it and run `kubectl get namespaces` to list available Kubernetes namespaces. If necessary create the target namespace before proceeding. If the Tanzu Kubernetes cluster does not exist, you can use the `default` namespace.

---

- **OPTIONAL:** Change the value for `name` to something meaningful, such as **harbor-registry-secret** Or **private-registry-secret**.

- 5 Create a kubeconfig file that can be used to access the Tanzu Kubernetes cluster.

```
kubectl get secret -n <vsphere-namespace> <cluster-name>-kubeconfig -o
jsonpath='{.data.value}' | base64 -d > <path>/cluster-kubeconfig
```

Replace `<vsphere-namespace>` with the name of the vSphere Namespace where the target Tanzu Kubernetes cluster is provisioned. Replace `<cluster-name>` with the name of the Tanzu Kubernetes cluster.

```
kubectl get secret -n tkgs-cluster-ns tkgs-cluster-5-kubeconfig -o
jsonpath='{.data.value}' | base64 -d > tanzu/cluster-kubeconfig
```

- 6 Create the Registry Service secret in the Tanzu Kubernetes cluster. Reference the image pull secret file that you saved and updated locally.

```
kubectl --kubeconfig=<path>/cluster-kubeconfig apply -f <path>/image-pull-secret.yaml
```

For example:

```
kubectl --kubeconfig=tanzu/cluster-kubeconfig apply -f tanzu/image-pull-secret.yaml
```

You should see that the Registry Service secret is successfully created.

```
secret/harbor-registry-secret created
```

## Configure a Tanzu Kubernetes Workload to Pull Images from a Private Container Registry

To pull images from a private container registry for a Tanzu Kubernetes cluster workload, configure the workload YAML with the private registry details.

This procedure can be used to pull images from a private container registry, or the embedded Harbor Registry. In this example, we create a pod specification that will use an image stored in the embedded Harbor Registry and utilize the image pull secret previously configured.

- 1 Create an example pod spec with the details about the private registry.

```
apiVersion: v1
kind: Pod
metadata:
  name: <workload-name>
  namespace: <kubernetes-namespace>
spec:
  containers:
  - name: private-reg-container
    image: <Registry-IP-Address>/<vsphere-namespace>/<image-name>:<version>
    imagePullSecrets:
    - name: <registry-secret-name>
```

- Replace <workload-name> with the name of the pod workload.
  - Replace <kubernetes-namespace> with the Kubernetes namespace in the cluster where the pod will be created. This must be the same Kubernetes namespace where the Registry Service image pull secret is stored in the Tanzu Kubernetes cluster (such as the default namespace).
  - Replace <Registry-IP-Address> with the IP address for the embedded Harbor Registry instance running on the Supervisor Cluster.
  - Replace <vsphere-namespace> with the vSphere Namespace where the target Tanzu Kubernetes is provisioned.
  - Replace <image-name> with an image name of your choice.
  - Replace <version> with an appropriate version of the image, such as "latest".
  - Replace <registry-secret-name> with the name of the Registry Service image pull secret that you created previously.
- 2 Create a workload in the Tanzu Kubernetes cluster based on the pod specification you defined.

```
kubectl --kubeconfig=<path>/cluster-kubeconfig apply -f <pod.yaml>
```

The pod should be created from the image pulled from the registry.

## Use an External Container Registry with Tanzu Kubernetes Clusters

You can use an external container registry with Tanzu Kubernetes cluster pods. This is an alternative to using the embedded Harbor Registry.

## External Private Registry Use Case

Container registries provide a critical function for Kubernetes deployments, serving as a centralized repository for storing and sharing container images. The most commonly used public container registry is [DockerHub](#). There are many private container registry offerings. VMware [Harbor](#) is an open-source, cloud native, private container registry. vSphere with Tanzu embeds an instance of Harbor that you can use as the private container registry for vSphere Pods and for pods running on Tanzu Kubernetes clusters. For more information, see [Enable the Embedded Harbor Registry on the Supervisor Cluster](#).

The embedded Harbor Registry that ships with vSphere with Tanzu requires NSX-T networking. If you are using vSphere networking, you cannot use it. In addition, you may already be running your own private container registry that you want to integrate with your Tanzu Kubernetes clusters. In this case you can configure the Tanzu Kubernetes Grid Service to trust private registries with self-signed certificates, thereby allowing Kubernetes pods running on Tanzu Kubernetes clusters to use the external registry.

## External Private Registry Requirements

To use an external private registry with Tanzu Kubernetes clusters, you must use vSphere with Tanzu version 7 U2 or later.

You can only use your own private registry with Kubernetes pods that run on Tanzu Kubernetes clusters and Tanzu Kubernetes release node VMs. You cannot use your own private registry with vSphere Pods that run natively on ESXi hosts. The supported registry for vSphere Pods is the Harbor Registry that is embedded in the vSphere with Tanzu platform.

Once you configure the Tanzu Kubernetes Grid Service for a private registry, any new cluster that is provisioned will support the private registry. For existing clusters to support the private registry, a rolling update is required to apply the `TkgServiceConfiguration`. See [Update Tanzu Kubernetes Clusters](#). In addition, the first time you create a custom `TkgServiceConfiguration`, the system will initiate a rolling update.

## External Private Registry Configuration

To use your own private registry with Tanzu Kubernetes clusters, you configure the Tanzu Kubernetes Grid Service with one or more self-signed certificates to serve private registry content over HTTPS.

The `TkgServiceConfiguration` is updated to support self-signed certificates for the private registry. Specifically, a new `trust` section with the `additionalTrustedCAs` field is added, allowing you to define any number of self-signed certificates that Tanzu Kubernetes clusters should trust. This functionality lets you easily define a list of certificates, and update those certificates should they need rotation.

Once the `TkgServiceConfiguration` is updated and applied, the TLS certificates will be applied to new clusters the next time a cluster is created. In other words, applying an update to `TkgServiceConfiguration.trust.additionalTrustedCAs` does not trigger an automatic rolling update of Tanzu Kubernetes clusters.

```
apiVersion: run.tanzu.vmware.com/v1alpha1
kind: TkgServiceConfiguration
metadata:
  name: tkg-service-configuration
spec:
  defaultCNI: antrea
  trust:
    additionalTrustedCAs:
      - name: first-cert-name
        data: base64-encoded string of a PEM encoded public cert 1
      - name: second-cert-name
        data: base64-encoded string of a PEM encoded public cert 2
```

To apply the update, run the following command.

```
kubectl apply -f tkg-service-configuration.yaml
```

Because the Tanzu Kubernetes Grid Service specification is being updated with the private registry certificates, you do not need to add the public key to the Tanzu Kubernetes cluster kubeconfig as you do when using the embedded Harbor Registry with Tanzu Kubernetes clusters.

## Configure a Tanzu Kubernetes Workload to Pull Images from a Private Container Registry

To pull images from a private container registry for a Tanzu Kubernetes cluster workload, configure the workload YAML with the private registry details.

This procedure can be used to pull images from a private container registry, or the embedded Harbor Registry. In this example, we create a pod specification that will use an image stored in the embedded Harbor Registry and utilize the image pull secret previously configured.

- 1 Create an example pod spec with the details about the private registry.

```
apiVersion: v1
kind: Pod
metadata:
  name: <workload-name>
  namespace: <kubernetes-namespace>
spec:
  containers:
```

```

- name: private-reg-container
  image: <Registry-IP-Address>/<vsphere-namespace>/<image-name>:<version>
imagePullSecrets:
- name: <registry-secret-name>

```

- Replace `<workload-name>` with the name of the pod workload.
  - Replace `<kubernetes-namespace>` with the Kubernetes namespace in the cluster where the pod will be created. This must be the same Kubernetes namespace where the Registry Service image pull secret is stored in the Tanzu Kubernetes cluster (such as the default namespace).
  - Replace `<Registry-IP-Address>` with the IP address for the embedded Harbor Registry instance running on the Supervisor Cluster.
  - Replace `<vsphere-namespace>` with the vSphere Namespace where the target Tanzu Kubernetes is provisioned.
  - Replace `<image-name>` with an image name of your choice.
  - Replace `<version>` with an appropriate version of the image, such as "latest".
  - Replace `<registry-secret-name>` with the name of the Registry Service image pull secret that you created previously.
- 2 Create a workload in the Tanzu Kubernetes cluster based on the pod specification you defined.

```
kubectl --kubeconfig=<path>/cluster-kubeconfig apply -f <pod.yaml>
```

The pod should be created from the image pulled from the registry.

## Trust Fields for External Private Registries

Add a certificate entry (base64-encoded string of a PEM-encoded public certificate) to the `additionalTrustedCAs` section in the `TkgServiceConfiguration`. The data is public certificates stored in plain text in the `TkgServiceConfiguration`.

**Table 15-1. Trust Fields for Private Registries**

Field	Description
<code>trust</code>	Section marker. Accepts no data.
<code>additionalTrustedCAs</code>	Section marker. Includes a array of certificates with name and data for each.
<code>name</code>	The name of the TLS certificate.
<code>data</code>	The base64-encoded string of a PEM encoded public certificate.



## Removing External Private Registry Certificates

Remove a certificate from the list of certificates in the `additionalTrustedCAs` section in the `TkgServiceConfiguration` and apply the `TkgServiceConfiguration` to the Tanzu Kubernetes Grid Service.

## Rotating External Private Registry Certificates

To rotate a certificate, the VI Admin or DevOps Engineer would change the contents of the certificate in the `TkgServiceConfiguration` or the Tanzu Kubernetes cluster specification and apply that configuration to trigger a rolling update of that TKC.

## Troubleshooting External Private Registry Certificates

If you configure the Tanzu Kubernetes Grid Service with the certificates to trust, and you add the self-signed certificate to the cluster kubeconfig, you should be able to successfully pull a container image from a private registry that uses that self-signed certificate.

The following command can help you determine if the container image has been successfully pulled for a Pod workload:

```
kubectl describe pod PODNAME
```

This command shows detailed status and error messages for a given pod. An example of attempting to pull an image before adding custom certificates to the cluster:

```
Events:
  Type      Reason          Age          From              Message
  ----      -
  Normal    Scheduled       33s         default-scheduler ...
  Normal    Image           32s         image-controller  ...
  Normal    Image           15s         image-controller  ...
  Normal    SuccessfulRealizeNSXResource 7s (x4 over 31s) nsx-container-ncp ...
  Normal    Pulling         7s          kubelet           Waiting test-gc-
e2e-demo-ns/testimage-8862e32f68d66f727d1baf13f7eddef5a5e64bbd-v10612
  Warning   Failed          4s          kubelet           failed to get
images: ... Error: ... x509: certificate signed by unknown authority
```

And, when running the following command:

```
kubectl get pods
```

The `ErrImagePull` error is also visible in the overall Pod status view:

NAME	READY	STATUS	RESTARTS	AGE
testimage-nginx-deployment-89d4fcff8-2d9pz	0/1	Pending	0	17s
testimage-nginx-deployment-89d4fcff8-7kp9d	0/1	ErrImagePull	0	79s

testimage-nginx-deployment-89d4fcff8-7mpkj	0/1	Pending	0	21s
testimage-nginx-deployment-89d4fcff8-fszth	0/1	ErrImagePull	0	50s
testimage-nginx-deployment-89d4fcff8-sjnjl	0/1	ErrImagePull	0	48s
testimage-nginx-deployment-89d4fcff8-xr5kg	0/1	ErrImagePull	0	79s

The errors “x509: certificate signed by unknown authority” and “ErrImagePull” indicate that cluster is not configured with the correct certificate to connect to the private container registry. Either the certificate is missing, or it is misconfigured.

If you are experiencing errors connecting to a private registry after configuring the certificates, you can check if certificates applied in the configuration are applied to the cluster. You can check whether the certificates were applied in their configuration have been applied properly by using SSH.

Two investigative steps can be done by connecting to a worker node over SSH.

- 1 Check the folder `/etc/ssl/certs/` for files named `tkg-<cert_name>.pem`, where `<cert_name>` is the "name" property of the certificate added in the `TkgServiceConfiguration`. If the certificates match what is in the `TkgServiceConfiguration`, and using a private registry still does not work, diagnose further by completing the next step.
- 2 Run the following openssl connection test to the target server using self-signed certificates by executing the command `openssl s_client -connect hostname:port_num`, where `hostname` is the host name/DNS name of the private registry that is using self-signed certificates, and `port_num` is the port number that the service is running on (usually 443 for HTTPS). You can check exactly what error is being returned by openssl when attempting to connect to the endpoint that is using self-signed certificates, and remedy the situation from there, for example, by adding the right certificates to the `TkgServiceConfiguration`. If the Tanzu Kubernetes cluster is embedded with the wrong certificate, you will need to update the Tanzu Kubernetes Grid Service configuration with the correct certificates, delete the Tanzu Kubernetes cluster, then recreate it using the configuration that contains the correct certificates.

# Working with vSphere Lifecycle Manager

# 16

As a vSphere administrator, you can enable vSphere with Tanzu on vSphere clusters that you manage with a single VMware vSphere Lifecycle Manager image. You can then use the Supervisor Cluster while it is managed by vSphere Lifecycle Manager.

vSphere Lifecycle Manager allows you to manage the ESXi hosts and clusters in your environment. You can upgrade a Supervisor Cluster to the latest version of vSphere with Tanzu. You can also upgrade the ESXi version of the hosts in the Supervisor Cluster.

vSphere Lifecycle Manager is a service that runs in vCenter Server. When you deploy vCenter Server, the vSphere Lifecycle Manager user interface is enabled in the HML5-based vSphere Client.

For more information about the vSphere Lifecycle Manager, see the *Managing Host and Cluster Lifecycle* documentation.

This chapter includes the following topics:

- [Requirements](#)
- [Enable vSphere with Tanzu on a Cluster Managed by vSphere Lifecycle Manager](#)
- [Upgrade a Supervisor Cluster](#)
- [Add Hosts to a Supervisor Cluster](#)
- [Remove Hosts from a Supervisor Cluster](#)
- [Disable a Supervisor Cluster](#)

## Requirements

To configure vSphere with Tanzu on a vSphere cluster that is managed by vSphere Lifecycle Manager, your environment must meet specific requirements.

## System Requirements

To enable vSphere with Tanzu, verify that the components on the vSphere cluster meet the following requirements:

- Verify that vCenter Server and ESXi are of version 7.0 Update 2 if you use NSX-T Data Center.

- Verify that vCenter Server and ESXi are of at least version 7.0 Update 1 if you use vSphere Networking.
- Verify that all ESXi hosts that you want to use as part of a Supervisor Cluster are assigned a VMware vSphere 7 Enterprise Plus with Add-on for Kubernetes license.
- Verify that HA and DRS are enabled on the vSphere cluster.
- Verify that vSphere Distributed Switch version 7.0 Update 2 is configured.
- Verify that vSphere Networking or NSX-T Data Center 3.1 or a later version is configured on the cluster. You cannot use vSphere Lifecycle Manager image to manage a cluster that is configured with earlier versions of NSX-T Data Center.

## Enable vSphere with Tanzu on a Cluster Managed by vSphere Lifecycle Manager

To run Kubernetes workloads, you can enable vSphere with Tanzu on a cluster that you manage with a single vSphere Lifecycle Manager image. After it is enabled, you can manage the Supervisor Cluster using vSphere Lifecycle Manager.

When you enable the cluster with vSphere with Tanzu that uses NSX-T Data Center, the vSphere Lifecycle Manager installs the Spherelet vSphere Installation Bundle (VIB) on every ESXi host in the cluster. Enabling the cluster assigns the version of the Kubernetes version that ships with vCenter. After the installation is complete, the WCP service performs the post installation tasks such as, starting and configuring the Spherelet.

For the steps to enable the cluster, see [Enable Workload Management with vSphere Networking](#).

## Upgrade a Supervisor Cluster

You can update to the latest version of vSphere with Tanzu, including the vSphere infrastructure supporting vSphere with Tanzu clusters, the Kubernetes versions, and the Kubernetes CLI Tools for vSphere on clusters that use a single vSphere Lifecycle Manager image.

You upgrade the ESXi version of the hosts in the Supervisor Cluster. During the upgrade the Spherelet VIB on every ESXi host is upgraded.

vSphere Lifecycle Manager uses DRS and puts the hosts in maintenance mode before remediation. DRS first attempts to migrate the virtual machine running vCenter Server to another host, such as VMs that are affinity to the host or running on the local storage of the host, and workloads, including vSphere Pods to other hosts, so that the remediation succeeds.

---

**Note** You can use vSphere Lifecycle Manager to upgrade a Supervisor Cluster only on clusters that use a single vSphere Lifecycle Manager image.

---

### Procedure

- 1 From the vSphere Client menu, select **Workload Management**.

- 2 Select the **Updates** tab.
- 3 Select the **Available Version** that you want to update to.  
For example, select the version `v1.17.4-vmc0.0.2-16293900`.
- 4 Select the Supervisor Cluster to apply the update to.
- 5 To initiate the update, click **Apply Updates**.
- 6 Use the **Recent Tasks** pane to monitor the status of the update.

## Add Hosts to a Supervisor Cluster

As a vSphere administrator, you might need to scale out the Supervisor Cluster to run more workloads. To add capacity to a cluster, you can add ESXi hosts to the cluster that uses a single vSphere Lifecycle Manager image.

When you add a host to the Supervisor Cluster that is configured with NSX-T Data Center, vSphere Lifecycle Manager installs the Spherelet VIB and the image on the host. After it is installed, vSphere with Tanzu configures the Spherelet process on the newly added host, which allows running containers natively on ESXi.

### Prerequisites

- Obtain the user name and password of the root user account for the host.
- Verify that hosts behind a firewall might communicate with the vCenter Server.

### Procedure

- 1 From the vSphere Client menu, select **Workload Management**.
- 2 Right-click the data center, cluster, or folder and select **Add Host**.
- 3 Enter the IP address or the name of the host and click **Next**.
- 4 Enter the administrator credentials and click **Next**.
- 5 Review the host summary and click **Next**.
- 6 Assign a license to the host and click **Finish**.
- 7 In the **Add Host** wizard, click **Next**.
- 8 Review the summary and click **Finish**.

---

**Note** If a host is part of the same data center, you can move it into the Supervisor Cluster. To move the host, put it in maintenance mode and drag it into the cluster.

---

## Remove Hosts from a Supervisor Cluster

As a vSphere administrator, you might need to scale in the Supervisor Cluster to save cost. To reduce the capacity of a Supervisor Cluster, you can remove ESXi hosts from a cluster that uses a single vSphere Lifecycle Manager image.

When you remove a host from the Supervisor Cluster that is configured with NSX-T Data Center, vSphere with Tanzu clears the configuration of the Spherelet and stops the Spherelet process on the ESXi host. vSphere Lifecycle Manager then uninstalls the Spherelet VIB and image from the host and vSphere with Tanzu removes the host metadata from the cluster control plane.

### Prerequisites

Before you can remove a host from a cluster, you must power off all virtual machines that are running on the host or migrate the virtual machines to a new host.

### Procedure

- 1 In the vSphere Client, navigate to the cluster from which you want to remove the host.
- 2 Right-click the host and select **Enter Maintenance Mode** from the pop-up menu.
- 3 In the confirmation dialog box that appears, click **Yes**.

The confirmation dialog box also asks if you want to move virtual machines that are powered off to other hosts. Select this option if you want those virtual machines to remain registered to a host within the cluster.

The host icon changes and the term “maintenance mode” is added to the name in parentheses.

- 4 Select the host icon from the inventory, and drag it to the new location.

The host can be moved to another cluster or another data center.

vCenter Server moves the host to the new location.

- 5 Right-click the host, and select **Exit Maintenance Mode** from the pop-up menu.
- 6 (Optional) Restart any virtual machines, if needed.

## Disable a Supervisor Cluster

You can disable vSphere with Tanzu from a vSphere cluster that uses a single vSphere Lifecycle Manager image, to make it available for traditional workloads.

When you disable a vSphere with Tanzu on a cluster, vSphere Lifecycle Manager uninstalls the Spherelet VIB and image from each ESXi host and the `WCP` service stops and deletes all workloads from the cluster.

### Procedure

- 1 From the vSphere Client menu, select **Workload Management**.

- 2 Select the **Clusters** tab.
- 3 Select the cluster on which you want to disable vSphere with Tanzu.
- 4 Click **Disable**.

The **Disable Cluster** dialog box appears with a message that all Kubernetes workloads and NSX-T Data Center configuration will be disabled on the cluster.

- 5 Click **Disable**.

# Updating the vSphere with Tanzu Environment

# 17

You can update to the latest version of vSphere with Tanzu, including the vSphere infrastructure supporting vSphere with Tanzu clusters, the Kubernetes versions, and the Kubernetes CLI Tools for vSphere.

This chapter includes the following topics:

- [About vSphere with Tanzu Updates](#)
- [Network Topology Upgrade](#)
- [Update the Supervisor Cluster by Performing a vSphere Namespaces Update](#)
- [Supervisor Cluster Auto Upgrade](#)
- [Update the vSphere Plugin for kubectl](#)
- [List of Tanzu Kubernetes releases](#)
- [Update Tanzu Kubernetes Clusters](#)

## About vSphere with Tanzu Updates

vSphere with Tanzu supports rolling updates for Supervisor Clusters and Tanzu Kubernetes clusters, and for the infrastructure supporting these clusters.

## How vSphere with Tanzu Clusters Are Updated

vSphere with Tanzu uses a rolling update model for Supervisor Clusters and Tanzu Kubernetes clusters. The rolling update model ensures that there is minimal downtime for cluster workloads during the update process. Rolling updates include upgrading the Kubernetes software versions and the infrastructure and services supporting the Kubernetes clusters, such as virtual machine configurations and resources, vSphere services and namespaces, and custom resources.

For the update to succeed, your configuration must meet several compatibility requirements, so the system enforces recheck conditions to ensure that clusters are ready for updates, and supports rollback if cluster upgrade is not successful.

---

**Note** A vSphere with Tanzu update involves more than just an upgrade of the Kubernetes software version. We use the term "update" to describe this process instead of the term "upgrade," which is a limited form of update that increments the software version.

---



## Dependency Between Supervisor Cluster Updates and Tanzu Kubernetes Cluster Updates

You update the Supervisor Cluster and the Tanzu Kubernetes clusters separately. Note, however, that there are dependencies between the two.

Updating a Supervisor Cluster will likely trigger a rolling update of the Tanzu Kubernetes clusters deployed there. See [Update the Supervisor Cluster by Performing a vSphere Namespaces Update](#).

You may need to update one or more Tanzu Kubernetes clusters before updating a Supervisor Cluster if the Tanzu Kubernetes cluster is not compliant with the target Supervisor Cluster version. See [List of Tanzu Kubernetes releases](#).

### About Supervisor Cluster Updates

When you initiate an update for a Supervisor Cluster, the system creates a new control plane node and joins it to the existing control plane. The vSphere inventory shows four control plane nodes during this phase of the update as the system adds a new updated node and then removes the older out-of-date node. Objects are migrated from one of the old control plane nodes to the new one, and the old control plane node is removed. This process repeats one-by-one until all control plane nodes are updated. Once the control plane is updated, the worker nodes are updated in a similar rolling update fashion. The worker nodes are the ESXi hosts, and each spherelet process on each ESXi host is updated one-by-one.

You can choose between the following updates:

- Update the Supervisor Namespaces.
- Update everything, including VMware versions and Kubernetes versions.

You use the vSphere Namespaces update workflow to update the Kubernetes version that the Supervisor Cluster is running, such as from Kubernetes 1.16.7 to Kubernetes 1.17.4, and the infrastructure supporting Kubernetes clusters. This type of update is more frequent and is used to maintain pace with the Kubernetes release cadence. The following is the vSphere Namespaces update sequence.

- 1 Upgrade vCenter Server.
- 2 Perform a vSphere Namespaces update (including Kubernetes upgrade).

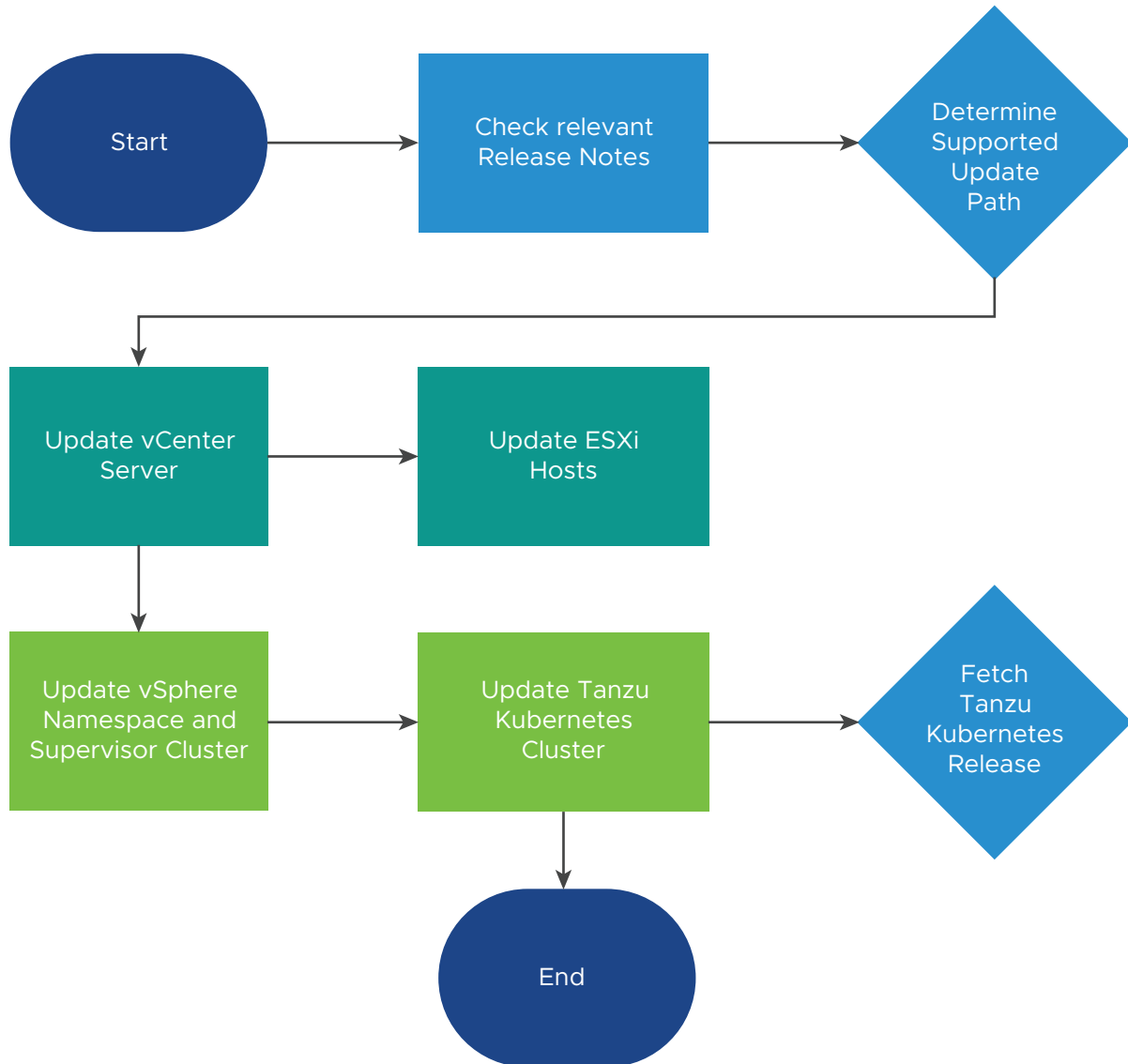
To perform a vSphere Namespaces update, see [Update the Supervisor Cluster by Performing a vSphere Namespaces Update](#).

You use the update everything workflow to update all vSphere with Tanzu components. This type of update is required when you are updating major releases, for example such as from NSX-T 3.0 to 3.X and from vSphere 7.0 to 7.X. This update workflow is infrequent depending on when there are new VMware product releases. This is the update everything sequence:

- 1 Upgrade NSX-T Data Center.
- 2 Upgrade vCenter Server.

- 3 Upgrade vSphere Distributed Switch.
- 4 Upgrade ESXi hosts.
- 5 Update vSphere Namespaces (including Kubernetes upgrade).
- 6 Update Tanzu Kubernetes.

The diagram illustrates the general workflow for vSphere with Tanzu updates.



## About Tanzu Kubernetes Cluster Updates

When you update a Supervisor Cluster, the infrastructure components supporting the Tanzu Kubernetes clusters deployed to that Supervisor Cluster, such as the Tanzu Kubernetes Grid Service, are likewise updated. Each infrastructure update can include updates for services supporting the Tanzu Kubernetes Grid Service (CNI, CSI, CPI), and updated configuration settings for the control plane and worker nodes that can be applied to existing Tanzu Kubernetes clusters. To ensure that your configuration meets compatibility requirements, vSphere with Tanzu performs pre-checks during rolling update and enforces compliance.

To perform a rolling update of a Tanzu Kubernetes cluster, typically you update the cluster manifest. See [Update Tanzu Kubernetes Clusters](#). Note, however, that when a vSphere Namespaces update is performed, the system immediately propagates updated configurations to all Tanzu Kubernetes clusters. These updates can automatically trigger a rolling update of the Tanzu Kubernetes control plane and worker nodes.

The rolling update process for replacing the cluster nodes is similar to the [rolling update of pods](#) in a Kubernetes Deployment. There are two distinct controllers responsible for performing a rolling update of Tanzu Kubernetes clusters: the Add-ons Controller and the TanzuKubernetesCluster controller. Within those two controllers there are three key stages to a rolling update: updating add-ons, updating the control plane, and updating the worker nodes. These stages occur in order, with pre-checks that prevent a step from beginning until the preceding step has sufficiently progressed. These steps might be skipped if they are determined to be unnecessary. For example, an update might only affect worker nodes and therefore not require any add-on or control plane updates.

During the update process, the system adds a new cluster node, and waits for the node to come online with the target Kubernetes version. The system then marks the old node for deletion, moves to the next node, and repeats the process. The old node is not deleted until all pods are removed. For example, if a pod is defined with PodDisruptionBudgets that prevent a node from being fully drained, the node is cordoned off but is not removed until those pods can be evicted. The system upgrades all control plane nodes first, then worker nodes. During an update, the Tanzu Kubernetes cluster status changes to "updating". After the rolling update process completes, the Tanzu Kubernetes cluster status changes to "running".

Pods running on a Tanzu Kubernetes cluster that are not governed by a replication controller will be deleted during a Kubernetes version upgrade as part of the worker node drain during the Tanzu Kubernetes cluster update. This is true if the cluster update is triggered manually or automatically by a vSphere Namespaces update. Pods not governed by a replication controller include pods that are not created as part of a Deployment or ReplicaSet spec. Refer to the topic [Pod Lifecycle: Pod lifetime](#) in the Kubernetes documentation for more information.

## Network Topology Upgrade

When you install vSphere with Tanzu version 7.0 Update 1c or upgrade the Supervisor Cluster from version 7.0 Update 1 to version 7.0 Update 1c, you upgrade the NSX Container Plug-in (NCP). This in turn migrates the networking topology of the Supervisor Cluster, namespaces,

and Tanzu Kubernetes clusters. After the upgrade, the networking topology is upgraded from a single tier-1 gateway topology to a topology that has a tier-1 gateway for each namespace within the Supervisor Cluster.

During the upgrade, the NCP configures the NSX-T Data Center resources to support the new topology. The NCP provides a shared network infrastructure for namespaces that have less of layer-4 and layer-7 load balancing services. This reduces the resources on NSX and makes more available for Tanzu Kubernetes clusters.

System namespaces are namespaces that are used by the core components that are integral to functioning of the Supervisor Cluster and Tanzu Kubernetes clusters. The shared network resources that include the tier-1 gateway, load balancer, and SNAT IP are grouped in a system namespace.

The NCP creates one shared tier-1 gateway for system namespaces and a tier-1 gateway and load balancer for each namespace, by default. The tier-1 gateway is connected to the tier-0 gateway and a default segment.

The NSX-T load balancer provides load balancing services in the form of virtual servers.

After migration, the networking topology has the following characteristics:

- Each vSphere Namespace has a separate network and set of networking resources shared by applications inside the namespace such as, tier-1 gateway, load balancer service, and SNAT IP address.
- Workloads running in vSphere Pods, regular VMs, or Tanzu Kubernetes clusters, that are in the same namespace, share a same SNAT IP for North-South connectivity.
- Workloads running in vSphere Pods or Tanzu Kubernetes clusters will have the same isolation rule that is implemented by the default firewall.
- A separate SNAT IP is not required for each Kubernetes namespace. East west connectivity between namespaces will be no SNAT.

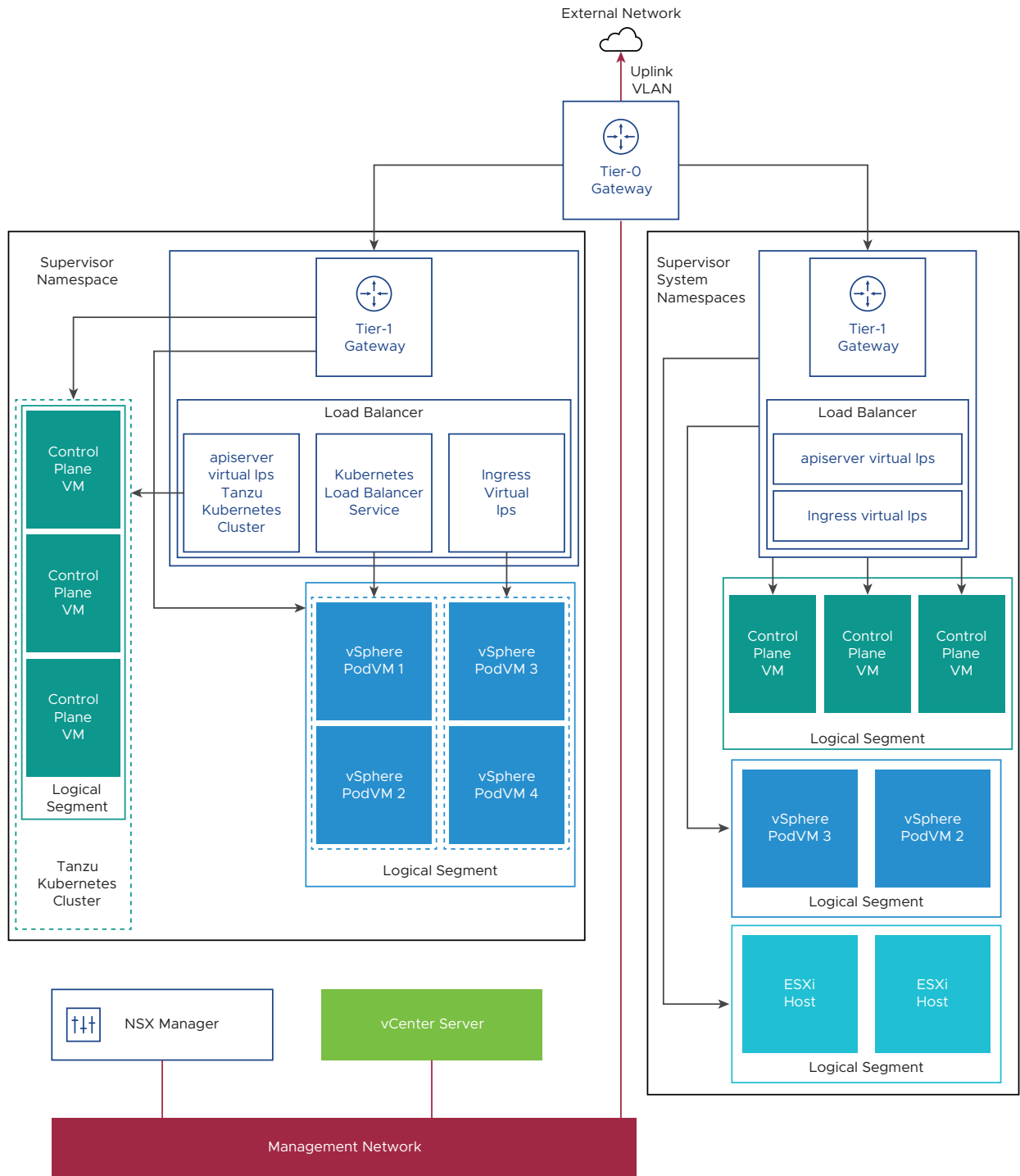
The maximum number of namespaces that can be run depends on Edge Node size (Medium, Large, or X-Large) and the number of Edge nodes in the NSX Edge Cluster. The number of namespaces that can be run is less than 20 times the number of Edge nodes. For example, if the NSX Edge cluster has 10 Edge nodes of Large size, the maximum number of Supervisor Namespaces that can be created is 199.

## Supervisor Cluster Networking

Supervisor clusters have separate segments within the shared tier-1 gateway. For each Tanzu Kubernetes cluster, segments are defined within the tier-1 gateway of the namespace.

Workloads, including vSphere Pods and Tanzu Kubernetes clusters, that are within the same namespace, will share a SNAT IP for north-south connectivity. East-west connectivity between namespaces will be no SNAT.

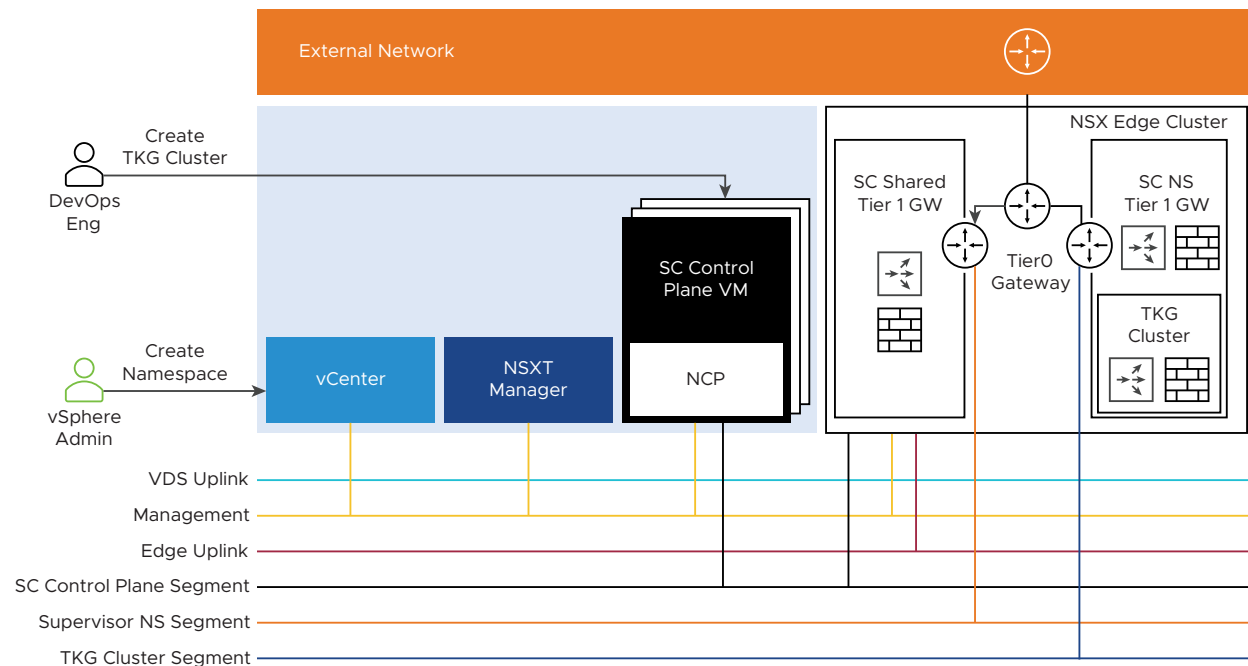
Figure 17-1. Supervisor Cluster Networking



## Tanzu Kubernetes Clusters Networking

After the Supervisor Cluster upgrade, when DevOps engineers provision the first Tanzu Kubernetes cluster in a Supervisor Namespace, the cluster will share the same tier-1 gateway and load balancer as the namespace. For each Tanzu Kubernetes cluster that is provisioned in that namespace, a segment is created for that cluster and it is connected to the shared tier-1 gateway in its Supervisor Namespace.

When a Tanzu Kubernetes cluster is provisioned by the Tanzu Kubernetes Grid Service, a single virtual server is created that provides layer-4 load balancing for the Kubernetes API. This virtual server is hosted on the shared load balancer with the namespace and is responsible for routing kubectl traffic to the control plane. In addition, for each Kubernetes service load balancer that is resourced on the cluster, a virtual server is created that provides layer-4 load balancing for that service.



## Upgrade the NSX-T Network Topology

To upgrade the network topology, you upgrade NSX-T Data Center, vCenter Server, and all vSphere with Tanzu components.

You can upgrade NSX-T Data Center version. When you perform the upgrade, the NSX-T Data Center components, which include the data plane, control plane, and management plane are upgraded with minimum system downtime.

For step-by-step information about upgrading the NSX-T Data Center components, see the NSX-T Data Center [Upgrade Guide](#).

**Note** Refer to the vSphere with Tanzu [Release Notes](#) for supported versions.

### Prerequisites

- Verify that your environment meets the system requirements. For information about requirements, see [System Requirements for Setting Up vSphere with Tanzu with NSX-T Data Center](#).
- For configuration limits specific to vSphere with Tanzu, see [vSphere Configuration Limits](#) in VMware Configuration Maximums tool.

### Procedure

- 1 Upgrade NSX-T Data Center from NSX-T Data Center 3.0.x to NSX-T Data Center 3.1.
- 2 Upgrade vCenter Server.
- 3 Upgrade ESXi hosts.
- 4 Update the Supervisor Namespace.

To perform an update, see [Update the Supervisor Cluster by Performing a vSphere Namespaces Update](#).

## Upgrade vSphere Distributed Switch

You can upgrade vSphere Distributed Switch version 7.0 to a later version. The upgrade of a distributed switch causes the hosts and virtual machines attached to the switch to experience a brief downtime.

### Prerequisites

- Upgrade vCenter Server to version 7.0.
- Upgrade all hosts connected to the distributed switch to ESXi 7.0.

### Procedure

- 1 From the vSphere Client home menu, select **Hosts and Clusters**.
- 2 Select **Networking** and navigate to the distributed switch.  
For example, **DSwitch**.  
The vSphere Client UI lists the versions that are available to upgrade to.
- 3 From the **Actions** menu, select **Upgrade > Upgrade Distributed Switch**.
- 4 Select the vSphere Distributed Switch version that you want to upgrade the switch to and click **Next**.
- 5 Review host compatibility and click **Next**.
- 6 Complete the upgrade configuration and click **Finish**.

# Update the Supervisor Cluster by Performing a vSphere Namespaces Update

To update one or more Supervisor Clusters, including the Kubernetes version that the Supervisor Cluster is running and the infrastructure supporting Tanzu Kubernetes clusters, including the Tanzu Kubernetes Grid Service, you perform a vSphere Namespaces update.

There is a version entity for vSphere with Tanzu. The version entity is a semantic version string in the form `v1.19.1+vmware.2-vsc0.0.8-17610687`, where the prefix is the Kubernetes version (`v1.19.1`) and the suffix is the vSphere Namespaces version (`vsc0.0.8-17610687`).

The tables lists the available Supervisor Cluster releases:

Version	Description
<code>v1.19.1+vmware.2-vsc0.0.8-17610687</code>	Most recent Supervisor Cluster release; Supports vSphere 7.0 Update 2.
<code>v1.18.2-vsc0.0.5-16762486</code>	Supports vSphere 7.0 Update 1.
<code>v1.17.4-vsc0.0.5-16762486</code>	Minimum Supervisor Cluster release that includes a Tanzu Kubernetes Grid Service that supports the Antrea CNI.
<code>v1.16.7-vsc0.0.5-16762486</code>	If you are running this release, you should update it to 1.17 at a minimum.

## Prerequisites

Read the release notes before you perform a vSphere Namespaces update.

To install the necessary binaries, upgrade the vCenter Server appliance and ESXi hosts to the supported version. See [Upgrading the vCenter Server Appliance](#) in the vCenter Server documentation.

---

**Note** When you perform a vSphere Namespaces update, all provisioned Tanzu Kubernetes clusters must be in a running state. If a Tanzu Kubernetes is in a creating or deleting state, wait until the process finishes before updating a Supervisor Cluster, otherwise might not succeed.

---

**Note** Updating a Supervisor Cluster will likely trigger a rolling update of the Tanzu Kubernetes clusters deployed there. See [Update Tanzu Kubernetes Clusters](#).

---

## Procedure

- 1 Log in to the vCenter Server as a vSphere administrator.
- 2 Select **Menu > Workload Management**.
- 3 Select the **Namespaces > Updates** tab.



- 4 Select the **Available Version** that you want to update to.

For example, select the version `v1.18.2-vmc0.0.5-16762486`.

---

**Note** You must update incrementally. Do not skip updates, such as from 1.16 to 1.18. The path should be 1.16, 1.17, 1.18.

---

- 5 Select one or more Supervisor Clusters to apply the update to.
- 6 To initiate the update, click **Apply Updates**.
- 7 Use the **Recent Tasks** pane to monitor the status of the update.

## Supervisor Cluster Auto Upgrade

You can automatically upgrade the Supervisor Cluster when you upgrade the vCenter Server Appliance.

vSphere with Tanzu components include components in the vCenter Server, Kubernetes components, and ESXi components. When you upgrade vCenter Server, only the vSphere with Tanzu components on the vCenter Server are upgraded. You must manually upgrade the Kubernetes components, and ESXi components.

With the auto upgrade feature, when you upgrade vCenter Server, you can automatically upgrade the Supervisor Cluster. For a list of vCenter Server releases, see the following KB article: <https://kb.vmware.com/s/article/2143838>.

When you upgrade the vCenter Server, prechecks are run to check the compatibility between the versions of the Supervisor Cluster and vCenter Server. Warnings are displayed in the following scenarios:

- The target vCenter Server has a version of Kubernetes that can make the Supervisor Cluster fall behind by one version. In this scenario, when you proceed with vCenter Server upgrade, the cluster is automatically upgraded.  
  
For example, the Supervisor Cluster version is 1.16 and the target vCenter Server version is 1.17, 1.18, or 1.19.
- The target vCenter Server has a version of Kubernetes that makes the Supervisor Cluster fall behind by more than one version. In this scenario, the vCenter Server is not upgraded.  
  
For example, the Supervisor Cluster version is 1.15 and the target vCenter Server version is 1.17, 1.18, or 1.19.
- The Supervisor Cluster license has expired. In this scenario, if you proceed with the vCenter Server upgrade, the Supervisor Cluster with the expired license becomes unusable and unrecoverable.

## Update the vSphere Plugin for kubectl

Once you have performed a vSphere Namespace update and upgraded the Supervisor Cluster, update the vSphere Plugin for kubectl.

The most recent version of the vSphere Plugin for kubectl downloads and installs the Tanzu Kubernetes cluster root CA certificate in the Kubernetes secret named `TANZU-KUBERNETES-CLUSTER-NAME-ca`. The plugin uses this certificate to populate the CA information in the corresponding cluster's certificate authority datastore.

To download and install the vSphere Plugin for kubectl, see [Download and Install the Kubernetes CLI Tools for vSphere](#). For more information about the `TANZU-KUBERNETES-CLUSTER-NAME-ca` secret, see [Get Tanzu Kubernetes Cluster Secrets](#).

## List of Tanzu Kubernetes releases

A Tanzu Kubernetes release provides the Kubernetes software distribution signed and supported by VMware for Tanzu Kubernetes clusters provisioned by the Tanzu Kubernetes Grid Service.

### Tanzu Kubernetes releases Release Notes

For a list of all Tanzu Kubernetes releases, refer to the [release notes](#).

## Check Tanzu Kubernetes Cluster Compatibility Before System Upgrade

Before upgrading the vSphere with Tanzu infrastructure, including the vCenter Server and the Supervisor Cluster, refer to the Knowledge Base article <https://kb.vmware.com/s/article/82592> for guidance on how to check if any Tanzu Kubernetes clusters are incompatible with the upgrade. If a Tanzu Kubernetes cluster is incompatible with the target infrastructure, upgrade the cluster before proceeding with the system upgrade.

## Use Kubectl to List Available Tanzu Kubernetes releases

You can list Tanzu Kubernetes releases and view the compatibility and updatability for each release using following command.

```
kubectl get tanzukubernetesreleases
```

The `COMPATIBLE` column indicates if that Tanzu Kubernetes release is compatible with the current Supervisor Cluster. The `UPDATES AVAILABLE` column indicates if there is a Kubernetes upgrade available and the recommended next Tanzu Kubernetes releases to be used.

NAME	VERSION	READY	COMPATIBLE
CREATED	UPDATES AVAILABLE		
v1.18.15---vmware.1-tkg.1.600e412	1.18.15+vmware.1-tkg.1.600e412	True	True

```

21h      [1.19.7+vmware.1-tkg.1.fc82c41]
v1.19.7---vmware.1-tkg.1.fc82c41    1.19.7+vmware.1-tkg.1.fc82c41    True    True
21h      [1.20.2+vmware.1-tkg.1.1d4f79a]
v1.20.2---vmware.1-tkg.1.1d4f79a    1.20.2+vmware.1-tkg.1.1d4f79a    True    True    21h

```

This same information is also available using `kubectl get tkc <tkgs-cluster-name>`.

## Update Tanzu Kubernetes Clusters

You can update a Tanzu Kubernetes cluster, including the Kubernetes version, by updating the distribution version, the virtual machine class, or the storage class.

### Tanzu Kubernetes Cluster Update Requirements

Read the release notes before you perform a Tanzu Kubernetes cluster update.

To update Tanzu Kubernetes clusters, first perform a vSphere Namespaces update. When you perform a vSphere Namespace update, all Tanzu Kubernetes clusters must be in a running state. See [Update the Supervisor Cluster by Performing a vSphere Namespaces Update](#).

The Kubernetes software version is a string in the cluster manifest that is semantic version notation. For example, if the version is `1.18.5`, "1" is the major version, "18" is the minor version, and "5" is the patch version.

When upgrading the Kubernetes version for an existing Tanzu Kubernetes cluster, observe the following requirements:

- You cannot decrease the version. For example, you cannot downgrade from Kubernetes v1.18 to v1.17.
- You can upgrade the minor version, but only incrementally. Skipping minor versions is not supported. For example, you can upgrade from Kubernetes v1.17 to v1.18, but you cannot upgrade from Kubernetes v1.16 to v1.18.
- You cannot change the major version, such as upgrading from v1.18 to v2.0.

You can specify the fully qualified version, or use version shortcuts, such as `version: v1.18.5`, which is resolved to the most recent image matching that patch version, or `version: v1.18`, which is resolved to the most recent matching patch version. The resolved version displays as the `fullVersion` in the cluster manifest such as `v1.18.5+vmware.1-tkg.1.c40d30d`.

---

**Note** When a version shortcut is used to create the cluster, the system adds the `fullVersion` to the manifest. To perform a Tanzu Kubernetes version upgrade using a version shortcut, you must unset (remove) the `fullVersion` from the manifest.

---

### Performing a Tanzu Kubernetes Cluster Update

You initiate a rolling update by making one or more of the following modifications to the `TanzuKubernetesCluster` specification:

- [Update a Tanzu Kubernetes Cluster by Upgrading the Kubernetes Version](#)

- [Update a Tanzu Kubernetes Cluster by Changing the VirtualMachineClass](#)
- [Update a Tanzu Kubernetes Cluster by Changing the Storage Class](#)

---

**Note** While these are the most common ways to initiate a rolling update, they are not the only ones. A change to any of the configuration elements can also initiate a rolling update. For example, renaming or replacing the `VirtualMachineImage` that corresponds to a distribution version initiates a rolling update as the system attempts to get all nodes running on the new image. Also, updating a Supervisor Cluster will likely trigger a rolling update of the Tanzu Kubernetes clusters deployed there. For example, when the `vmware-system-tkg-controller-manager` is updated, the system introduces new values into the manifest generator and the controller initiates a rolling update to deploy those values.

---

## Cluster Manifest Update Methods

Updating a cluster requires updating the cluster manifest. There are various ways to do this, including:

- By using the `kubectl edit tanzukubernetescluster/CLUSTER-NAME` command. This command opens the entire cluster manifest in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable. When you save the file, the cluster is updated with the changes. For more information on the `kubectl edit` command, see [edit command](#) in the Kubernetes documentation. To use the `kubectl edit` approach, refer to the following topics:
  - [Update a Tanzu Kubernetes Cluster by Upgrading the Kubernetes Version](#)
  - [Update a Tanzu Kubernetes Cluster by Changing the VirtualMachineClass](#)
  - [Update a Tanzu Kubernetes Cluster by Changing the Storage Class](#)
- By using the `kubectl patch` command. This command performs an "in-place" update of a cluster. The purpose of the this command is to provide a method for upgrading Kubernetes versions, and is the approach documented here. For more information on the `kubectl patch` command, see [Update API Objects in Place Using kubectl patch](#) in the Kubernetes documentation. To use the `kubectl patch` approach, refer to the following topic:
  - [Update Tanzu Kubernetes Clusters Using the Patch Method](#)
- By using the `kubectl apply` command with a local YAML file that you manually update. While this approach has the advantage of being similar to the way you [Workflow for Provisioning Tanzu Kubernetes Clusters](#), if you do not have access to the current cluster YAML this approach can be destructive and is therefore not recommended.

## Update a Tanzu Kubernetes Cluster by Upgrading the Kubernetes Version

Update a Tanzu Kubernetes cluster by upgrading the Kubernetes version.

You can update a Tanzu Kubernetes cluster by upgrading the Kubernetes version. To do this, change the distribution version for the cluster in the `.spec.distribution.version` and `.spec.distribution.fullVersion` properties of the cluster manifest.

### Prerequisites

Refer to the list of supported Tanzu Kubernetes Releases for version compatibility and upgrade recommendations.

This task uses the command `kubectl edit tanzukubernetescluster/CLUSTER-NAME` to update the cluster manifest. The `kubectl edit` command opens the cluster manifest in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable. When you save the file, the cluster is updated with the changes. See [Specify a Default Text Editor for Kubectl](#).

### Procedure

- 1 Authenticate with the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

```
kubectl vsphere login --server=IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the vSphere Namespace where the target Tanzu Kubernetes cluster is provisioned.

```
kubectl config use-context SUPERVISOR-NAMESPACE
```

- 3 Get the target Tanzu Kubernetes cluster and version.

```
kubectl get tanzukubernetescluster
```

For example:

```
kubectl get tanzukubernetescluster
NAME                CONTROL PLANE  WORKER  DISTRIBUTION                                AGE   PHASE
tkgs-cluster-1     3              3      v1.17.8+vmware.1-tkg.1.5417466           19h   running
```

- 4 List the available Tanzu Kubernetes versions by running either of the following commands.

```
kubectl get tanzukubernetesreleases
```

```
kubectl get virtualmachineimages
```

In this example scenario we upgrade a Tanzu Kubernetes cluster from v1.17.8 to v1.18.5.

- 5 Run the following command to edit the cluster manifest.

```
kubectl edit tanzukubernetescluster/CLUSTER-NAME
```

- 6 Edit the manifest by changing the `version` string and unsetting or nulling out the `fullVersion` to avoid a potential version mismatch during discovery.

For example, change the manifest from the following:

```
spec:
  distribution:
    fullVersion: v1.17.8+vmware.1-tkg.1.5417466
    version: v1.17.8
```

To the following:

```
spec:
  distribution:
    fullVersion: null
    version: v1.18.5
```

- 7 Save the changes you made to the manifest file.

When you save the file, `kubectl` applies the changes to the cluster. In the background, the Virtual Machine Service on the Supervisor Cluster provisions the new worker node.

- 8 Verify that `kubectl` reports that the manifest edits were successfully recorded.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
tanzukubernetescluster.run.tanzu.vmware.com/tkgs-cluster-1 edited
```

**Note** If you receive an error, or `kubectl` does not report that the cluster manifest was successfully edited, make sure you have properly configured your default text editor using the `KUBE_EDITOR` environment variable. See [Specify a Default Text Editor for Kubectl](#).

- 9 Verify that the cluster is updating.

```
kubectl get tanzukubernetescluster
NAME                CONTROL PLANE  WORKER  DISTRIBUTION                                AGE  PHASE
tkgs-cluster-1     3              3      v1.18.5+vmware.1-tkg.1.c40d30d           21h  updating
```

- 10 Verify that the cluster is updated.

```
kubectl get tanzukubernetescluster
NAME                CONTROL PLANE  WORKER  DISTRIBUTION                                AGE  PHASE
tkgs-cluster-1     3              3      v1.18.5+vmware.1-tkg.1.c40d30d           22h  running
```

## Update a Tanzu Kubernetes Cluster by Changing the VirtualMachineClass

You can update a Tanzu Kubernetes cluster by changing the virtual machine class used to host the cluster nodes.

The Tanzu Kubernetes Grid Service supports updating a cluster by changing the `VirtualMachineClass` definition. If you do this, the service rolls out new nodes with that new class and spins down the old nodes. See [About Tanzu Kubernetes Cluster Updates](#).

---

**Note** The `VirtualMachineClass` must be bound to the vSphere Namespace where the Tanzu Kubernetes cluster is provisioned. See [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).

---

### Prerequisites

This task uses the command `kubectl edit tanzukubernetescluster/CLUSTER-NAME` to update the cluster manifest. The `kubectl edit` command opens the cluster manifest in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable. When you save the file, the cluster is updated with the changes. See [Specify a Default Text Editor for Kubectl](#).

### Procedure

- 1 Authenticate with the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

```
kubectl vsphere login --server=IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the vSphere Namespace where the target Tanzu Kubernetes cluster is provisioned.

```
kubectl config use-context SUPERVISOR-NAMESPACE
```

- 3 Describe the target Tanzu Kubernetes cluster and check the VM class.

```
kubectl describe tanzukubernetescluster CLUSTER-NAME
```

For example, this cluster is using the best-effort-medium VM class:

```
Spec:
  ...
  Topology:
    Control Plane:
      Class:          best-effort-medium
      ...
    Workers:
      Class:          best-effort-medium
      ...
```

- 4 List and describe the available VM classes in the namespace.

```
kubectl get virtualmachineclassbindings
```

---

**Note** The command `kubectl get virtualmachineclasses` lists all the VM classes present on the Supervisor Cluster. Because you must associate VM classes with the vSphere Namespace, you can only use those VM classes that are bound to the target namespace.

---

- Run the following command to edit the cluster manifest.

```
kubectl edit tanzukubernetescluster/CLUSTER-NAME
```

- Edit the manifest by changing the `version` string and unsetting or nulling out the `fullVersion` to avoid a potential version mismatch during discovery.

For example, change the cluster manifest from using the `best-effort-medium` VM class for control plane and worker nodes:

```
spec:
  topology:
    controlPlane:
      class: best-effort-medium
      ...
    workers:
      class: best-effort-medium
      ...
```

To using the `guaranteed-large` VM class for control plane and worker nodes:

```
spec:
  topology:
    controlPlane:
      class: guaranteed-large
      ...
    workers:
      class: guaranteed-large
      ...
```

- Save the changes you made to the manifest file.

When you save the file, `kubectl` applies the changes to the cluster. In the background, the Tanzu Kubernetes Grid Service provisions the new node VMs and spins down the old ones.

- Verify that `kubectl` reports that the manifest edits were successfully recorded.

```
kubectl edit tanzukubernetescluster/tkgs-cluster-1
tanzukubernetescluster.run.tanzu.vmware.com/tkgs-cluster-1 edited
```

---

**Note** If you receive an error, or `kubectl` does not report that the cluster manifest was successfully edited, make sure you have properly configured your default text editor using the `KUBE_EDITOR` environment variable. See [Specify a Default Text Editor for Kubectl](#).

---

- Verify that the cluster is updating.

```
kubectl get tanzukubernetescluster
NAME                CONTROL PLANE  WORKER  DISTRIBUTION                                AGE  PHASE
tkgs-cluster-1     3              3      v1.18.5+vmware.1-tkg.1.c40d30d           21h  updating
```



**10** Verify that the cluster is updated.

```
kubectl get tanzukubernetescluster
NAME                CONTROL PLANE  WORKER  DISTRIBUTION                AGE  PHASE
tkgs-cluster-1     3              3      v1.18.5+vmware.1-tkg.1.c40d30d  22h  running
```

## Update a Tanzu Kubernetes Cluster by Changing the Storage Class

You can update a Tanzu Kubernetes cluster by changing the storage class used by the cluster nodes.

The Tanzu Kubernetes Grid Service supports updating a cluster by changing the `StorageClass` for the node pools, that is, by changing the property `.spec.topology.controlPlane.storageClass` or the property `.spec.topology.workers.storageClass`. See [About Tanzu Kubernetes Cluster Updates](#).

### Prerequisites

This task uses the command `kubectl edit tanzukubernetescluster/CLUSTER-NAME` to update the cluster manifest. The `kubectl edit` command opens the cluster manifest in the text editor defined by your `KUBE_EDITOR` or `EDITOR` environment variable. When you save the file, the cluster is updated with the changes. See [Specify a Default Text Editor for Kubectl](#).

### Procedure

- 1 Authenticate with the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).

```
kubectl vsphere login --server=IP-ADDRESS --vsphere-username USERNAME
```

- 2 Switch context to the vSphere Namespace where the target Tanzu Kubernetes cluster is provisioned.

```
kubectl config use-context SUPERVISOR-NAMESPACE
```

- 3 To determine available storage classes and decide which to use, run the following command.

```
kubectl describe tanzukubernetescluster CLUSTER-NAME
```

- 4 Run the following command to edit the cluster manifest.

```
kubectl edit tanzukubernetescluster/CLUSTER-NAME
```

- 5 Edit the manifest by changing the `storageClass` value.

For example, change the cluster manifest from the `silver-storage-class` class for control plane and worker nodes:

```
spec:
```

```

topology:
  controlPlane:
    ...
    storageClass: silver-storage-class
  workers:
    ...
    storageClass: silver-storage-class

```

To the `gold-storage-class` class for control plane and worker nodes:

```

spec:
  topology:
    controlPlane:
      ...
      storageClass: gold-storage-class
    workers:
      ...
      storageClass: gold-storage-class

```

- 6 Save the changes you made to the manifest file.

When you save the file, `kubectl` applies the changes to the cluster. In the background, the Tanzu Kubernetes Grid Service provisions the new node VMs and spins down the old ones.

- 7 Verify that `kubectl` reports that the manifest edits were successfully recorded.

```

kubectl edit tanzukubernetescluster/tkgs-cluster-1
tanzukubernetescluster.run.tanzu.vmware.com/tkgs-cluster-1 edited

```

**Note** If you receive an error, or `kubectl` does not report that the cluster manifest was successfully edited, make sure you have properly configured your default text editor using the `KUBE_EDITOR` environment variable. See [Specify a Default Text Editor for Kubectl](#).

- 8 Verify that the cluster is updating.

```

kubectl get tanzukubernetescluster

```

NAME	CONTROL PLANE	WORKER	DISTRIBUTION	AGE	PHASE
tkgs-cluster-1	3	3	v1.18.5+vmware.1-tkg.1.c40d30d	21h	updating

- 9 Verify that the cluster is updated.

```

kubectl get tanzukubernetescluster

```

NAME	CONTROL PLANE	WORKER	DISTRIBUTION	AGE	PHASE
tkgs-cluster-1	3	3	v1.18.5+vmware.1-tkg.1.c40d30d	22h	running

## Update Tanzu Kubernetes Clusters Using the Patch Method

You can use the `kubectl patch` method to perform an "in-place" update of a Tanzu Kubernetes cluster. The `kubectl patch` method is an alternative to using the `kubectl edit` command to perform one of the supported cluster update operations.

### About the Kubectl Patch Command

The `kubectl patch` command performs an "in-place" update of a cluster. The purpose of this command is to provide a method for upgrading Kubernetes versions, and is the approach documented here. For more information on the `kubectl patch` command, see [Update API Objects in Place Using kubectl patch](#) in the Kubernetes documentation.

The approach demonstrated here uses the UNIX shell command `read` to take input from the keyboard and assign it to a variable named `$PATCH`. The `kubectl patch` command invokes the Kubernetes API to update the cluster manifest. The `--type=merge` flag indicates that the data contains only those properties that are different from the existing manifest.

### Upgrade the Kubernetes Version Using the Patch Method

The most common method to trigger a rolling update is by changing the Kubernetes distribution version for the cluster, using the `.spec.distribution.version` and `.spec.distribution.fullVersion` properties. You update the `version` hint and unset or null out the `fullVersion` to avoid a potential version mismatch during discovery.

```
$ read -r -d '' PATCH <<'EOF'
spec:
  distribution:
    fullVersion: null    # NOTE: Must set to null when updating just the version field
    version: v1.18.5
EOF
```

Apply the update using the `kubectl patch` command. You must include the quotes around the `"$PATCH"` variable to preserve newline characters in the cluster manifest. Replace the `TKG-CLUSTER-NAME` value with the actual name of your cluster.

```
kubectl patch --type=merge tanzukubernetescluster TKG-CLUSTER-NAME --patch "$PATCH"
```

Expected result:

```
tanzukubernetescluster.run.tanzu.vmware.com/TKG-CLUSTER-NAME patched
```

## Update by the Cluster Changing the VirtualMachineClass for the Nodes Using the Patch Method

Another way to trigger a rolling update of a Tanzu Kubernetes cluster is by changing the `VirtualMachineClass` for the node pools, that is, by changing the property `.spec.topology.controlPlane.class` or the property `.spec.topology.workers.class`.

```
read -r -d '' PATCH <<'EOF'
spec:
  topology:
    controlPlane:
      class: best-effort-xlarge
    workers:
      class: best-effort-xlarge
EOF
```

Apply the update using the `kubectl patch` command, replacing the variable with the cluster name.

```
kubectl patch --type=merge tanzukubernetescluster TKG-CLUSTER-NAME --patch "$PATCH"
```

Expected result:

```
tanzukubernetescluster.run.tanzu.vmware.com/TKG-CLUSTER-NAME patched
```

## Update the Cluster by Changing the StorageClass for the Nodes Using the Patch Method

Another way to trigger a rolling update of a Tanzu Kubernetes cluster is by changing the `StorageClass` for the node pools, that is, by changing the property `.spec.topology.controlPlane.storageClass` or the property `.spec.topology.workers.storageClass`.

```
$ read -r -d '' PATCH <<'EOF'
spec:
  topology:
    controlPlane:
      storageClass: gc-storage-profile
    workers:
      storageClass: gc-storage-profile
EOF
```

Apply the update using the `kubectl patch` command, replacing the variable with the cluster name.

```
kubectl patch --type=merge tanzukubernetescluster TKG-CLUSTER-NAME --patch "$PATCH"
```

Expected result:

```
tanzukubernetescluster.run.tanzu.vmware.com/TKG-CLUSTER-NAME patched
```

# Backing Up and Restoring vSphere with Tanzu

# 18

You can backup and restore the workloads running on vSphere Pods and Tanzu Kubernetes clusters, as well as the vCenter Server and NSX-T infrastructure supporting your vSphere with Tanzu installation.

This chapter includes the following topics:

- [Considerations for Backing Up and Restoring vSphere with Tanzu](#)
- [Install and Configure the Velero Plugin for vSphere on the Supervisor Cluster](#)
- [Backup and Restore vSphere Pods Using the Velero Plugin for vSphere](#)
- [Install and Configure the Velero Plugin for vSphere on a Tanzu Kubernetes Cluster](#)
- [Backup and Restore Tanzu Kubernetes Cluster Workloads Using the Velero Plugin for vSphere](#)
- [Install and Configure Standalone Velero and Restic on a Tanzu Kubernetes Cluster](#)
- [Backup and Restore Tanzu Kubernetes Cluster Workloads Using Standalone Velero and Restic](#)
- [Backup and Restore vCenter Server](#)
- [Backup and Restore NSX-T Data Center](#)

## Considerations for Backing Up and Restoring vSphere with Tanzu

This topic provides an overview of the backup and restore process for vSphere with Tanzu, and provides high-level considerations for implementing your backup and restore strategy for vSphere with Tanzu.

vSphere with Tanzu backup and restore comprises various layers and tools.

The table summarizes these layers and tools from the top-down, workload to infrastructure. Refer to the individual sections for details on performing backup and restore for that layer.

Scenario	Tools	Comments
Backup and restore vSphere Pods	Velero Plugin for vSphere	<p>Install and configure the plugin on the Supervisor Cluster.</p> <p><b>Note</b> The plugin is not backing up Supervisor Cluster state.</p> <p>See <a href="#">Install and Configure the Velero Plugin for vSphere on the Supervisor Cluster</a>.</p> <p>See <a href="#">Backup and Restore vSphere Pods Using the Velero Plugin for vSphere</a>.</p>
Backup stateless and stateful workloads on a Tanzu Kubernetes cluster and restore to a cluster provisioned by the Tanzu Kubernetes Grid Service	Velero Plugin for vSphere	<p>Both Kubernetes metadata and persistent volumes can be backed up and restored.</p> <p>Velero snapshotting (not Restic) is used for persistent volumes.</p> <p>See <a href="#">Install and Configure the Velero Plugin for vSphere on a Tanzu Kubernetes Cluster</a>.</p> <p>See <a href="#">Backup and Restore Tanzu Kubernetes Cluster Workloads Using the Velero Plugin for vSphere</a>.</p>
Backup stateless and stateful workloads on a Tanzu Kubernetes cluster and restore to a conformant Kubernetes cluster not provisioned by the Tanzu Kubernetes Grid Service	Standalone Velero and Restic	<p>If you require portability, use standalone Velero. Must include Restic for stateful applications.</p> <p>See <a href="#">Install and Configure Standalone Velero and Restic on a Tanzu Kubernetes Cluster</a>.</p> <p>See <a href="#">Backup and Restore Tanzu Kubernetes Cluster Workloads Using Standalone Velero and Restic</a>.</p>
Supervisor Cluster After a Supervisor Cluster upgrade, you must do a new backup. Restoring a vCenter Server to a backup where it expects an older version of Supervisor Cluster is not supported.	vCenter Server Velero Plugin for vSphere Standalone Velero and Restic	<p>Restore vCenter Server from backup. vCenter will recreate all three Supervisor Cluster control plane VMs.</p> <p>Restore cluster workloads from backup using the plugin or standalone Velero and Restic.</p>
vCenter Configuration	vCenter Server	<p>If vCenter is lost, use vCenter Server to backup and restore vCenter objects.</p> <p>See <a href="#">Backup and Restore vCenter Server</a>.</p>
NSX-T Data Center	NSX-T Manager	<p>Load balancer and ingress services depend on NSX-T backup.</p> <p>Use NSX-T Manager to backup and restore the NSX-T database.</p> <p>See <a href="#">Backup and Restore NSX-T Data Center</a>.</p>

# Install and Configure the Velero Plugin for vSphere on the Supervisor Cluster

You can use the Velero Plugin for vSphere to backup and restore workloads running on vSphere Pods by installing the Velero Plugin for vSphere on the Supervisor Cluster.

## Overview

The Velero Plugin for vSphere provides a solution for backing up and restoring vSphere with Tanzu workloads. The solution requires the installation and configuration of several components. Once you have the Velero Plugin for vSphere installed and configured on the Supervisor Cluster, you can backup and restore vSphere Pods. For persistent workloads, the Velero Plugin for vSphere lets you take snapshots of the persistent volumes.

Installing Velero Plugin for vSphere on the Supervisor Cluster is also a prerequisite for using the Velero Plugin for vSphere to backup and restore Tanzu Kubernetes cluster workloads.

---

**Note** The Velero Plugin for vSphere cannot be used to backup and restore Supervisor Cluster state. See [Considerations for Backing Up and Restoring vSphere with Tanzu](#).

---

**Note** The Velero Plugin for vSphere by itself does not perform incremental backups. Dell EMC [PowerProtect](#) supports incremental backup and leverages Velero and the Velero Plugin for vSphere.

---

## Prerequisites

Before installing the Velero Plugin for vSphere, adhere to the following prerequisites:

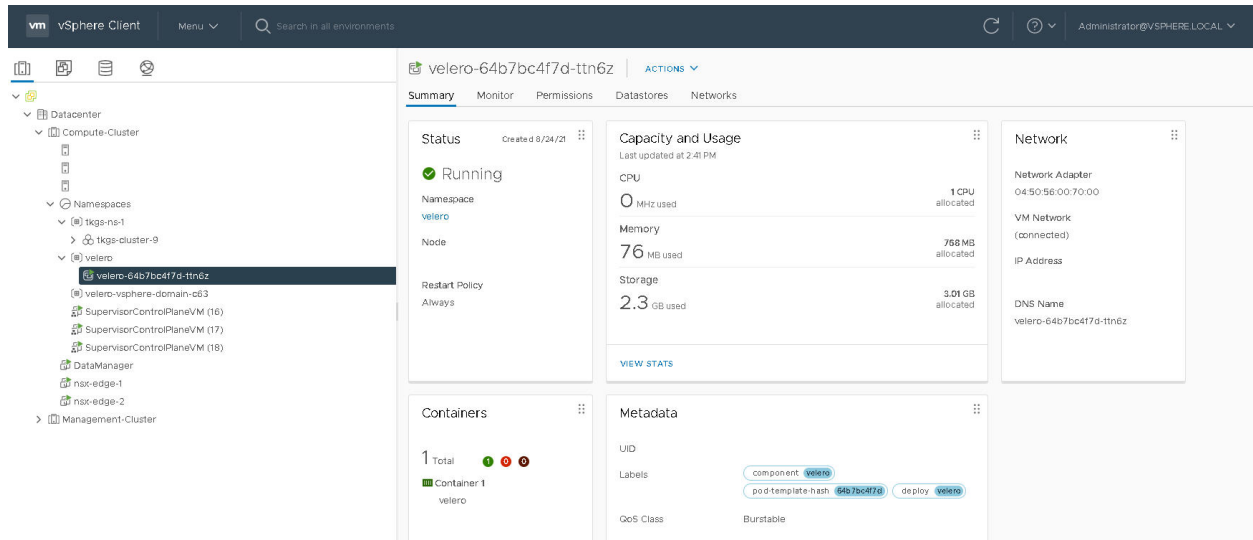
- Workload Management is enabled with NSX-T Data Center networking. See [Enable Workload Management with NSX-T Data Center Networking](#)
- Supervisor Cluster is version 1.21.1 or later.
- vSphere Namespace is created and configured.
- You must be a member of the vSphere Administrator role, or have following vSphere privileges:
  - **SupervisorServices.Manage**
  - **Namespaces.Manage**
  - **Namespaces.Configure**

The screenshot shows the end state of a Velero Plugin for vSphere installation.

- NSX-T networking is used to support the deployment of vSphere Pods
- A Data Manager VM is deployed
- The Velero Operator is enabled and running in the `velero-vsphere-domain-cXX` namespace
- A namespace called `velero` is configured



- The Velero Plugin for vSphere is running as a vSphere Pod in the `velero` namespace



## Upgrades

These instructions assume that you are running vSphere 7 U3. If you previously installed the Velero Plugin for vSphere on a vSphere 7 U2 P3 environment, on upgrade the Data Manager VM and **Velero vSphere Operator** are migrated to the new framework. The **Velero vSphere Operator** is converted to the new vSphere Services format. No action is required.

## Create a Dedicated Network for Backup and Restore Traffic (Optional)

Although not required, it is recommended that for production environments you separate the backup and restore traffic from the vSphere with Tanzu management network traffic. There are two aspects to this:

- Tag the ESXi hosts to support network file copy (NFC)
- Configure the backup and restore network using NSX-T Data Center

To configure vSphere 7.x ESXi hosts to support a dedicated network block device (NBD) transport, you add a VMkernel NIC on each ESXi host in the vCenter Server cluster where Workload Management is enabled and set the `vSphereBackupNFC` on that NIC. When the tag `vSphereBackupNFC` is applied to the NIC type for a VMkernel adapter, backup and restore traffic goes through the chosen virtual NIC.

To perform this configuration, you use the Virtual Disk Development Kit. See the [NBD documentation](#).

**Note** If the `vSphereBackupNFC` is not enabled on the VMkernel NIC, the backup and restore traffic will not be sent on the backup and restore network, even if you configure one. If `vSphereBackupNFC` is not enabled, the traffic will travel on the vSphere management network.

Once the `vSphereBackupNFC` tag is enabled, configure the backup and restore network using NSX-T by updating the existing vSphere Distributed Switch (vDS) for the cluster as follows:

- In the vSphere Client, select **Menu > Networking**.
- Select the existing vDS for the cluster.
- Right-click the vDS and select **Distributed Port Group > New Distributed Port Group**.
- Create a new Distributed Port Group named **BackupRestoreNetwork**.
- Add a VMkernel adapter to the **BackupRestoreNetwork** Distributed Port Group.
- Attach all the ESXi hosts in the vCenter cluster where Workload Management is enabled to the **BackupRestoreNetwork** Distributed Port Group.
- Enable the `vSphereBackupNFC` tag.

For guidance on creating an NSX-T network on the existing vDS, see [Install and Configure NSX-T Data Center for vSphere with Tanzu](#).

## Create an S3-Compatible Object Store

For backup and restore of persistent volumes, you need to provide an S3-compatible object store. Velero supports a number of [object store providers](#).

To install the Velero Plugin for vSphere, you will need to provide the following information about your S3-compatible object store:

Data Item	Example Value
s3Url	<a href="http://my-s3-store.example.com">http://my-s3-store.example.com</a>
aws_access_key_id	ACCESS-KEY-ID-STRING
aws_secret_access_key	SECRET-ACCESS-KEY-STRING

Create a secrets file name `s3-credentials` with the following information. You will reference this file when you install the Velero Plugin for vSphere.

```
aws_access_key_id = ACCESS-KEY-ID-STRING
aws_secret_access_key = SECRET-ACCESS-KEY-STRING
```

MinIO is an S3-compatible object store that is easy to install and use. vSphere with Tanzu ships with a MinIO Supervisor Service that you can enable. For more information, see [Enable Stateful Services in vSphere with Tanzu](#).

Alternatively, you can manually install a MinIO server on a Linux VM. For instructions, see [Install and Configure Standalone Velero and Restic on a Tanzu Kubernetes Cluster](#).

## Install and Configure Data Manager

To facilitate backup and restore using the Velero Plugin for vSphere, you deploy one or more Data Manager VMs to move persistent volume backup data into and out of S3-compatible object storage. The Data Manager moves the volume snapshot data from the vSphere volume to the remote durable S3-compatible storage on backup, and from remote S3-compatible storage to a vSphere volume during restore.

In a vSphere with Tanzu environment, install the Data Manager as a virtual machine.

---

**Note** Do not power on the Data Manager VM until after you have enabled the Velero vSphere Operator.

---

- 1 Download the Data Manager OVA:  
<https://vsphere-velero-datamgr.s3-us-west-1.amazonaws.com/datamgr-ob-17253392-photon-3-release-1.1.ova>
- 2 Using the vSphere Client, right-click the **Datacenter** where Workload Management is enabled and select **Deploy OVF Template**.
- 3 Select the Data Manager OVA file that you downloaded and upload it to the vCenter Server.
- 4 Name the virtual machine **DataManager**, for example.
- 5 Select the compute resource which is the vCenter cluster where the Supervisor Cluster is configured.
- 6 Review the VM deployment details and click **Next**.
- 7 Accept the license agreements and click **Next**.
- 8 Select the storage and click **Next**.
- 9 Select the destination network for the Data Manager VM.
  - Select the **BackupRestoreNetwork** if you configured a dedicated backup and restore network. See [Create a Dedicated Network for Backup and Restore Traffic \(Optional\)](#).
  - Select the **Management Network** if you did not configure a dedicated backup and restore network.
- 10 Confirm the selections and click **Finish** to complete the process.
- 11 Use the Recent Tasks panel to monitor the progress of the deployment.

---

**Note** If you receive an error that the "OVF descriptor is not available," use Chrome browser.

---

- 12 Once the Data Manager VM is deployed, configure the input parameters for the VM.
- 13 Right-click the VM and select **Edit Settings**.
- 14 In the Virtual Hardware tab, for CD/DVD Drive, change from **Host Device** to **Client Device**.

---

**Note** If you do not do this, you cannot save the required advanced configuration settings.

---

- 15 In the **Edit Settings > VM Options** tab, select **Advanced > Edit Configuration Parameters**.
- 16 Configure the input parameters for each of the following settings:

Parameter	Value
<code>questinfo.cnsdp.vcUser</code>	Enter the vCenter Server user name with sufficient privileges to deploy VMs.
<code>questinfo.cnsdp.vcAddress</code>	Enter the vCenter Server IP address or FQDN.
<code>questinfo.cnsdp.vcPasswd</code>	Enter the vCenter Server user password.
<code>questinfo.cnsdp.vcPort</code>	The default is <b>443</b> . Do not change this value.
<code>questinfo.cnsdp.wcpControlPlaneIP</code>	Enter the Supervisor Cluster IP address. Get this value by navigating to the vCenter cluster where Workload Management is enabled and selecting <b>Configure &gt; Namespaces &gt; Network &gt; Management Network &gt; Starting IP Address</b>
<code>questinfo.cnsdp.updateKubect1</code>	The default is <b>false</b> . Do not change this value.
<code>questinfo.cnsdp.veleroNamespace</code>	The default is <b>velero</b> and you should leave it as such unless you have a compelling reason to change it. Later in the process you will create a vSphere Namespace on the Supervisor Cluster with the name <code>velero</code> . These names must match.
<code>questinfo.cnsdp.datamgrImage</code>	If not configured (unset), the system by default will pull the container image from Docker Hub at <code>vsphereveleroplugin/data-manager-for-plugin:1.1.0</code>

- 17 Click OK to save the configuration and OK again to save the VM settings.

---

**Note** If you did not change the CD/DVD Drive from **Host Device** to **Client Device**, you cannot save the settings. If this is the case, cancel the operation, change the drive and repeat the advanced configuration settings.

---

- 18 Do not power on the Data Manager VM until after you enable the Velero vSphere Operator (next section).

## Install and Configure the Velero vSphere Operator on the Supervisor Cluster

vSphere with Tanzu provides the Velero vSphere Operator as a vSphere Service. The Velero vSphere Operator works with the Velero Plugin for vSphere to support backup and restore of Kubernetes workloads, including snapshotting persistent volumes. For more information about vSphere Services, see [Chapter 8 Managing Supervisor Services with vSphere with Tanzu](#).

Complete the following tasks to install and configure the **Velero vSphere Operator** vSphere Service using the vSphere Client.

The first task is to download the service specification for the **Velero vSphere Operator** and install it onto the vCenter Server where **Workload Management** is enabled.

- 1 Download the YAML for the **Velero vSphere Operator** from the following location:  
<http://vmware.com/go/supervisor-service>
- 2 From the vSphere Client home menu, select **Workload Management**.
- 3 Select the **Services** tab.
- 4 Select the target vCenter Server from the drop-down menu at the top.
- 5 Drag and drop the service specification file `velero-supervisor-service-1.0.0.yaml` that you downloaded to the **Add New Service** card.
- 6 Click **Next** and accept the licence agreement.
- 7 Click **Finish**.

The **Velero vSphere Operator** is installed and the service is registered with the vCenter Server. Verify that the service is in an **Active** state. You cannot proceed with configuring the service if it is Deactivated.

The next task is to configure the **Velero vSphere Operator** on the Supervisor Cluster.

- 1 From the vSphere Client home menu, select **Workload Management**.
- 2 Select the **Services** tab.
- 3 Select the **Velero vSphere Operator** service that you want to configure.
- 4 Select the target Supervisor Cluster where you want to configure it.
- 5 Configure the **Velero vSphere Operator** service as follows:
  - a Select the version from the drop-down: **1.1.0**.
  - b Do not specify a **Repository endpoint**.
  - c Do not enter a username.
  - d Do not enter a password.
  - e Click **Next**.
  - f Click **Finish**.

The last task is to verify the **Velero vSphere Operator** service on the Supervisor Cluster and to start the Data Manager VM.

- 1 From the vSphere Client home menu, select **Inventory**.
- 2 Select the vCenter cluster where **Workload Management** is enabled.
- 3 Select **Configure > vSphere Services > Overview**.
- 4 Verify that you see the **Velero vSphere Operator** installed and its status is **Configured**.

- 5 In the **Namespaces** resource pool, verify that you see a new namespace named `svc-velero-vsphere-domain-xxx`, where `xxx` is a unique alphanumeric token. This is the namespace created by the system for the **Velero vSphere Operator**.

---

**Note** You do not need to configure this namespace and you should not edit it.

---

- 6 In the **Hosts and Clusters** view, select the **Data Manager** VM.
- 7 Right-click the **Data Manager** VM and power it on.

## Create a vSphere Namespace for the Velero Plugin for vSphere

Using the vSphere Client, manually create a vSphere Namespace on the Supervisor Cluster. This namespace is required for the Velero Plugin for vSphere. For guidance, see [Create and Configure a vSphere Namespace](#).

- Name the namespace **velero**.
- Select the **velero** namespace and configure it.
- Specify the Storage for the **velero** namespace.
- Grant a user with appropriate privileges the Edit permission on the **velero** namespace.

## Install the Velero Plugin for vSphere

Now you are ready to install the Velero Plugin for vSphere. To do this, download and run the **velero-vsphere** CLI.

---

**Note** This procedure requires a Linux VM. You should download and run the **velero-vsphere** to the Linux jump host where you run the `kubectl-vsphere` and `kubectl` CLIs.

---

- 1 Create a Linux VM where you can run the CLI. Or use an existing Linux jump host where you access the Supervisor Cluster.
- 2 Download the Velero Plugin for vSphere CLI from the following location:

<https://github.com/vmware-tanzu/velero-plugin-for-vsphere/releases/download/v1.1.0/velero-vsphere-1.1.0-linux-amd64.tar.gz>

- 3 Securely copy the CLI to the Linux jump host. For example:

```
pscp -P 22 C:\temp\velero-vsphere-1.1.0-linux-amd64.tar.gz ubuntu@10.117.29.131:/home/
ubuntu/tanzu
```

- 4 Extract the `velero-vsphere` CLI and make it writable.

```
tar -xf velero-vsphere-1.1.0-linux-amd64.tar.gz
chmod +x velero-vsphere
```

- 5 Create the `s3-credentials` file with the following contents.

```
aws_access_key_id = ACCESS-KEY-ID-STRING
aws_secret_access_key = SECRET-ACCESS-KEY-STRING
```

- 6 Obtain the region, URL, and bucket name for your S3-compatible object store.
- 7 Log in to the Supervisor Cluster using the vSphere Plugin for kubectl.
- 8 Switch context to the Supervisor Cluster.

```
kubectl config use-context SUPERVISOR-CLUSTER-IP-ADDRESS
```

- 9 Run the following `velero-vsphere` CLI command to install the Velero Plugin for vSphere into the **velero** namespace you created.

Replace the placeholder values for the **BUCKET-NAME**, **REGION** (two instances), and **s3Url** fields with the appropriate values. If you deviated from any of the preceding instructions, adjust those values as well, such as the name or location of the secrets file, the name of the manually created `velero` namespace, etc.

```
./velero-vsphere install \
  --namespace velero \
  --image velero/velero:v1.5.1 \
  --provider aws \
  --plugins velero/velero-plugin-for-aws:v1.1.0,vsphereveleroplugin/velero-plugin-for-
vsphere:1.1.0 \
  --bucket BUCKET-NAME \
  --secret-file s3-credentials \
  --snapshot-location-config region=REGION \
  --backup-location-config region=REGION,s3ForcePathStyle="true",s3Url=http://my-s3-
store.example.com
```

---

**Note** You can use Velero Plugin for vSphere v1.1.0 and higher on the Supervisor Cluster, for example `vsphereveleroplugin/velero-plugin-for-vsphere:v1.1.1` or `vsphereveleroplugin/velero-plugin-for-vsphere:v1.2.0`. The Velero version must be v1.5.1 (`velero/velero:v1.5.1`).

---

- 10 Verify successful installation of the Velero Plugin for vSphere.

On successful installation you should see the following message:

```
Send the request to the operator about installing Velero in namespace velero
```

Run the following command to further verify. You should see "Completed" and the version.

```
kubectl -n velero get veleroservice default -o json | jq '.status'
```

Expected result:

```
{
  "enabled": true,
  "installphase": "Completed",
  "version": "v1.5.1"
}
```

**Note** The above command assumes you have the `jq` utility installed, which formats JSON output sent to the terminal. If you do not have `jq` installed, either install it or remove that part of the command (everything after `json`).

- 11 Troubleshoot as necessary.

If the installation is not successful, remove the installation and try again. To remove the installation, complete the steps in the next section in the order listed.

## Install the Velero Plugin in an Air-gapped Environment

If you plan to install the Velero Plugin for vSphere in an air-gapped environment, you must install it with customized images. You must make sure that the matching images of `backup-driver` and `data-manager-for-plugin` of the customized images are available in the expected registry and are accessible from the Kubernetes cluster. In an air-gapped environment, customized images from private registry are expected since the released images in docker hub are not accessible.

To install the plugin, perform the following steps:

- 1 Download the released images of `velero-plugin-for-vsphere`, `backup-driver`, and `data-manager-for-plugin`.
- 2 Rename the images, that is, tag them with matching `<Registry endpoint and path>` and `<Version tag>` and upload them in customized repositories.
- 3 Install the plugin the customized `velero-plugin-for-vsphere` image.

When you install Velero Plugin for vSphere in a vanilla cluster, it deploys two additional components, a `backup-driver` deployment and a `data-manager-for-plugin` DaemonSet in the background. In the Supervisor Cluster and Tanzu Kubernetes clusters, only a `backup-driver` deployment is deployed.

When you provide the container image of `velero-plugin-for-vsphere`, the matching `backup-driver` and `data-manager-for-plugin` images are parsed using an image parsing mechanism.

Container images are formalized into the following pattern:

```
<Registry endpoint and path>/<Container name>:<Version tag>
```

When you provide the `velero-plugin-for-vsphere` container image, the corresponding images of `backup-driver` and `data-manager-for-plugin` with matching `<Registry endpoint and path>` and `<Version tag>` are parsed.



For example, consider the following `velero-plugin-for-vsphere` container image:

```
abc.io:8989/x/y/.../z/velero-plugin-for-vsphere:vX.Y.Z
```

The following matching images of `backup-driver` and `data-manager-for-plugin` are expected to be pulled:

```
abc.io:8989/x/y/.../z/backup-driver:vX.Y.Z
abc.io:8989/x/y/.../z/data-manager-for-plugin:vX.Y.Z
```

#### 4 Troubleshoot the installation.

If there are any issues or errors in parsing the matching images of `backup-driver` and `data-manager-for-plugin`, the installation falls back to corresponding images from the official `velerovsphereplugin` repositories in Docker hub. The following issues trigger the fall-back mechanism:

- a An unexpected container name is used in the customized `velero-plugin-for-vsphere` image in the user input.

For example, `x/y/velero-velero-plugin-for-vsphere:v1.1.1` is used.

- b The Velero deployment name is customized to anything other than `velero`. For example, an issue is triggered if the Velero deployment name is updated to `velero-server` in the Velero `manifests` file before deploying Velero.

The existing image parsing mechanism in `velero-plugin-for-vsphere` can only recognize the Velero deployment with the fixed name, `velero`.

## Uninstall the Velero Plugin for vSphere

Complete these steps to uninstall the Velero Plugin for vSphere. Complete these steps in the order listed.

- 1 Run the `velero-vsphere` CLI to uninstall the Velero Plugin for vSphere.

```
./velero-vsphere uninstall -n velero
```

- 2 Verify that the vSphere Pod named `velero` is removed.

```
kubectl get pods -n velero
```

If you see that the pod is "Terminating," wait for it to be removed before proceeding.

- 3 Using the vSphere Client, delete the vSphere Namespace named `velero` that you manually created.

---

**Note** Do not proceed with the next step until the namespace deletion is complete. You can use `kubectl` to verify that the `velero` namespace is removed (but do not use `kubectl` to remove the `velero` namespace).

---

- 4 Using the vSphere Client, uninstall the **Velero vSphere Operator** from the Supervisor Cluster.
  - a Select the vCenter cluster where **Workload Management** is enabled.
  - b Select **Configure > vSphere Services > Overview**.
  - c Select the **Velero vSphere Operator**.
  - d Click **Uninstall**.

This action uninstalls the **Velero vSphere Operator** from the Supervisor Cluster. The operator remains available for re-installation at the **Workload Management > Services** page. To remove the service entirely, select **Actions > Delete**.

## Backup and Restore vSphere Pods Using the Velero Plugin for vSphere

You can use the Velero Plugin for vSphere to backup and restore workloads running on vSphere Pods.

### Overview

You can use the Velero Plugin for vSphere to backup and restore workloads running on vSphere Pods in the Supervisor Cluster. You can backup and restore both stateless and stateful applications running on vSphere Pods. For stateful applications, you use the Velero Plugin for vSphere to take snapshots of the persistent volumes (PVs).

---

**Note** You cannot use Velero standalone with Restic to backup and restore vSphere Pods. You must use the Velero Plugin for vSphere installed on the Supervisor Cluster.

---

### Prerequisites

Before you can backup and restore vSphere Pods, you need to install and configure the Velero Plugin for vSphere. See [Install and Configure the Velero Plugin for vSphere on the Supervisor Cluster](#).

---

**Note** The Velero Plugin for vSphere is not backing up and restoring the state of the Supervisor Cluster.

---

### Backup a vSphere Pod

To backup a stateless vSphere Pod, run the following command:

```
velero backup create <backup name> --include-namespaces=my-namespace
```

The backup is marked `Completed` after all local snapshots have been taken and Kubernetes metadata is uploaded to the object store. However, the backup of volume snapshots occurs asynchronously and may still be occurring in the background and take some time to complete.

You can check the status of volume snapshots by monitoring Snapshot and Upload custom resources.

### Snapshot CRD

For each volume snapshot, a Snapshot custom resource is created in the same namespace as the PVC that is snapshotted. You can get all Snapshots in PVC namespace by running the following command.

```
kubectl get -n <pvc namespace> snapshot
```

The Snapshot CRD has several phases for the `status.phase` field, including:

State	Description
New	Not processed yet
Snapshotted	Local snapshot was taken
SnapshotFailed	Local snapshot failed
Uploading	Snapshot is being uploaded
Uploaded	Snapshot is uploaded
UploadFailed	Snapshot failed to be uploaded
Canceling	Upload of snapshot is being cancelled
Canceled	Upload of snapshot is cancelled
CleanupAfterUploadFailed	Cleanup of local snapshot after the upload of snapshot failed

### Upload CRD

For each volume snapshot to be uploaded to object store, an Upload CR will be created in the same namespace as Velero. You can get all Uploads in Velero namespace by running the following command.

```
kubectl get -n <velero namespace> upload
```

Upload CRD has several phases for the `status.phase` field, including:

State	Description
New	Not processed yet
InProgress	Upload in progress
UploadError	Upload failed
CleanupFailed	Delete local snapshot failed after the upload Will be retried
Canceling	Upload is being cancelled Can occur if <code>velero backup delete</code> is called while snapshot upload is in progress
Canceled	Upload is cancelled

UploadError uploads will be periodically retried. At that point their phase will return to InProgress. After an upload has been successfully completed, its record will remain for a period of time and eventually be removed.

## Restore a vSphere Pod

To restore a vSphere Pod workload that has been backed up using the Velero Plugin for vSphere, complete the following steps.

- 1 Create a vSphere Namespace for the workload you will restore.
- 2 Configure the storage policy for the namespace.
- 3 Run the following Velero command to restore the workload:

```
velero restore create --from-backup backup-name
```

Velero restore will be marked as `Completed` when volume snapshots and other Kubernetes metadata have been successfully restored to the current cluster. At this point, all tasks of vSphere plugin related to this restore are completed as well. There are no asynchronous data movement tasks behind the scene as that in the case of Velero backup.

Before Velero restore is `Completed`, you can check the status of volume restore by monitoring `CloneFromSnapshot/Download` CRs as below.

### CloneFromSnapshots CRD

For restore from each volume snapshot, a `CloneFromSnapshot` CR will be created in the same namespace as the PVC that is originally snapshotted. We can get all `CloneFromSnapshots` in PVC namespace by running the following command.

```
kubectl -n <pvc namespace> get clonefromsnapshot
```

`CloneFromSnapshot` CRD has several phases for the `status.phase` field, including:

State	Description
New	Clone from snapshot is not completed
Completed	Clone from snapshot is completed
Failed	Clone from snapshot failed

### Download CRD

From each restore of volume snapshot to be downloaded from object store, a `Download` CR will be created in the same namespace as Velero. We can get all `Downloads` in Velero namespace by running the following command.

```
kubectl -n <velero namespace> get download
```

The `Download` CRD has several phases for the `status.phase` field, including:

Status	Description
New	Not processed yet
InProgress	Download in progress
Completed	Download is completed
Retry	Download is retried. When there is any failure during the download of backup data, the download is retried
Failed	Download is failed

## Install and Configure the Velero Plugin for vSphere on a Tanzu Kubernetes Cluster

You can use the Velero Plugin for vSphere to backup and restore workloads running on a Tanzu Kubernetes cluster by installing the Velero Plugin for vSphere on that cluster.

### Overview

The Velero Plugin for vSphere provides a solution for backing up and restoring Tanzu Kubernetes cluster workloads for clusters provisioned by the Tanzu Kubernetes Grid Service. For persistent workloads, the Velero Plugin for vSphere lets you take snapshots of the persistent volumes.

**Note** If you require portability for the Tanzu Kubernetes cluster workloads you want to backup and restore, do not use the Velero Plugin for vSphere. For portability across Kubernetes clusters, use standalone Velero with Restic. See [Install and Configure Standalone Velero and Restic on a Tanzu Kubernetes Cluster](#).

### Prerequisite: Install the Velero Plugin for vSphere on the Supervisor Cluster

Installing the Velero Plugin for vSphere on a Tanzu Kubernetes cluster requires the Supervisor Cluster to have the Velero Plugin for vSphere installed. In addition, the Supervisor Cluster must be configured with NSX-T networking.

Prior to the installation of the Velero Plugin for vSphere on a Tanzu Kubernetes cluster, you must first install the Velero Plugin for vSphere on the Supervisor Cluster. See [Install and Configure the Velero Plugin for vSphere on the Supervisor Cluster](#).

### Install the Velero CLI on a Linux Workstation

The Velero CLI is the standard tool for interfacing with Velero. The Velero CLI provides more functionality than the Velero Plugin for vSphere CLI (`velero-vsphere`) and is required for backing up and restoring Tanzu Kubernetes cluster workloads.

Install the Velero CLI on a Linux workstation. Ideally this is the same jump host where you run associated CLIs for your vSphere with Tanzu environment, including `kubect1`, `kubect1-vsphere`, and `velero-vsphere`.

Complete the following steps to install the Velero CLI.

- 1 Download the supported version of the Velero CLI from the VMware product downloads page. For more information about the supported Velero version, see the [Release Notes](#).
- 2 Open a command line and change directory to the Velero CLI download.

```
gunzip velero-linux-v1.x.x_vmware.1.gz
```

- 3 Check for the Velero binary.

```
ls -l
-rw-r--r-- 1 root root 7142128 Aug 14 14:14 velero-linux-v1.x.x_vmware.1
```

- 4 Grant execute permissions to the Velero CLI.

```
chmod +x velero-linux-v1.x.x_vmware.1
```

- 5 Make the Velero CLI globally available by moving it to the system path.

```
cp velero-linux-v1.x.x_vmware.1 /usr/local/bin/velero
```

- 6 Verify the installation of the Velero CLI.

```
velero version
Client:
  Version: v1.x.x
```

## Get the S3-Compatible Bucket Details

For convenience, the steps assume that you are using the same S3-compatible object store that you configured when you installed the Velero Plugin for vSphere on the Supervisor Cluster. In production you may want to create a separate object store.

To install the Velero Plugin for vSphere, you will need to provide the following information about your S3-compatible object store.

Data Item	Example Value
s3Url	<a href="http://my-s3-store.example.com">http://my-s3-store.example.com</a>
aws_access_key_id	ACCESS-KEY-ID-STRING
aws_secret_access_key	SECRET-ACCESS-KEY-STRING

Create a secrets file name `s3-credentials` with the following information. You will reference this file when you install the Velero Plugin for vSphere.

```
aws_access_key_id = ACCESS-KEY-ID-STRING
aws_secret_access_key = SECRET-ACCESS-KEY-STRING
```

## Install the Velero Plugin for vSphere on the Tanzu Kubernetes Cluster

You are going to use the Velero CLI to install the Velero Plugin for vSphere on the target Tanzu Kubernetes cluster that you want to backup and restore.

The Velero CLI context will automatically follow the `kubect1` context. Before running Velero CLI commands to install Velero and the Velero Plugin for vSphere on the target cluster, be sure to set the `kubect1` context to the target cluster.

- 1 Using the vSphere Plugin for `kubect1`, authenticate with the Supervisor Cluster. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).
- 2 Set the `kubect1` context to the target Tanzu Kubernetes cluster.

```
kubect1 config use-context TARGET-TANZU-KUBERNETES-CLUSTER
```

- 3 Run the following Velero CLI command to install Velero on the target cluster.

Replace the placeholder values for the **BUCKET-NAME**, **REGION** (two instances), and **s3Url** fields with the appropriate values. If you deviated from any of the preceding instructions, adjust those values as well, such as the name or location of the secrets file, the name of the manually created `velero` namespace, etc.

```
./velero install --provider aws \
--bucket BUCKET-NAME \
--secret-file ./s3-credentials \
--features=EnableVSphereItemActionPlugin \
--plugins velero/velero-plugin-for-aws:v1.1.0 \
--snapshot-location-config region=REGION \
--backup-location-config region=REGION,s3ForcePathStyle="true",s3Url=http://my-s3-
store.example.com
```

- 4 Install the Velero Plugin for vSphere on the target cluster. The installed Velero will communicate with Kubernetes API server to install the plugin.

```
velero plugin add vsphereveleroplugin/velero-plugin-for-vsphere:1.1.0
```

## Uninstall the Velero Plugin for vSphere from the Cluster

Complete these steps to uninstall the Velero Plugin for vSphere.

- 1 Set the `kubectl` context to the target Tanzu Kubernetes cluster.

```
kubectl config use-context TARGET-TANZU-KUBERNETES-CLUSTER
```

- 2 To uninstall the plugin, run the following command to remove the InitContainer of `velero-plugin-for-vsphere` from the Velero deployment.

```
velero plugin remove vsphereveleroplugin/velero-plugin-for-vsphere:1.1.0
```

- 3 To complete the un-installation, delete the Backup Driver deployment and related CRDs.

```
kubectl -n velero delete deployment.apps/backup-driver
```

```
kubectl delete crds \
  backuprepositories.backupdriver.cnsdp.vmware.com \
  backuprepositoryclaims.backupdriver.cnsdp.vmware.com \
  clonefromsnapshots.backupdriver.cnsdp.vmware.com \
  deletesnapshots.backupdriver.cnsdp.vmware.com \
  snapshots.backupdriver.cnsdp.vmware.com
```

```
kubectl delete crds uploads.datamover.cnsdp.vmware.com downloads.datamover.cnsdp.vmware.com
```

## Backup and Restore Tanzu Kubernetes Cluster Workloads Using the Velero Plugin for vSphere

You can backup and restore Tanzu Kubernetes cluster workloads using the Velero Plugin for vSphere. However, if you require portability, use standalone Velero.

### Prerequisites

To backup and restore Tanzu Kubernetes clusters workloads using the Velero Plugin for vSphere, you must first install Velero and the Velero Plugin for vSphere on the target cluster. See [Install and Configure the Velero Plugin for vSphere on a Tanzu Kubernetes Cluster](#).

### Backup a Workload

Below is an example command for creating a Velero backup.

```
velero backup create <backup name> --include-namespaces=my-namespace
```

Velero backup will be marked as `Completed` after all local snapshots have been taken and Kubernetes metadata, except volume snapshots, has been uploaded to the object store. At this point, asynchronous data movement tasks, i.e., the upload of volume snapshot, are still happening in the background and may take some time to complete. We can check the status of volume snapshot by monitoring [Snapshot Custom Resources \(CRs\)](#).



## Snapshots

Snapshots are used for backing up persistent volumes. For each volume snapshot, a Snapshot CR is created in the same namespace as the persistent volume claim (PVC) that is snapshotted.

You can get all Snapshots in PVC namespace by running the following command.

```
kubectl get -n <pvc namespace> snapshot
```

The Snapshot Custom Resource Definition (CRD) has a number of phases for the `.status.phase` field, including:

Snapshot Phase	Description
New	Not processed yet
Snapshotted	Local snapshot was taken
SnapshotFailed	Local snapshot was failed
Uploading	The snapshot is being uploaded
Uploaded	The snapshot is uploaded
UploadFailed	The snapshot is failed to be uploaded
Canceling	The upload of snapshot is being cancelled
Canceled	The upload of snapshot is cancelled
CleanupAfterUploadFailed	The Cleanup of local snapshot after the upload of snapshot was failed

## Restore a Workload

Below is an example command of Velero restore.

```
velero restore create --from-backup <velero-backup-name>
```

Velero restore will be marked as `Completed` when volume snapshots and other Kubernetes metadata have been successfully restored to the current cluster. At this point, all tasks of vSphere plugin related to this restore are completed as well. There are no any asynchronous data movement tasks behind the scene as that in the case of Velero backup.

## CloneFromSnapshots

To restore from each volume snapshot, a `CloneFromSnapshot` Custom Resource (CR) will be created in the same namespace as the PVC that is originally snapshotted. We can get all `CloneFromSnapshots` in PVC namespace by running the following command.

```
kubectl -n <pvc namespace> get clonefromsnapshot
```

`CloneFromSnapshot` CRD has some key phases for the `.status.phase` field:

Snapshot Phase	Description
New	Clone from snapshot is not completed
InProgress	The vSphere volume snapshot is being downloaded from remote repository
Completed	Clone from snapshot is completed
Failed	Clone from snapshot is failed

## Install and Configure Standalone Velero and Restic on a Tanzu Kubernetes Cluster

To backup and restore workloads on Tanzu Kubernetes, create a data store and install Velero with Restic on the Kubernetes cluster.

### Overview

Tanzu Kubernetes clusters run on virtual machine nodes. To backup and restore Tanzu Kubernetes clusters, you install Velero and Restic on the cluster.

### Prerequisites

Ensure that your environment meets the following prerequisites for installing Velero and Restic to back up and restore workloads running on Tanzu Kubernetes clusters.

- A Linux VM with sufficient storage to store several workload backups. You will install MinIO on this VM.
- A Linux VM where the Kubernetes CLI Tools for vSphere are installed, including the vSphere Plugin for kubectl and kubectl. You will install the Velero CLI on this client VM. If you do not have such a VM, you can install the Velero CLI locally, but you must adjust the installation steps accordingly.
- The Kubernetes environment has internet access and can be reached by the client VM.

### Install and Configure MinIO Object Store

Velero requires an S3-compatible object store as the destination for Kubernetes workload backups. Velero supports several such [object store providers](#). For simplicity, these instructions use [MinIO](#), an S3-compatible storage service that runs locally on the object store VM.

- 1 Install MinIO.

```
wget https://dl.min.io/server/minio/release/linux-amd64/minio
```

- 2 Grant execute permissions to MinIO.

```
chmod +x minio
```

- 3 Create a directory on the file system for MinIO.

```
mkdir /DATA-MINIO
```

- 4 Start the MinIO server.

```
./minio server /DATA-MINIO
```

- 5 After the MinIO server starts, you are provided with important data store instance details, including the Endpoint URL, AccessKey, and SecretKey. Record the Endpoint URL, AccessKey, and SecretKey in the table.

Data Store Metadata	Value
Endpoint URL	
AccessKey	
SecretKey	

- 6 Browse to the MinIO data store by opening a browser to the MinIO server endpoint URL.
- 7 Log in to the MinIO server and provide the AccessKey and SecretKey.
- 8 To enable MinIO as a service, configure MinIO for automatic start-up by download the `minio.service` script.

```
curl -O https://raw.githubusercontent.com/minio/minio-service/master/linux-systemd/minio.service
```

- 9 Edit the `minio.service` script and add the following value for `ExecStart`.

```
ExecStart=/usr/local/bin/minio server /DATA-MINIO path
```

- 10 Save the revised script.
- 11 Configure the MinIO service by running the following commands.

```
cp minio.service /etc/systemd/system
cp minio /usr/local/bin/
systemctl daemon-reload
systemctl start minio
systemctl status minio
systemctl enable minio
```

- 12 Create a MinIO bucket for backup and restore by launching the MinIO browser and logging in to your object store.
- 13 Click the Create Bucket icon.
- 14 Enter the bucket name, for example: `my-cluster-backups`.
- 15 Verify that the bucket was created.

- 16 By default, a new MinIO bucket is read-only. For Velero standalone backup and restore, the MinIO bucket must be read-write. To set the bucket to read-write, select the bucket and click on the ellipses (dots) link.
- 17 Select **Edit Policy**.
- 18 Change the policy to **Read and Write**.
- 19 Click **Add**.
- 20 To close the dialog box, click X.

## Install the Velero CLI

Install the Velero CLI on the VM client or on your local machine.

- 1 Download the supported version of the signed Velero binary for vSphere with Tanzu from the VMware product downloads page.

---

**Note** You must use the Velero binary signed by VMware to be eligible for support from VMware.

---

- 2 Open a command line and change directory to the Velero CLI download.
- 3 Unzip the download file. For example:

```
gunzip velero-linux-vX.X.X_vmware.1.gz
```

- 4 Check for the Velero binary.

```
ls -l
```

- 5 Grant execute permissions to the Velero CLI.

```
chmod +x velero-linux-vX.X.X_vmware.1
```

- 6 Make the Velero CLI globally available by moving it to the system path:

```
cp velero-linux-vX.X.X_vmware.1 /usr/local/bin/velero
```

- 7 Verify the installation.

```
velero version
```

## Install Velero and Restic on the Tanzu Kubernetes Cluster

The Velero CLI context will automatically follow the kubectl context. Before running Velero CLI commands to install Velero and Restic on the target cluster, set the kubectl context.

- 1 Retrieve the name of the MinIO bucket. For example, `my-cluster-backups`.
- 2 Get the AccessKey and SecretKey for the MinIO bucket.

- 3 Set the context for the target Kubernetes cluster so that the Velero CLI knows which cluster to work on.

```
kubectl config use-context tkgs-cluster-name
```

- 4 Create a secrets file named `credentials-minio`. Update the file with the MinIO server access credentials that you collected. For example:

```
aws_access_key_id = 0XXN08JCCGV41QZBV0RQ
aws_secret_access_key = c1Z1bf8Ljkvkmg7fHucrKCkxV39BRbcycGeXQDfx
```

**Note** If you receive an error message "Error getting a backup store" with the description "NoCredentialProviders: no valid providers in chain," prepend the line `[default]` to the beginning of the credentials file. For example:

```
[default]
aws_access_key_id = 0XXN08JCCGV41QZBV0RQ
aws_secret_access_key = c1Z1bf8Ljkvkmg7fHucrKCkxV39BRbcycGeXQDfx
```

- 5 Save the file and verify that the file is in place.

```
ls
```

- 6 Run the following command to install Velero and Restic on the target Kubernetes cluster. Replace both URLs with the URL of your MinIO instance.

```
velero install \
--provider aws \
--plugins velero/velero-plugin-for-aws:v1.0.0 \
--bucket tkgs-velero \
--secret-file ./credentials-minio \
--use-volume-snapshots=false \
--use-restic \
--backup-location-config \
region=minio,s3ForcePathStyle="true",s3Url=http://10.199.17.63:9000,publicUrl=http://
10.199.17.63:9000
```

- 7 Verify the installation of Velero and Restic.

```
kubectl logs deployment/velero -n velero
```

- 8 Verify the `velero` namespace.

```
kubectl get ns
```

- 9 Verify the `velero` and `restic` pods.

```
kubectl get all -n velero
```

## Troubleshoot Restic DaemonSet (If Necessary)

To run the three-pod Restic DaemonSet on a Kubernetes cluster, you may have to update the Restic DaemonSet spec and modify the hostPath. For more information about this issue, see [Restic Integration](#) in the Velero documentation.

- 1 Verify the three-pod Restic DaemonSet.

```
kubectl get pod -n velero
```

If the pods are in a CrashLoopBackOff status, edit them as follows.

- 2 Run the `edit` command.

```
kubectl edit daemonset restic -n velero
```

- 3 Change hostPath from `/var/lib/kubelet/pods` to `/var/vcap/data/kubelet/pods`.

```
- hostPath:
  path: /var/vcap/data/kubelet/pods
```

- 4 Save the file.
- 5 Verify the three-pod Restic DaemonSet.

```
kubectl get pod -n velero
```

NAME	READY	STATUS	RESTARTS	AGE
restic-5jln8	1/1	Running	0	73s
restic-bpvtq	1/1	Running	0	73s
restic-vg8j7	1/1	Running	0	73s
velero-72c84322d9-1e7bd	1/1	Running	0	10m

## Adjust Velero Memory Limits (If Necessary)

If your Velero backup returns `status=InProgress` for many hours, increase the limits and requests memory settings.

- 1 Run the following command.

```
kubectl edit deployment/velero -n velero
```

- 2 Change the limits and request memory settings from the default of 256Mi and 128Mi to 512Mi and 256Mi.

```
ports:
- containerPort: 8085
  name: metrics
  protocol: TCP
```

```
resources:
  limits:
    cpu: "1"
    memory: 512Mi
  requests:
    cpu: 500m
    memory: 256Mi
terminationMessagePath: /dev/termination-log
terminationMessagePolicy: File
```

## Backup and Restore Tanzu Kubernetes Cluster Workloads Using Standalone Velero and Restic

You can backup and restore Tanzu Kubernetes cluster workloads using standalone Velero and Restic. This method is an alternative to using the Velero Plugin for vSphere. The primary reason for using standalone Velero instead of the Velero Plugin for vSphere is if you require portability. Restic is required for stateful workloads.

### Prerequisites

To backup and restore Tanzu Kubernetes clusters workloads using standalone Velero and Restic, you must install the standalone version of Velero and Restic on the target cluster. See [Install and Configure Standalone Velero and Restic on a Tanzu Kubernetes Cluster](#).

---

**Note** Backing up and restoring a Kubernetes cluster using standalone Velero with Restic gives you portability. This means if you want to be able to restore cluster workloads to a Kubernetes cluster not provisioned by Tanzu Kubernetes Grid Service, you need to use standalone Velero.

---

### Backup a Stateless Application Running on a Tanzu Kubernetes Cluster

Backing up a stateless application running on a Tanzu Kubernetes cluster requires the use of Velero.

This example shows how to backup and restore an example stateless application using the `--include namespaces` tag where all application components are in that namespace.

```
velero backup create example-backup --include-namespaces example-backup
```

You should see the following:

```
Backup request "example-backup" submitted successfully.
Run `velero backup describe example-backup` or `velero backup logs example-backup` for more
details.
```

Verify the backup that was created.

```
velero backup get
```

```
velero backup describe example-backup
```

Check the Velero bucket on the S3-compatible object store such as the MinIO server.

Velero writes some metadata in Kubernetes custom resource definitions (CRDs).

```
kubectl get crd
```

The Velero CRDs let you run certain commands, such as the following:

```
kubectl get backups.velero.io -n velero
```

```
kubectl describe backups.velero.io guestbook-backup -n velero
```

## Restore a Stateless Application Running on a Tanzu Kubernetes Cluster

Restoring a stateless application running on a Tanzu Kubernetes cluster requires the use of Velero.

To test the restoration of an example application, delete it.

Delete the namespace:

```
kubectl delete ns guestbook  
namespace "guestbook" deleted
```

Restore the app:

```
velero restore create --from-backup example-backup
```

You should see the following:

```
Restore request "example-backup-20200721145620" submitted successfully.  
Run `velero restore describe example-backup-20200721145620` or `velero restore logs example-  
backup-20200721145620` for more details.
```

Verify that the app is restored:

```
velero restore describe example-backup-20200721145620
```



Run the following commands to verify:

```
velero restore get
```

```
kubectl get ns
```

```
kubectl get pod -n example
```

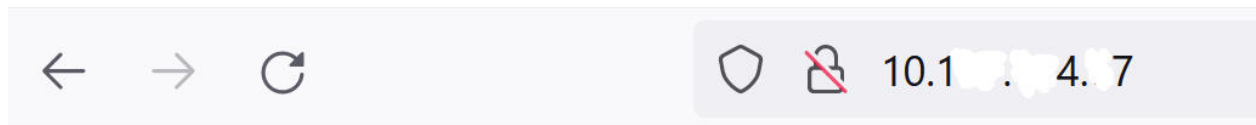
```
kubectl get svc -n example
```

## Backup a Stateful Application Running on a Tanzu Kubernetes Cluster

Backing up a stateful application running on a Tanzu Kubernetes cluster involves backing up both the application metadata and the application data stored on a persistent volume. To do this you need both Velero and Restic.

For this example we are going to use the Guestbook application. It is assumed that you have deployed the Guestbook application to a Tanzu Kubernetes cluster. See [Tanzu Kubernetes Guestbook Tutorial](#) for guidance.

So that we can demonstrate stateful backup and restore, submit some message to the Guestbook application using the frontend web page so that the messages are persisted. For example:



This example shows how to backup and restore the Guestbook app using the `--include namespace` tag as well as pod annotations.

**Note** This example uses annotations. However, annotations are no longer needed for Velero version 1.5 and later. To not use annotations, you can use the `--default-volumes-to-restic` option when creating the backup. This will automatically backup all PVs using Restic. See <https://velero.io/docs/v1.5/restic/> for more information.

To begin the backup procedure, get the names of the pods:

```
kubectl get pod -n guestbook
```

For example:

```
kubectl get pod -n guestbook
```

NAME	READY	STATUS	RESTARTS	AGE
guestbook-frontend-deployment-85595f5bf9-h8cff	1/1	Running	0	55m
guestbook-frontend-deployment-85595f5bf9-lw6tg	1/1	Running	0	55m
guestbook-frontend-deployment-85595f5bf9-wpgc8	1/1	Running	0	55m
redis-leader-deployment-64fb8775bf-kbs6s	1/1	Running	0	55m
redis-follower-deployment-84cd76b975-jrn8v	1/1	Running	0	55m
redis-follower-deployment-69df9b5688-zml4f	1/1	Running	0	55m

The persistent volumes are attached to the Redis pods. Because we are backing up these stateful pods with Restic, we need to add annotations to the stateful pods with the `volumeMount` name.

You need to know the `volumeMount` to annotate the stateful pod. To get the `mountName`, run the following command.

```
kubectl describe pod redis-leader-deployment-64fb8775bf-kbs6s -n guestbook
```

In the results you see `Containers.leader.Mounts: /data from redis-leader-data`. This last token is the `volumeMount` name to use for the leader pod annotation. For the follower it will be `redis-follower-data`. You can also obtain the `volumeMount` name from the source YAML.

Annotate each of the Redis pods, for example:

```
kubectl -n guestbook annotate pod redis-leader-64fb8775bf-kbs6s backup.velero.io/backup-volumes=redis-leader-data
```

You should see the following:

```
pod/redis-leader-64fb8775bf-kbs6s annotated
```

Verify the annotations:

```
kubectl -n guestbook describe pod redis-leader-64fb8775bf-kbs6s | grep Annotations
Annotations:  backup.velero.io/backup-volumes: redis-leader-data
```

```
kubectl -n guestbook describe pod redis-follower-779b6d8f79-5dphr | grep Annotations
Annotations:  backup.velero.io/backup-volumes: redis-follower-data
```

Perform the Velero backup:

```
velero backup create guestbook-backup --include-namespaces guestbook
```

You should see the following:

```
Backup request "guestbook-backup" submitted successfully.
Run `velero backup describe guestbook-pv-backup` or `velero backup logs guestbook-pv-backup`
for more details.
```

Verify the backup that was created.

```
velero backup get
```

NAME	STATUS	ERRORS	WARNINGS	CREATED
EXPIRES	STORAGE LOCATION	SELECTOR		
guestbook-backup	Completed	0	0	2020-07-23 16:13:46 -0700 PDT
29d	default	<none>		

Verify backup details.

```
velero backup describe guestbook-backup --details
```

Note that Velero lets you run other commands, such as:

```
kubectl get backups.velero.io -n velero
```

NAME	AGE
guestbook-backup	4m58s

And:

```
kubectl describe backups.velero.io guestbook-backup -n velero
```

## Restore a Stateful Application Running on a Tanzu Kubernetes Cluster

Restoring a stateful application running on a Tanzu Kubernetes cluster involves restoring both the application metadata and the application data stored to a persistent volume. To do this you need both Velero and Restic.

This example assumes that you backed up the stateful Guestbook application as described in the previous section.

To test the restoration of the stateful application, delete its namespace:

```
kubectl delete ns guestbook
namespace "guestbook" deleted
```

Verify application deletion:

```
kubectl get ns
kubectl get pvc,pv --all-namespaces
```

Restore the application:

```
Restore request "guestbook-backup-20200723161841" submitted successfully.
Run `velero restore describe guestbook-backup-20200723161841` or `velero restore logs
guestbook-backup-20200723161841` for more details.
```

Verify that the stateful Guestbook application is restored:

```
velero restore describe guestbook-backup-20200723161841

Name:          guestbook-backup-20200723161841
Namespace:    velero
Labels:       <none>
Annotations:  <none>

Phase: Completed

Backup: guestbook-backup

Namespaces:
  Included:  all namespaces found in the backup
  Excluded: <none>

Resources:
  Included:  *
  Excluded:  nodes, events, events.events.k8s.io, backups.velero.io,
restores.velero.io, resticrepositories.velero.io
  Cluster-scoped: auto

Namespace mappings: <none>

Label selector: <none>

Restore PVs: auto

Restic Restores (specify --details for more information):
  Completed: 3
```

Run the following additional command to verify restoration:

```
velero restore get
```

NAME	BACKUP	STATUS	ERRORS	WARNINGS
CREATED	SELECTOR			
guestbook-backup-20200723161841	guestbook-backup	Completed	0	0
2021-08-11 16:18:41 -0700 PDT	<none>			

Check that the namespace is restored:

```
kubectl get ns
```

NAME	STATUS	AGE
default	Active	16d
guestbook	Active	76s
...		
velero	Active	2d2h

Check that the application is restored:

```
vkubectl get all -n guestbook
```

NAME	READY	STATUS	RESTARTS	AGE
pod/frontend-6cb7f8bd65-h2pnb	1/1	Running	0	6m27s
pod/frontend-6cb7f8bd65-kwlpr	1/1	Running	0	6m27s
pod/frontend-6cb7f8bd65-snw14	1/1	Running	0	6m27s
pod/redis-leader-64fb8775bf-kbs6s	1/1	Running	0	6m28s
pod/redis-follower-779b6d8f79-5dphr	1/1	Running	0	6m28s
pod/redis-follower-899c7e2z65-8apnk	1/1	Running	0	6m28s

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP
PORT(S) AGE			
service/guestbook-frontend	LoadBalancer	10.10.89.59	10.19.15.99
80:31513/TCP 65s			
service/redis-follower	ClusterIP	10.111.163.189	<none>
6379/TCP 65s			
service/redis-leader	ClusterIP	10.111.70.189	<none>
6379/TCP 65s			

NAME	READY	UP-TO-DATE	AVAILABLE	AGE
deployment.apps/guestbook-frontend-deployment	3/3	3	3	65s
deployment.apps/redis-follower-deployment	1/2	2	1	65s
deployment.apps/redis-leader-deployment	1/1	1	1	65s

NAME	DESIRED	CURRENT	READY	AGE
replicaset.apps/guestbook-frontend-deployment-56fc5b6b47	3	3	3	65s
replicaset.apps/redis-follower-deployment-6fc9cf5759	2	2	1	65s
replicaset.apps/redis-leader-deployment-7d89bbdbcf	1	1	1	65s

Check that the persistent volumes are restored:

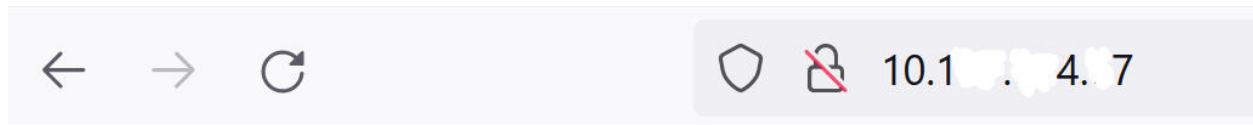
```
kubectl get pvc,pv -n guestbook
```

NAME	STATUS		CAPACITY	ACCESS MODES	STORAGECLASS	AGE	
persistentvolumeclaim/redis-leader-claim	Bound		pvc-a2f6e6d4-42db-4fb8-a198-5379a2552509	2Gi	RWO	thin-disk	2m40s
persistentvolumeclaim/redis-follower-claim	Bound		pvc-55591938-921f-452a-b418-2cc680c0560b	2Gi	RWO	thin-disk	2m40s

NAME	POLICY	STATUS	CLAIM	CAPACITY	ACCESS MODES	RECLAIM	AGE
persistentvolume/pvc-55591938-921f-452a-b418-2cc680c0560b	Delete	Bound	guestbook/redis-follower-claim	2Gi	RWO	thin-disk	2m40s
persistentvolume/pvc-a2f6e6d4-42db-4fb8-a198-5379a2552509	Delete	Bound	guestbook/redis-leader-claim	2Gi	RWO	thin-disk	2m40s

Lastly, access the Guestbook frontend using the external IP of the guestbook-frontend service and verify that the messages you submitted at the beginning of the tutorial are restored. For example:



# Guestbook

Messages

Submit

message 1  
message 2  
message 3

## Backup and Restore vCenter Server

This topic describes how to back up and restore the vCenter Server in context of a vSphere with Tanzu deployment.

### vCenter Cluster HA

To support a highly available Supervisor Cluster, vSphere with Tanzu requires that the vCenter cluster where the vSphere with Tanzu is enabled be configured with high-availability. For more information, see [vSphere Availability](#) in the VMware vSphere documentation.

### vCenter Server Backup and Recover

vCenter Server supports file backup to network attached storage. To backup and restore the vCenter Server, create a backup of the primary vCenter Server. For more information, see [File-Based Backup and Restore of vCenter Server](#) in the vCenter documentation.

## Backup and Restore NSX-T Data Center

To support network functionality in the case of a vSphere with Tanzu workload outage, back up and restore NSX-T Data Center.

### Requirements

To backup and restore NSX-T Data Center, it is assumed that 3 NSX Manager Nodes are deployed, and there is an HA VIP configured for access to the NSX Management Plane. In addition, there are at least 2 Edge Nodes deployed with an HA VIP for the Edge Nodes. For more information, see [Configuring NSX-T Data Center for vSphere with Tanzu](#).

### NSX-T Backup and Restore

NSX-T Data Center provides in-product backup and recovery that supports backup and restore of the NSX Manager Nodes and objects. For more information, see [Backing Up and Restoring NSX Manager](#) in the NSX-T documentation.

# Troubleshooting vSphere with Tanzu

# 19

Use the following troubleshooting techniques and best practices for your infrastructure in vSphere with Tanzu.

This chapter includes the following topics:

- [Storage Best Practices and Troubleshooting](#)
- [Troubleshooting Networking](#)
- [Troubleshooting the NSX Advanced Load Balancer](#)
- [Troubleshooting Network Topology Upgrade](#)
- [Troubleshooting Tanzu Kubernetes Clusters](#)
- [Troubleshooting Workload Management](#)

## Storage Best Practices and Troubleshooting

You can use best practices and troubleshooting techniques for your storage environment in vSphere with Tanzu.

### Use Anti-Affinity Rules for Control Plane VMs on Non-vSAN Datastores

When you use datastores other than vSAN in your cluster with vSphere with Tanzu, place the three control plane VMs on different datastores for availability reasons.

Because the control plane VMs are system managed, you cannot manually migrate them. Use a combination of a Datastore Cluster and Storage DRS to rebalance the control plane VMs and place them on separate datastores.

#### Procedure

- 1 In the vSphere Client, create a datastore cluster.
  - a Navigate to data centers.
  - b Right-click the data center object and select **New Datastore Cluster**.
  - c Name your datastore cluster and make sure **Turn ON Storage DRS** is enabled.
  - d Set the cluster automation level to **No Automation (Manual Mode)**.



- e Leave the Storage DRS runtime settings as default.
  - f Select the ESXi cluster enabled with vSphere with Tanzu.
  - g Select all shared datastores to add to the datastore cluster.
  - h Click **Finish**.
- 2** Define Storage DRS rules for control Plane VMs.
- a Navigate to the datastore cluster.
  - b Click the **Configure** tab and click **Rules** under **Configuration**.
  - c Click the **Add** icon and enter a name for the rule.
  - d Make sure **Enable rule** is enabled.
  - e Set **Rule type** to **VM anti-affinity**.
  - f Click the **Add** icon and select the three supervisor control plane VMs.
  - g Click **OK** to finish your configuration.
- 3** Create VM overrides.
- a Navigate to the datastore cluster.
  - b Click the **Configure** tab and click **VM Overrides** under **Configuration**.
  - c Click the **Add** icon and select the three control plane VMs.
  - d To enable the Storage DRS automation level, select the **Override** check box and set the value to **Fully Automated**.
  - e Click **Finish**.

### Results

This task enables Storage DRS for the control plane VMs only and rebalances the VMs to be on different datastores.

Once the Storage vMotion takes place, you can remove the SDRS rules and overrides, disable Storage DRS, and remove the datastore cluster.

## Storage Policy Removed from vSphere Continues to Appear as Kubernetes Storage Class

When you use the vSphere Client to remove the storage policy from vCenter Server or a namespace in the Supervisor Cluster, its matching storage class remains in the Kubernetes environment, but cannot be used.

### Problem

If you run the `kubectl get sc` command, the output continues to list the storage class as available in the namespace. However, the storage class cannot be used. For example, your attempts to use the storage class for a new persistent volume claim fail.

If the storage class is already used by a Kubernetes deployment, the deployment might behave unpredictably.

### Solution

- 1 To verify which storage classes exist in the namespace, run the `kubectl describe namespace namespace_name` command.

The output for this command does not list the storage class if its matching storage policy is removed.

- 2 If the storage class is already used by a deployment, restore the storage class.
  - a Use the vSphere Client to create a new storage policy with the same name as the policy you removed.
 

For example, if you deleted the *Gold* policy, name the new policy *Gold*. See [Create Storage Policies for vSphere with Tanzu](#).
  - b Assign the policy to the namespace.

See [Change Storage Settings on a Namespace](#).

After you assign the policy to the namespace, vSphere with Tanzu deletes the old storage class and creates a matching storage class with the same name.

## Use External Storage with vSAN Direct

When you use vSAN Direct in the vSphere with Tanzu environment, you can use external shared storage to store management internal VMs and other metadata.

### Problem

When you deploy a homogeneous vSAN Direct cluster, you must create a replicated vSAN datastore on each ESXi host in the cluster to store vSphere with Tanzu management VMs and other metadata. The vSAN datastore consumes space, requires an additional I/O controller on each host, and limits hardware configuration on which vSAN Direct can be supported.

Instead of configuring the vSAN datastore, you can use external shared storage for storing management internal VMs and other metadata.

### Solution

- 1 If vSAN or vSAN Direct was deployed on the ESXi hosts in the cluster, clear the hosts from any configuration.
  - a Remove any disks assigned to vSAN or vSAN Direct. See [Remove Disk Groups or Devices from vSAN](#).
  - b (Optional) Use the script to tag disks on the hosts for vSAN Direct. See [Using Script to Tag Storage Devices for vSAN Direct](#).

## 2 Use VMware Cloud Foundation to create a workload domain with external storage.

Make sure to select one of the storage options, such as NFS, vVols, or FC. Only one of these options can be selected.

For more information, see *Working with Workload Domains* in the [VMware Cloud Foundation Operations and Administration Guide](#).

This step deploys a workload domain with vCenter Server and specified ESXi hosts. The external storage is mounted on all hosts and added to the default cluster.

## 3 Enable vSAN.

Make sure that no disks are claimed for vSAN.

For more information, see [Enable vSAN on an Existing Cluster](#).

This step creates a zero byte vSAN datastore with vSAN network. No local disks are used for vSAN.

## 4 Claim local disks on the hosts for vSAN Direct.

For information, see [Set Up vSAN Direct for vSphere with Tanzu](#).

For each device you claim, vSAN Direct creates a separate datastore.

## 5 Create storage policies for vSAN Direct.

For information, see [Create vSAN Direct Storage Policy](#).

## 6 Configure and enable Workload Management.

For information, see [Chapter 5 Configuring and Managing a Supervisor Cluster](#).

### Example

In this example, a setup includes external NFS storage and a vSAN Direct datastore. Control plane VMs and vSphere Pods are running on external NFS storage. Persistent volume claims run on vSAN Direct.

The screenshot shows the vSphere Client interface for a workload domain named 'sample-1-0'. The 'Datastores' tab is selected, displaying a table of datastores:

Name	Status	Type	Datastore Cl...	Capacity	Free
nfs0-1	✓ Normal	NFS 3		295.17 GB	263.03 GB
vSANDirect	✓ Normal	vSAN Direct		199.75 GB	197.34 GB

The left sidebar shows a tree view of the environment, including namespaces and workload domains. The 'sample-1-0' workload domain is selected, showing its components: fio-0, fio-1, fio-2, sample-1-0, sample-1-1, sample-1-2, test-ext-ns, and SupervisorControlPlaneVM (1), (2), and (3).

## Troubleshooting Networking

You can troubleshoot networking problems that you might encounter when you configure vSphere with Tanzu with NSX.

### Register vCenter Server with NSX Manager

You might need to re-register vCenter Server OIDC with NSX Manager in certain situations, for example when the FQDN/PNID of vCenter Server changes.

#### Procedure

- 1 Connect to the vCenter Server Appliance through SSH.
- 2 Run the command `shell`.
- 3 To get the vCenter Server thumbprint, run the command – `openssl s_client -connect <vcenterserver-FQDN:443 </dev/null 2>/dev/null | openssl x509 -fingerprint -sha256 -noout -in /dev/stdin`.

The thumbprint is displayed. For example,

```
08:77:43:29:E4:D1:6F:29:96:78:5F:BF:D6:45:21:F4:0E:3B:2A:68:05:99:C3:A4:89:8F:F2:0B
:EA:3A:BE:9D
```

- 4 Copy the SHA256 thumbprint and remove colons.

```
08774329E4D16F2996785FBFD64521F40E3B2A680599C3A4898FF20BEA3ABE9D
```

- 5 To update the OIDC of vCenter Server, run the following command:

```
curl --location --request POST 'https://<NSX-T_ADDRESS>/api/v1/trust-management/oidc-uris' \
  --header 'Content-Type: application/json' \
  --header 'Authorization: Basic <AUTH_CODE>' \
  --data-raw '{
  "oidc_type": "vcenter",
  "oidc_uri": "https://<VC_ADDRESS>/openidconnect/vsphere.local/.well-known/openid-
configuration",
  "thumbprint": "<VC_THUMBPRINT>"
}'
```

### Unable to Change NSX Appliance Password

You might be unable to change the NSX appliance password for the `root`, `admin`, or `audit` users.

#### Problem

Attempts to change the NSX appliance password for the `root`, `admin`, or `audit` users. through the vSphere Client may fail.

### Cause

During the installation of the NSX Manager, the procedure only accepts one password for all three roles. Attempts to change this password later may fail.

### Solution

- ◆ Use the NSX APIs to change the passwords.

For more information, see <https://kb.vmware.com/s/article/70691> and the *NSX-T Data Center Administration Guide*.

## Troubleshooting Failed Workflows and Unstable NSX Edges

If your workflows fail or the NSX Edges are unstable, you can perform troubleshooting steps.

### Problem

When you change the distributed port group configuration on the vSphere Client, workflows might fail and the NSX Edges might become unstable.

### Cause

Removal or modification of the distributed port groups for overlay and uplink that were created during the NSX Edge cluster setup of cluster configuration, is not allowed by design.

### Solution

If you require to change the VLAN or IP Pool configuration of NSX Edges, you must first remove elements of NSX-T Data Center and the vSphere with Tanzu configuration from the cluster.

For information about removing elements of NSX-T Data Center, see the *NSX-T Data Center Installation Guide*.

## Collect Support Bundles for Troubleshooting NSX-T

You can collect support bundles on registered cluster and fabric nodes for troubleshooting and download the bundles to your machine or upload them to a file server.

If you choose to download the bundles to your machine, you get a single archive file consisting of a manifest file and support bundles for each node. If you choose to upload the bundles to a file server, the manifest file and the individual bundles are uploaded to the file server separately.

### Procedure

- 1 From your browser, log in with admin privileges to an NSX Manager.
- 2 Select **System > Support Bundle**.
- 3 Select the target nodes.

The available types of nodes are **Management Nodes**, **Edges**, **Hosts**, and **Public Cloud Gateways**.

- 4 (Optional) Specify log age in days to exclude logs that are older than the specified number of days.
- 5 (Optional) Toggle the switch that indicates whether to include or exclude core files and audit logs.

---

**Note** Core files and audit logs might contain sensitive information such as passwords or encryption keys.

---

- 6 (Optional) Select the check box to upload the bundles to a file server.
- 7 Click **Start Bundle Collection** to start collecting support bundles.  
The number of log files for each node determines the time taken for collecting support bundles.
- 8 Monitor the status of the collection process.  
The **Status** tab shows the progress of collecting support bundles.
- 9 Click **Download** to download the bundle if the option to send the bundle to a file server was not set.

## Collect Log Files for NSX-T

You can collect logs that are in the vSphere with Tanzu and NSX-T Data Center components to detect and troubleshoot errors. The log files might be requested by VMware Support.

### Procedure

- 1 Log in to the vCenter Server using the vSphere Client .
- 2 Collect the following log files.

Log File	Description
<code>/var/log/vmware/wcp/wcpsvc.log</code>	Contains information related to vSphere with Tanzu enablement.
<code>/var/log/vmware/wcp/nsxd.log</code>	Contains information related to the NSX-T Data Center components configuration.

- 3 Log in to NSX Manager.
- 4 Collect the `/var/log/proton/nsxapi.log` for information on the error that the NSX Manager returns when a specific vSphere with Tanzu operation has failed.

## Restart the WCP Service If the NSX-T Management Certificate, Thumbprint, or IP Address Changes

If the NSX-T Management certificate, thumbprint or IP address changes after you have installed vSphere with Tanzu, you must restart the `WCP` service.

## Restart the vSphere with Tanzu Service If the NSX-T Certificate Changes

Currently, vSphere with Tanzu requires that if the NSX-T certificate or thumbprint, or if the NSX-T IP address changes, you must restart the `wcp` service for the change to take effect. If either change occurs without a restart of the service, communication between vSphere with Tanzu and NSX-T fails and certain symptoms can arise, such as NCP entering into CrashLoopBackoff stage or Supervisor Cluster resources becoming undeployable.

To restart the `wcp` service, use the `vmon-cli`.

- 1 SSH to the vCenter Server and log in as the root user.
- 2 Run the command `shell`.
- 3 Run the command `vmon-cli -h` to view usage syntax and options.
- 4 Run the command `vmon-cli -l` to view the `wcp` process.  
You see the `wcp` service at the bottom of the list.
- 5 Run the command `vmon-cli --restart wcp` to restart the `wcp` service.  
You see the message `Completed Restart service request`.
- 6 Run the command `vmon-cli -s wcp` and verify that the `wcp` service is started.

For example:

```
root@localhost [ ~ ]# vmon-cli -s wcp
Name: wcp
Starttype: AUTOMATIC
RunState: STARTED
RunAsUser: root
CurrentRunStateDuration(ms): 22158
HealthState: HEALTHY
FailStop: N/A
MainProcessId: 34372
```

## VDS Required for Host Transport Node Traffic

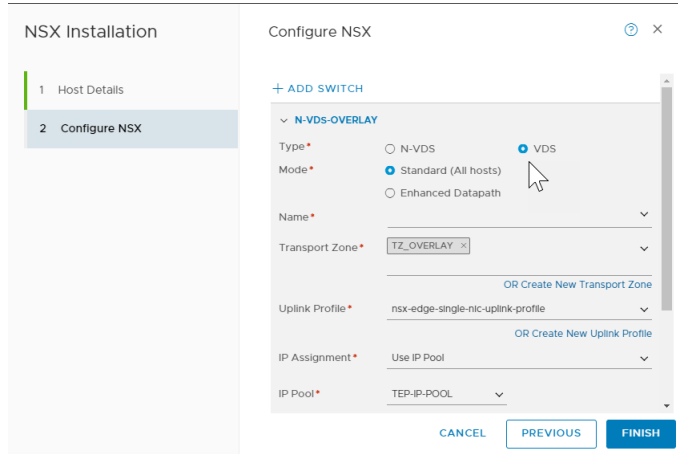
vSphere with Tanzu requires the use of a vSphere 7 Virtual Distributed Switch (VDS) for host transport node traffic. You cannot use the NSX-T VDS (N-VDS) for host transport node traffic with vSphere with Tanzu.

### VDS Is Required

vSphere with Tanzu requires a converged VDS that supports both vSphere 7 traffic and NSX-T 3 traffic on the same VDS. With previous releases of vSphere and NSX-T, you have one VDS (or VSS) for vSphere traffic and one N-VDS for NSX-T traffic. This configuration is not supported by vSphere with Tanzu. If you attempt to enable Workload Management using an N-VDS, the system reports that the vCenter cluster is not compatible. For more information, see [Troubleshoot Workload Management Enablement Cluster Compatibility Errors](#).

To use a converged VDS, create a vSphere 7 VDS using vCenter and in NSX-T specify this VDS when preparing the ESXi hosts as transport nodes. Just having VDS-DSwitch on the vCenter side is not sufficient. The VDS-DSwitch 7.0 has to be configured with NSX-T transport node profile as documented in the topic [Create a Transport Node Profile](#) and shown below.

**Figure 19-1. VDS Configuration in NSX-T**



If you have upgraded to vSphere 7 and NSX-T 3 from previous versions, you must uninstall the N-VDS from each ESXi transport node and reconfigure each host with a VDS. Contact VMware Global Support Service for guidance.

## Troubleshooting the NSX Advanced Load Balancer

You can troubleshoot NSX Advanced Load Balancer problems that you might encounter by collecting support bundles.

### Collect Support Bundles for Troubleshooting

To troubleshoot NSX Advanced Load Balancer problems, you can collect support bundles. The support bundles might be requested by VMware Support.

When you generate the support bundle, you get a single file for the debug logs that you can download.

#### Procedure

- 1 In the Avi Controller dashboard, click the menu in the upper-left hand corner and select **Administration**.
- 2 In the **Administration** section, select **System**.
- 3 In the **System** screen, select **Tech Support**.
- 4 To generate a diagnostics bundle, click **Generate Tech Support**.
- 5 In the **Generate Tech Support** window, select **Debug Logs** type and click **Generate**.



- 6 Once the bundle is generated, click the download icon to download it to your machine.

## Troubleshooting Network Topology Upgrade

When you install vSphere with Tanzu version 7.0 Update 1c or upgrade the Supervisor Cluster from version 7.0 Update 1 to version 7.0 Update 1c, the networking topology is upgraded from a single tier-1 gateway topology to a topology that has a tier-1 gateway for each namespace within the Supervisor Cluster.

You can troubleshoot problems that you might encounter during the upgrade.

### Upgrade Precheck Fails Due to Insufficient Edge Load Balancer Capacity

The upgrade precheck fails and the error message indicates insufficient load balancer capacity.

#### Problem

The upgrade precheck process fails with an error message that indicates that the load balancer capacity is less than the capacity required by the Supervisor Cluster.

#### Solution

Perform one of the following steps to resolve the problem:

- Force the upgrade by clicking on the **Force Upgrade** button in the error message or use the vCenter Server command line with the `--ignore-precheck-warnings true` flag.

---

**Note** This solution is recommended only if the Edge cluster can support the existing namespace workloads. Otherwise, these workloads might be skipped during upgrade.

---

- Delete unused workloads.
- Add additional Edge nodes to the cluster.

### Supervisor Cluster Workload Namespaces Skipped During Upgrade

During the Supervisor Cluster upgrade some namespace workloads are not upgraded.

#### Problem

The Supervisor Cluster upgrade succeeds but some namespace workloads are skipped during the upgrade. The Kubernetes resources indicate insufficient resources and the newly created tier-1 gateway is in `ERROR` state.

#### Cause

The load balancer capacity is insufficient to support the workloads.

## Solution

Perform one of the following steps to resolve the problem:

- Delete unused workloads, restart NCP, and run the upgrade again.
- Add additional Edge nodes to the cluster and trigger a re-allocation to the tier-1 gateway. Restart NCP and run the upgrade again.

## Load Balancer Service Skipped During Upgrade

During the Supervisor Cluster upgrade some load balancer services are not upgraded.

### Problem

The Supervisor Cluster upgrade succeeds but some Kubernetes load balancer services are skipped during the upgrade.

### Cause

The number of Kubernetes load balancer type services in the Supervisor Cluster workloads and associated Tanzu Kubernetes cluster exceed the NSX Edge virtual server limit.

### Solution

Delete unused workloads, restart NCP, and run the upgrade again.

## Troubleshooting Tanzu Kubernetes Clusters

You can troubleshoot Tanzu Kubernetes clusters by connecting to any cluster node, viewing the cluster resource hierarchy, and collecting log files.

### Collect a Support Bundle for Tanzu Kubernetes Clusters

To troubleshoot Tanzu Kubernetes cluster errors, you can run a utility to collect a diagnostic log bundle.

VMware provides the TKC Support Bundler utility that you can use to collect Tanzu Kubernetes cluster log files and troubleshoot problems.

To obtain and use the utility, refer to the article [How to collect a diagnostic log bundle from a Tanzu Kubernetes cluster \(80949\)](#) at the VMware Support Knowledge Base.

### Troubleshoot vCenter Single Sign-On Connection Errors

If you do not have sufficient permissions on the vSphere Namespace, you cannot connect to the Supervisor Cluster or to a Tanzu Kubernetes cluster as a vCenter Single Sign-On user.

### Problem

The vSphere Plugin for kubectl returns the error message `Error from server (Forbidden)` when you attempt to connect to a Supervisor Cluster or a Tanzu Kubernetes cluster as a vCenter Single Sign-On user.

### Cause

You do not have sufficient permissions on the vSphere Namespace, or do not have cluster access.

### Solution

If you are a DevOps engineer who operates the cluster, verify with your vSphere administrator that you have been granted **Edit** permissions for the vSphere Namespace. See [Create and Configure a vSphere Namespace](#).

If you are a developer who is using the cluster to deploy workloads, verify with your cluster administrator that you have been granted cluster access. See [Grant Developer Access to Tanzu Kubernetes Clusters](#).

## Troubleshoot Subscribed Content Library Errors

If the Subscribed Content Library reaches storage capacity limits, you cannot provision Tanzu Kubernetes clusters.

### Problem

When attempting to provision a Tanzu Kubernetes cluster, you are unable to pull items from the Subscribed Content Library, and the following error appears:

```
Internal error occurred: get library items failed for.
```

### Cause

The Subscribed Content Library has reached capacity. The Content Library is backed by attached storage. Over time, as more Kubernetes versions are released and OVA files are pulled into the library, the storage might fill to capacity.

### Solution

Migrate to a new Content Library. See [Migrate Tanzu Kubernetes Clusters to a New Content Library](#).

## Troubleshoot Cluster Provisioning Errors

If you have provisioned a Tanzu Kubernetes cluster, but the control plane virtual machines do not start, you might need to change the virtual machine size or class.

**Problem**

You have provisioned a Tanzu Kubernetes cluster. The system is attempting to power on the control plane virtual machine(s), but it errors out with the following message:

```
The host does not have sufficient CPU resources to satisfy the reservation.
```

**Cause**

The virtual machine size or class is not sufficient for the cluster deployment.

**Solution**

Change the virtual machine type or class. See [Virtual Machine Classes for Tanzu Kubernetes Clusters](#).

## Troubleshoot Workload Deployment Errors

Workload deployment errors might occur if PodSecurityPolicy and bindings are not configured for authenticated users.

**Problem**

You deploy a container workload to a Tanzu Kubernetes cluster but the workload does not start. You see an error similar to the following:

```
Error: container has runAsNonRoot and image will run as root.
```

**Cause**

Tanzu Kubernetes clusters are provisioned with the PodSecurityPolicy Admission Controller enabled. No authenticated users can create privileged or unprivileged pods until the cluster administrator binds PodSecurityPolicy to the authenticated users.

**Solution**

Create an appropriate binding to default PodSecurityPolicy, or define custom PodSecurityPolicy. See [Using Pod Security Policies with Tanzu Kubernetes Clusters](#) and [Tanzu Kubernetes Guestbook Tutorial](#).

## Troubleshoot Virtual Machine Class Errors

Virtual machine classes must be bound to the vSphere Namespace for Tanzu Kubernetes clusters and VM classes.

## Virtual Machine Class Binding Error

Virtual machine classes must be bound to the vSphere Namespace. See [Associate a VM Class with a Namespace in vSphere with Tanzu](#). If you do not associate the VM class with the namespace, you receive the error `VirtualMachineClassBindingNotFound` similar to the following:

```
conditions:
  - lastTransitionTime: "2021-04-25T02:50:58Z"
    message: 1 of 2 completed
    reason: VirtualMachineClassBindingNotFound @ Machine/test-cluster
    severity: Error
    status: "False"
    type: ControlPlaneReady
  - lastTransitionTime: "2021-04-25T02:49:21Z"
    message: 0/1 Control Plane Node(s) healthy. 0/2 Worker Node(s) healthy
    reason: WaitingForNodesHealthy
    severity: Info
    status: "False"
    type: NodesHealthy
```

## Restart a Failed Tanzu Kubernetes Cluster Update Job

If the update of a Tanzu Kubernetes cluster fails, you can restart the update job and try the update again.

### Problem

The update of a Tanzu Kubernetes cluster fails and results in cluster status of `upgradefailed`.

### Cause

There can be a number of reasons for a failed cluster update, such as insufficient storage. To restart a failed update job and try the cluster update again, complete the following procedure.

### Solution

- 1 Log in to the Supervisor Cluster as an administrator. See [Connect to the Supervisor Cluster as a vCenter Single Sign-On User](#).
- 2 Look up the `update_job_name`.

```
kubectl get jobs -n vmware-system-tkg -l "run.tanzu.vmware.com/cluster-namespace=${cluster_namespace},cluster.x-k8s.io/cluster-name=${cluster_name}"
```

- 3 Run `kubectl proxy` so that `curl` can be used to issue requests.

```
kubectl proxy &
```

You should see `Starting to serve on 127.0.0.1:8001`.

---

**Note** You cannot use `kubectl` to patch or update the `.status` of a resource.

---

- Using `curl` issue the following patch command to raise the `.spec.backoffLimit`.

```
curl -H "Accept: application/json" -H "Content-Type: application/json-patch+json"
--request PATCH --data '[{"op": "replace", "path": "/spec/backoffLimit", "value": 8}]'
http://127.0.0.1:8001/apis/batch/v1/namespaces/vmware-system-tkg/jobs/${update_job_name}
```

- Using `curl` issue the following patch command to clear the `.status.conditions` so that the Job controller will create new pods.

```
$ curl -H "Accept: application/json" -H "Content-Type: application/json-patch+json"
--request PATCH --data '[{"op": "remove", "path": "/status/conditions"}]'
http://127.0.0.1:8001/apis/batch/v1/namespaces/vmware-system-tkg/jobs/${update_job_name}/
status
```

## Troubleshooting Workload Management

Refer to this section for troubleshooting Workload Management or if you need to collect a support bundle for the .

### Collect the Support Bundle for Workload Management

Follow this procedure to collect the support bundle for Workload Management.

#### Procedure

- Log in to your vSphere with Tanzu environment using the vSphere Client.
- Select **Menu > Workload Management**.
- Select the **Clusters** tab.
- Select the target Supervisor Cluster
- Select **Export Logs**.

### Tail the Workload Management Log File

Tailing the Workload Management log file can help troubleshoot enablement problems and Supervisor Cluster deployment errors.

#### Solution

- Establish an SSH connection to the vCenter Server Appliance.
- Log in as the `root` user.
- Run the command `shell`.

You see the following:

```
Shell access is granted to root
root@localhost [ ~ ]#
```

- 4 Run the following command to tail the log.

```
tail -f /var/log/vmware/wcp/wcpsvc.log
```

## Troubleshoot Workload Management Enablement Cluster Compatibility Errors

Follow these troubleshooting tips if the system indicates that your vSphere cluster is incompatible for enabling Workload Management.

### Problem

The **Workload Management** page indicates that your vCenter cluster is incompatible when you try to enable Workload Management.

### Cause

There can be multiple reasons for this. First, make sure that your environment meets the minimum requirements for enabling Workload Management:

- Valid license: VMware vSphere 7 Enterprise Plus with Add-on for Kubernetes
- At least two ESXi hosts
- Fully automated DRS
- vSphere HA
- vSphere Distributed Switch 7.0
- Sufficient storage capacity

If your environment meets these prerequisites, but the target vCenter cluster is not compatible, use the VMware Datacenter CLI (DCLI) to help identify the problems.

### Solution

- 1 SSH to vCenter Server.
- 2 Log in as the root user.
- 3 Run the command `dcli` to list the VMware Datacenter CLI help.
- 4 List the available vCenter clusters by running the following DCLI command.

```
dcli com vmware vcenter cluster list
```

For example:

```
dcli +username VI-ADMIN-USER-NAME +password VI-ADMIN-PASSWORD com vmware vcenter cluster list
```

Example result:

```
|-----|-----|-----|-----|
|drs_enabled|cluster  |name      |ha_enabled|
|-----|-----|-----|-----|
|True       |domain-d7|vSAN Cluster|True      |
|-----|-----|-----|-----|
```

- 5 Verify vCenter cluster compatibility by running the following DCLI command.

```
dcli com vmware vcenter namespacemanagement clustercompatibility list
```

For example:

```
dcli +username VI-ADMIN-USER-NAME +password VI-ADMIN-PASSWORD com vmware vcenter
namespacemanagement clustercompatibility list
```

The following example result indicates that the environment is missing a compatible NSX-T VDS switch.

```
|-----|-----|-----|-----|
|-----|
|cluster  |compatible|
incompatibility_reasons |
|-----|-----|-----|-----|
|-----|
|domain-d7|False      |Failed to list all distributed switches in vCenter 2b1c1fa5-
e9d4-45d7-824c-fa4176da96b8.|
|         |          |Cluster domain-d7 is missing compatible NSX-T
VDS.
|-----|-----|-----|-----|
|-----|
```

- 6 Run additional DCLI commands as necessary to determine additional compatibility issues. In addition to NSX-T errors, other common reasons for incompatibility are DNS and NTP connectivity problems.
- 7 To troubleshoot further, complete the following steps.
  - a Tail the `wcpsvc.log` file. See [Tail the Workload Management Log File](#).
  - b Navigate to the **Workload Management** page and click **Enable**.

## Shut Down and Start Up the vSphere with Tanzu Workload Domain

To avoid data loss and maintain the components and workloads of your vSphere with Tanzu environment operational, you must follow the specified order when shutting down or starting up the components.



Typically, you perform the shutdown and startup operations after you apply a patch, upgrade, or restore your vSphere with Tanzu environment. For more information, see the [VMware Validated Design Shutdown and Startup](#) documentation that provides step-by-step instructions for these operations.