Cisco and Hitachi Adaptive Solutions with Kubernetes and Hitachi Virtual Storage Platform

Reference Architecture Guide

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Feedback

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Revision history

Changes	Date
Initial release.	December 12, 2022

Reference Architecture Guide

As Hitachi Vantara customers move to deliver new revenue-generating services to their end customers, IT development teams are moving aggressively to cloud-native techniques, including containers as the form factor to provide these application services. These containerized application services are hosted on Kubernetes clusters that run across private, hybrid, and service provider clouds.

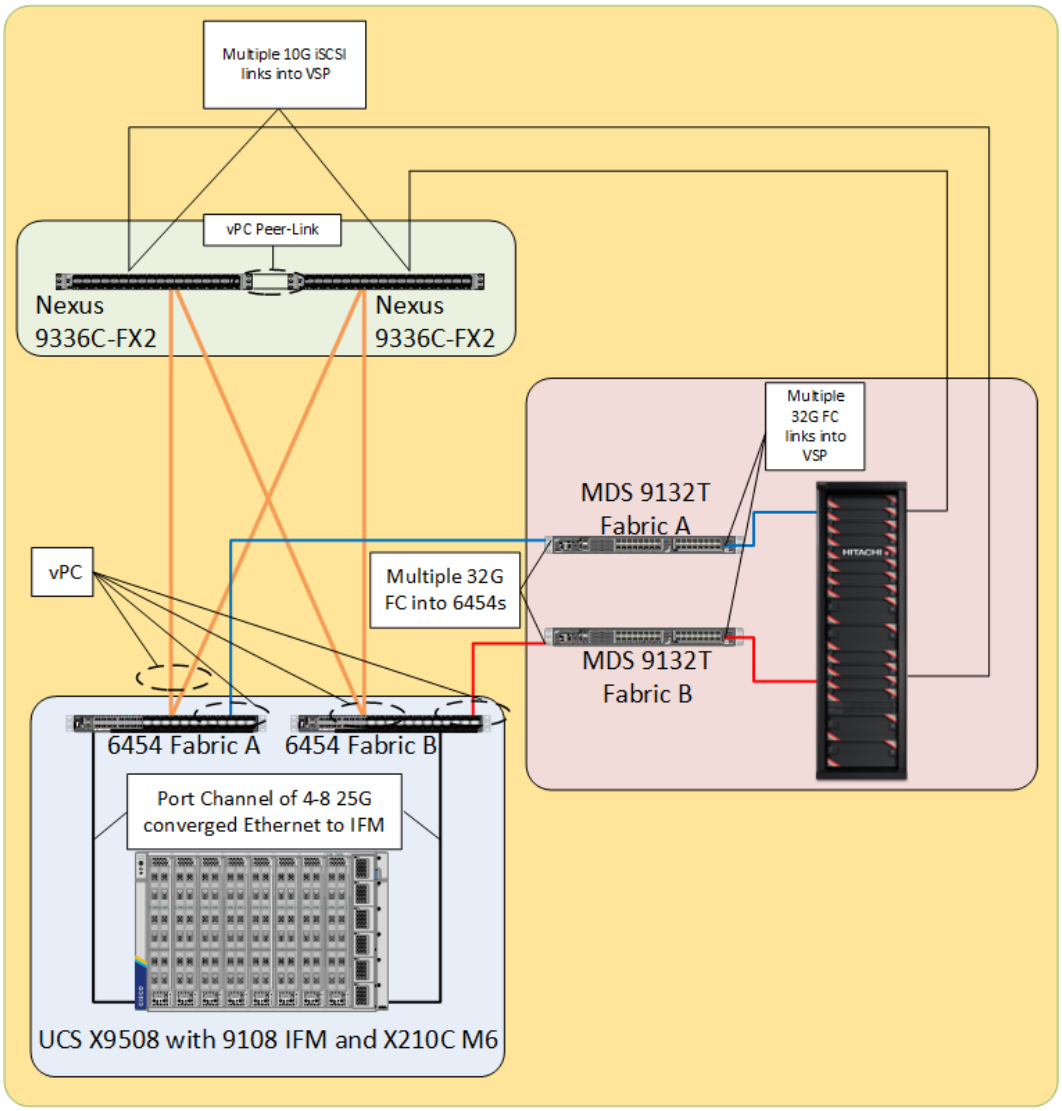
As with any application service, data eventually needs to be persisted and stored reliably. This data could be a grocery order placed from a mobile app or a data stream from a drone service for analysis by artificial intelligence (AI) and machine language (ML) models. The data location could be a SQL/NoSQL database, temporary file system using volumes from internal storage on a server, or a reliable storage system such as Hitachi Virtual Storage Platform (VSP). As adoption grows for containers and the supporting ecosystem, including software to manage Kubernetes clusters and a range of data storage options, Cisco Systems and Hitachi Vantara have collaborated to provide additional solutions.

Hitachi offers a solution with two flexible options that can be used concurrently to meet the majority of deployment configurations that require persistent storage services for applications running in Kubernetes clusters backed by Cisco Unified Computing Systems (UCS). UCS unifies computing, networking, and management resources into an integrated system for UCS servers.

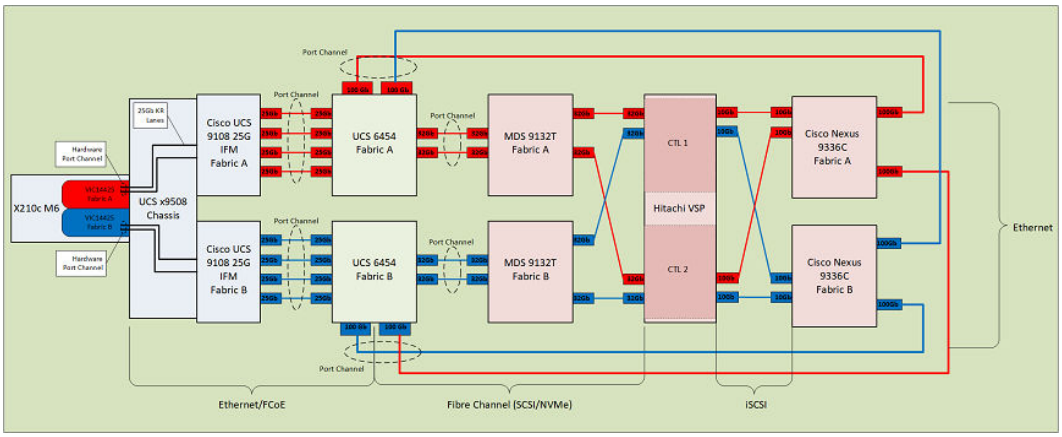
This solution integrates Hitachi Storage Plug-in for Containers and VMware Container Storage Interface (CSI) with Cloud Native Storage (CNS) using Hitachi Storage Provider for VMware vCenter (VASA) software. This document covers Hitachi storage integration with Cisco UCS X-Series servers in conjunction with Kubernetes platforms such as Red Hat OpenShift, VMware Tanzu, or any other generic Kubernetes platform.

Cisco and Hitachi Adaptive Solutions for Virtual System Infrastructure

The following figure shows the architecture of the Cisco and Hitachi Adaptive Solutions for Virtual System Infrastructure (VSI) with Cisco UCS X-series and Hitachi Virtual Storage Platform. The components are configured to implement a powerful and scalable infrastructure for VSI to support fully virtualized VMware environments for various Kubernetes container platforms. This design is presented as a validated reference architecture that covers the specifications of products used within the Hitachi lab. Equivalent supported products can also be replaced which are listed in the compatibility matrixes published by Cisco and Hitachi. See https://www.cisco.com/c/en/us/td/docs/unified_computing/ucs/UCS_CVDs/cisco_hitachi_adaptivesolutions_ci.html for more information on this pre-validated architecture.



The Hitachi Virtual Storage Platform provides Fibre Channel support in the form of SCSI and NVMe along with iSCSI connectivity for supporting various persistent volume deployments across multiple container management platforms. With this architecture, Fibre Channel links from the VSP provides data paths to the Cisco MDS while iSCSI links from the VSP provide data paths to Cisco Nexus switches. Respectively from both Nexus and MDS switches, connections are port channeled into the 6454 Fabric Interconnect which provides Fibre Channel over Ethernet (FCoE) connectivity to the Cisco x9508 chassis via the Intelligent Fabric Module (IFM) from which data flows to the Virtual Interface Card (VIC) in the respective nodes. The following figure represents the data path from the VSP to Cisco VIC 14425 switches.



Cisco UCS X-Series system with Hitachi Virtual Storage Platform

The Cisco UCS X-Series system is the latest converged infrastructure offering from Cisco which is managed exclusively by the Cisco Intersight cloud management tool. It is designed to meet the requirements of modern applications and improve operational efficiency, agility, and scale via its new modular architecture. With this modular architecture, customers are provided the capabilities of both blade and rack servers by offering a combination of compute density, storage capacity, and expandability in a single system, which enables a greater range of workloads in your data center such as Kubernetes deployments.

Whether virtual, bare metal, or a hybrid mix of Kubernetes worker nodes, Cisco UCS-X and Intersight provide administrators ease of deployment and management across the entire UCS ecosystem by offering cloud-based infrastructure management of not only compute and network but also Hitachi Virtual Storage Platform storage systems, which truly enables a simplified approach to managing the datacenter. UCS-X with VSP provides customers a future-proof converged infrastructure stack backed by one of the most reliable storage systems which guarantees 100% data availability.

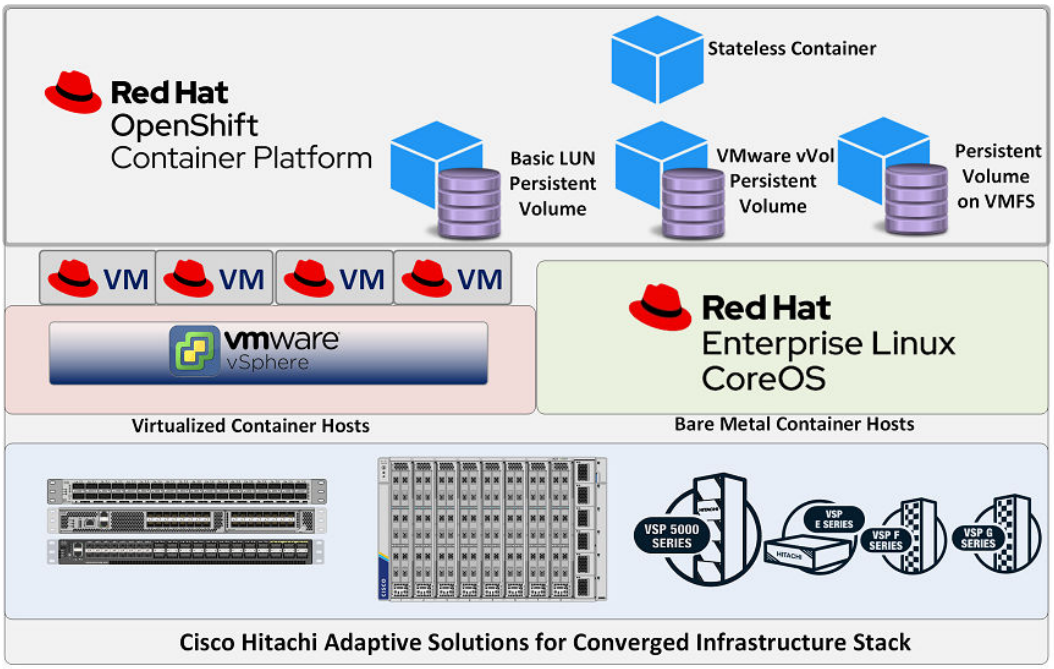
Enterprise container management platforms

A container management platform is orchestration software that creates, manages, and secures containerized applications. Container management software enables easier, faster networking and container orchestration. This platform handles several containerized application processes, such as governance, automation, layered security, extensibility, and enterprise support.

Red Hat OpenShift

Red Hat OpenShift Container Platform (OCP) provides a single platform to build, deploy, and manage applications consistently across on-premises and hybrid cloud deployments. OCP provides the control plane and data plane within the same interface. OCP provides administrator views to deploy operators, monitor container resources, manage container health, manage users, work with operators, manage pods and deployment configurations, as well as define storage resources.

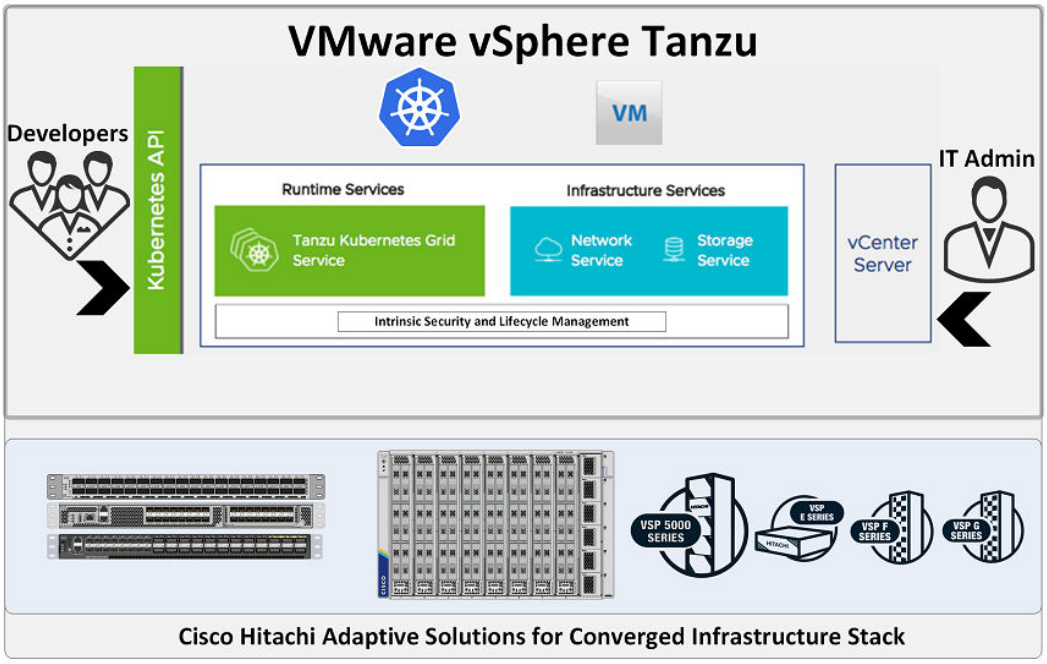
OCP also provides a developer view for deploying application resources from various pre-defined resources such as YAML files, Docker files, Catalogs, or GIT within user-defined namespaces. With OCP `kubectl`, a native binary of Kubernetes is replaced by the `oc` command which provides further support for OCP resources, such as deployment and build configurations, routes, image streams, and tags. OCP has a GUI and a CLI interface.



VMware Tanzu

VMware Tanzu is a container management platform that datacenter administrators and development teams use to build, run, and manage Kubernetes-controlled container-based applications all from a single and familiar vSphere UI. VMware provides three VMware Tanzu deployment types: Basic, Standard, and Advanced.

VMware Tanzu helps organizations standardize their cloud-native operations and abstract away the complexity of deploying to the cloud infrastructure with templates, automation, and role-based UIs. It offers a centralized, automated, and secure operating model for modern apps and Kubernetes on private and public clouds, including a consistent, productive developer experience for any Kubernetes environment. The VMware Tanzu model enables organizations to choose the best landing zones for their applications and get more value from their public cloud strategies.



Kubernetes storage concepts with Hitachi Virtual Storage Platform

The following sections cover the basic framework that administrators need to understand to use Hitachi VSP storage in conjunction with Kubernetes environments.

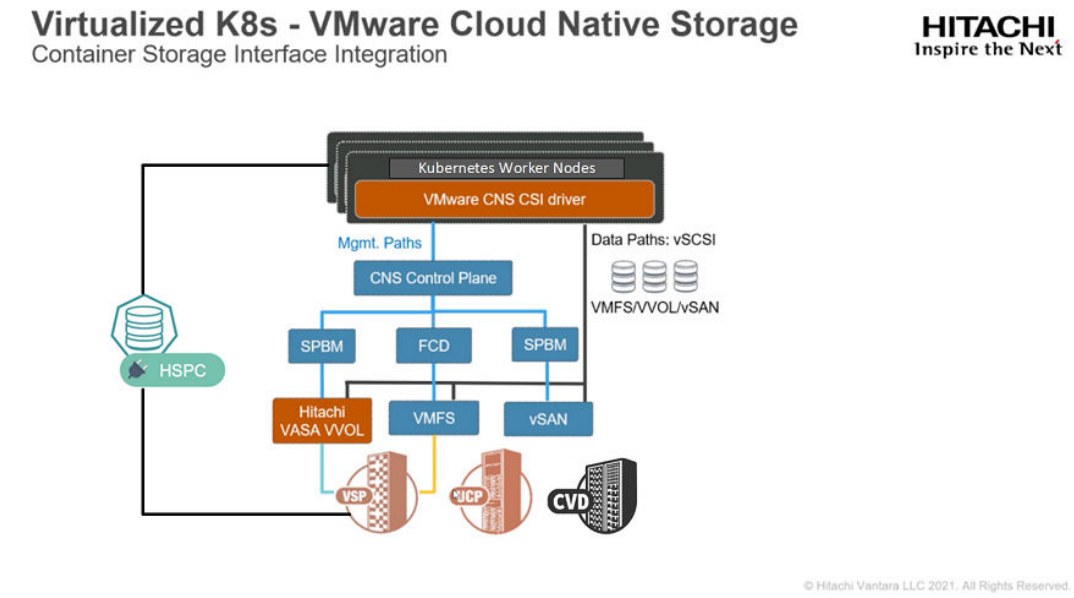
vSphere Cloud Native storage concepts

Cloud Native Storage (CNS) integrates vSphere and Kubernetes and offers capabilities to create and manage container volumes deployed in a vSphere environment. CNS consists of two components, a CNS component in vCenter Server and vSphere CSI driver in Kubernetes.

CNS enables vSphere and vSphere storage (VMFS, vVols, and NFS), including vSAN as a platform, to run stateful applications. CNS enables access to this data path for Kubernetes and brings information about Kubernetes volume and pod abstractions to vSphere. CNS uses several components to work with vSphere storage including VMFS or vVols provided by the Hitachi Storage Provider for VMware vCenter. After you create persistent volumes (PVs), you can review them and their backing virtual disks in the vSphere Client and monitor their storage policy compliance.

Container Storage Interface concepts

The Container Storage Interface (CSI) driver is installed in the Kubernetes cluster and can provide persistent storage to worker nodes within the Kubernetes cluster. Administrators can use VMware via the `csi.vsphere.vmware.com` driver or the Hitachi `hspc.csi.hitachi.com` driver which enables 1-to-1 persistent volume creation on VSP storage. A Persistent Volume Claim (PVC) is created that references an available StorageClass, which maps to a vSphere storage policy-based management (SPBM) policy. A first-class disk (FCD) is created within vSphere, and a resultant PV is presented to the OpenShift layer from the CSI driver. The FCD is then mounted to the pod when requested for use as a PV. The following figure illustrates how CNS components, the CNS in vCenter Server, and the vSphere Container Storage Plug-in interact with other components in a vSphere environment (credit to VMware).

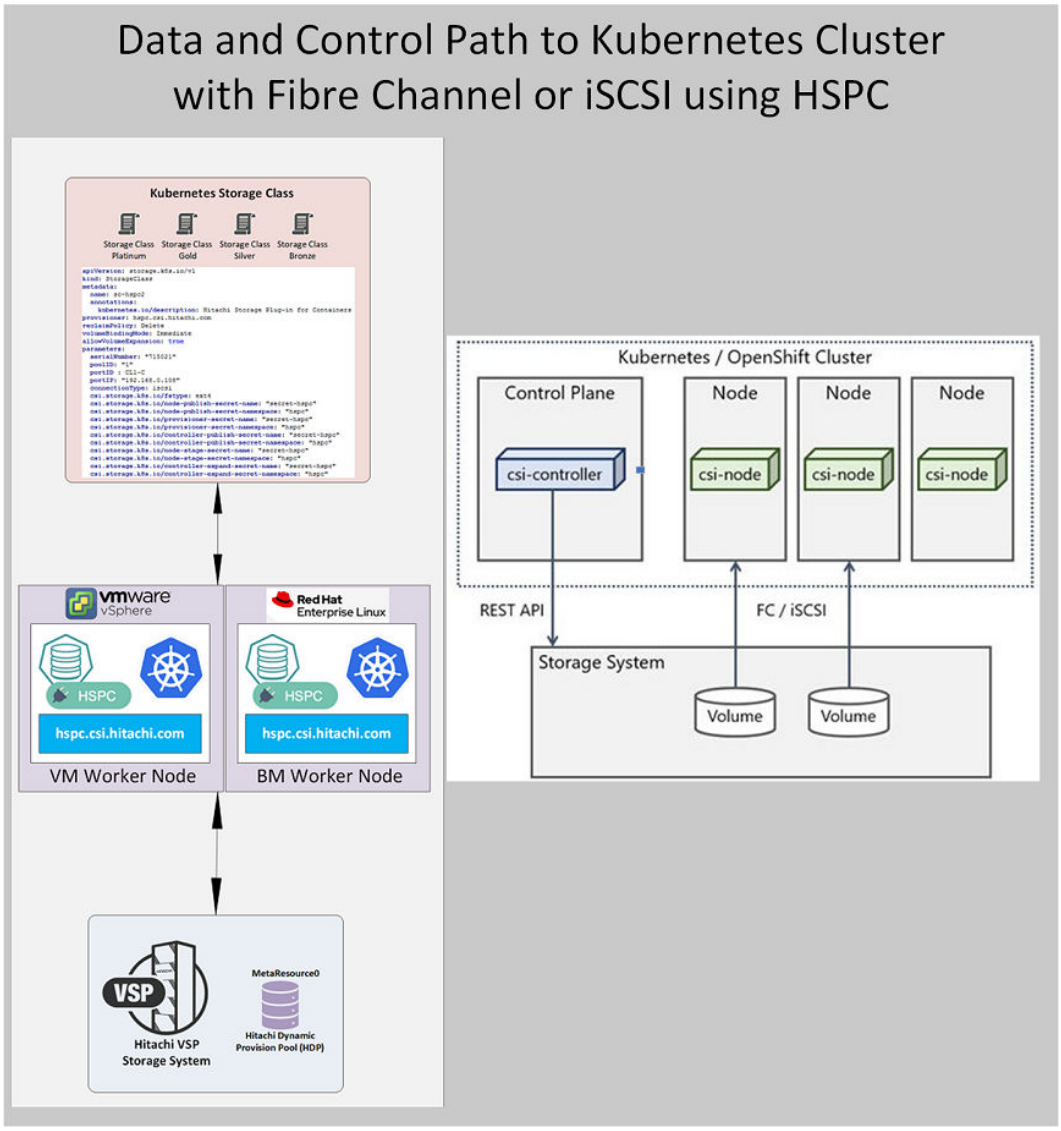


The vSphere Container Storage Plug-in has different components that provide an interface used by the Container Orchestrators such as OpenShift to manage the lifecycle of vSphere volumes. It is also used to create volumes, expand and delete volumes, attach and detach volumes to the cluster worker node VMs, and use bind mounts for the volumes inside the pods.

Hitachi Storage Plug-in for Containers

Hitachi Storage Plug-in for Containers is a software component that contains libraries, settings, and commands that you can use to create persistent storage on Hitachi Virtual Storage Platform to run your stateful applications. Storage Plug-in for Containers uses the Storage Plug-in for Containers CSI driver interface instead of the VMware CSI driver to create persistent volumes directly in a 1-to-1 correlation on the VSP. Storage Plug-in for Containers provides persistent volumes from Hitachi Dynamic Provisioning (HDP) or Hitachi Thin Image (HTI) pools to bare metal or hybrid deployments via the Fibre Channel or iSCSI protocols using the Storage Plug-in for Containers CSI driver. The iSCSI protocol is supported for both bare metal and virtual environments.

The following illustration shows a container environment where the Storage Plug-in for Containers is deployed.



Configuration

After Storage Plug-in for Containers is installed, a secret and StorageClass must be configured.

- Secret

  The secret file contains the storage URL, username, and password settings that are necessary for Storage Plug-in for Containers to work with your environment. The following YAML example can be used:

```
apiVersion: v1
kind: Secret
metadata:
name: secret-hspc
type: Opaque
data:
url: aHR0cDovLzE3Mi4xNi4xLjE=
user: VXNlcjAx
password: UGFzc3dvcmQwMQ==
```

  Entries for the VSP SVP URL, user, and password are base64-encoded. Run the following commands to encode parameters based on your environment using a Linux host:

```
echo -n "http://172.16.1.1" | base64 echo -n "User01" | base64
echo -n "Password01" | base64
```

- StorageClass

  The Storage Plug-in for Containers StorageClass enables the definition of the VSP storage system and storage protocol being used with the Kubernetes environment. Define the VSP serial number, HDP pool ID, port ID, and connection protocol. The StorageClass also points to the previously created secret and pre-configured namespace. The following YAML example of StorageClass used on a fully virtualized Kubernetes cluster:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
name: sc-hspc
annotations:
kubernetes.io/description: Hitachi Storage Plug-in for Containers
provisioner: hspc.csi.hitachi.com
reclaimPolicy: Delete
volumeBindingMode: Immediate
allowVolumeExpansion: true
parameters:
serialNumber: "715021"
poolID: "1"
portID: CL1-C,CL2-C,CL3-C,CL4-C
portIP: "192.168.0.108, 192.168.0.172, 192.169.0.109,
192.169.0.173"
connectionType: iscsi
csi.storage.k8s.io/fstype: ext4
csi.storage.k8s.io/node-publish-secret-name: "secret-hspc"
```

```
csi.storage.k8s.io/node-publish-secret-namespace: "hspc"
csi.storage.k8s.io/provisioner-secret-name: "secret-hspc"
csi.storage.k8s.io/provisioner-secret-namespace: "hspc"
csi.storage.k8s.io/controller-publish-secret-name: "secret-hspc"
csi.storage.k8s.io/controller-publish-secret-namespace: "hspc"
csi.storage.k8s.io/node-stage-secret-name: "secret-hspc"
csi.storage.k8s.io/node-stage-secret-namespace: "hspc"
csi.storage.k8s.io/controller-expand-secret-name: "secret-hspc"
csi.storage.k8s.io/controller-expand-secret-namespace: "hspc"
```

Hitachi Replication Plug-in for containers and disaster recovery

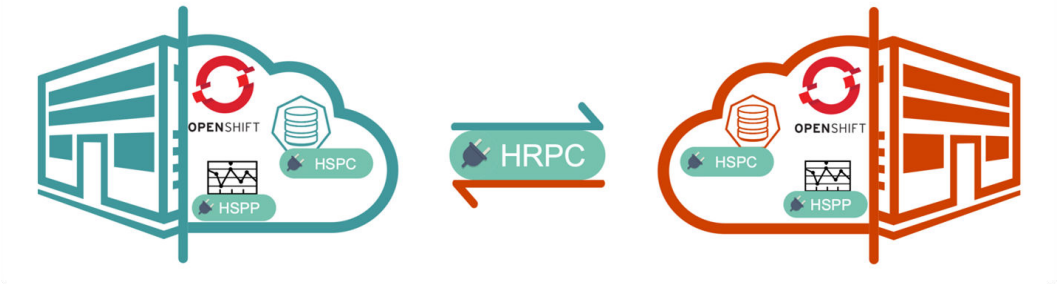
Hitachi Replication Plug-in for Containers (HRPC) automates storage replication between two different Kubernetes clusters and storage systems located at different sites. This enables your organization to take a self-service approach when creating replications using the Kubernetes command-line tools, kubectl or oc. HRPC supports any Kubernetes cluster configured with Hitachi Storage Plug-in for Containers.

Replication services for persistent storage on Hitachi VSP storage systems can be enabled with a storage class which uses Hitachi Storage Provider (VASA)-supported VMware CNS-CSI persistent storage virtual machine disks (VMDKs) or HRPC for Hitachi CSI-managed persistent volumes with HSPC.

HRPC provides replication data services for the persistent volumes on Hitachi VSP storage systems, covering use cases such as the following:

- Migration — Persistent volumes can be snapshotted and cloned locally or to remote Kubernetes clusters with their own remote VSP storage system.
- Disaster Recovery — Persistent volumes can be protected against datacenter failures by having the data replicated at extensive distances using Hitachi Universal Replicator.
- Backup — Persistent volumes can be protected with point-in-time snapshots locally with Hitachi Storage Plug-in for Containers, or they can be backed up to remote VSP storage using HRPC.

See https://knowledge.hitachivantara.com/Documents/Adapters_and_Drivers/Storage_Adapters_and_Drivers/Containers/Replication_Plug-in_for_Containers and https://community.hitachivantara.com/blogs/jose-perez/2022/02/22/hitachi-storage-integration-for-kubernetes for more details.

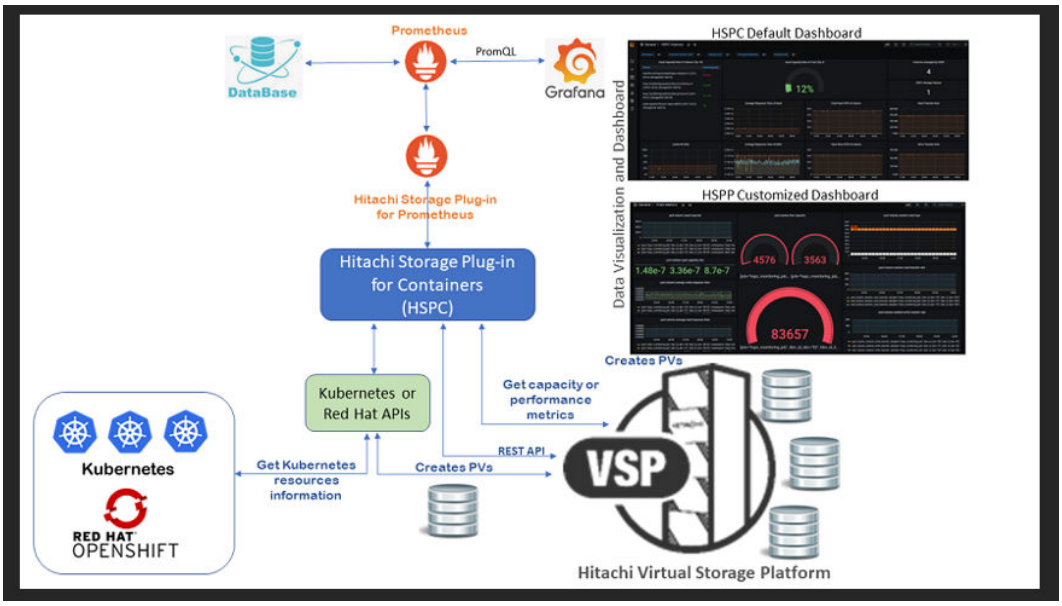


Kubernetes backups

Backups are a critical aspect of any data center infrastructure. Backup and recovery for Kubernetes is focused on the backup of the entire application, including its configurations, secrets, and persistent metadata, from the local Kubernetes cluster to an offsite location. The location could be object storage in a public or private cloud or storage available on-premises in different regions or failure domains. Backup solutions can also have multiple backup targets. For these scenarios, organizations that use Kubernetes can take advantage of third-party tools such as Velero or Kasten K10.

Hitachi Storage Plug-in for Prometheus

In addition to automated persistent storage creation and mapping using HSPC, Hitachi also provides the Hitachi Storage Plug-in for Prometheus (HSPP). This plugin enables administrators to view and monitor metrics of persistent volumes provided from the Hitachi Virtual Storage Platform storage system to the Kubernetes cluster from a Grafana dashboard. This enables administrators to understand the performance metrics of their persistent storage in terms of IOPS, response time, transfer rate, capacity, and cache hit rate, all from a single dashboard. These metrics can be presented by Namespace, Persistent Volume Claims (PVC), Storage Class, Storage Serial Number, or Storage Pool ID. The following figure illustrates the monitoring flow of HSPP.



See https://knowledge.hitachivantara.com/Documents/Adapters_and_Drivers/Storage_Adapters_and_Drivers/Containers/Storage_Plug-in_for_Prometheus and https://community.hitachivantara.com/blogs/hossein-heidarian/2022/09/06/hitachi-storage-plug-in-for-prometheus-custom-dash for additional details about HSPP configuration.

Configuration

Hitachi Storage Plug-in for Prometheus users must configure a secret with parameters to match their environment requirements.

The secret file contains the storage SVP IP or target controller depending on the VSP model being used, as well as the username and password.

Note: Multiple Hitachi Virtual Storage Platform storage systems can be defined in the secret file as needed by the Kubernetes cluster requirements.

In the following YAML example, a VSP E1090 is used with its controller target IP address. For other models, a VSP SVP IP address is used.

The following YAML example can be used:

```
apiVersion: v1
kind: Secret
metadata:
 name: storage-exporter-secret
 namespace: hspc-monitoring-system
type: Opaque
stringData:
 storage-exporter.yaml: |-
  storages:
  - serial: 715021
   url: https://192.25.44.117
   user: maintenance
   password: raid-maintenance
```

VMware vVols and storage policy-based management

Hitachi Storage Provider for VMware vCenter (VASA) enables VASA APIs for storage awareness to be used with Hitachi storage systems. VASA enables policies to be made by making the storage attribute information available in vSphere. VASA enables organizations to deploy Hitachi storage infrastructure with VMware vSphere Virtual Volumes (vVols) to bring customers on a reliable enterprise journey to a software-defined, policy-controlled datacenter.

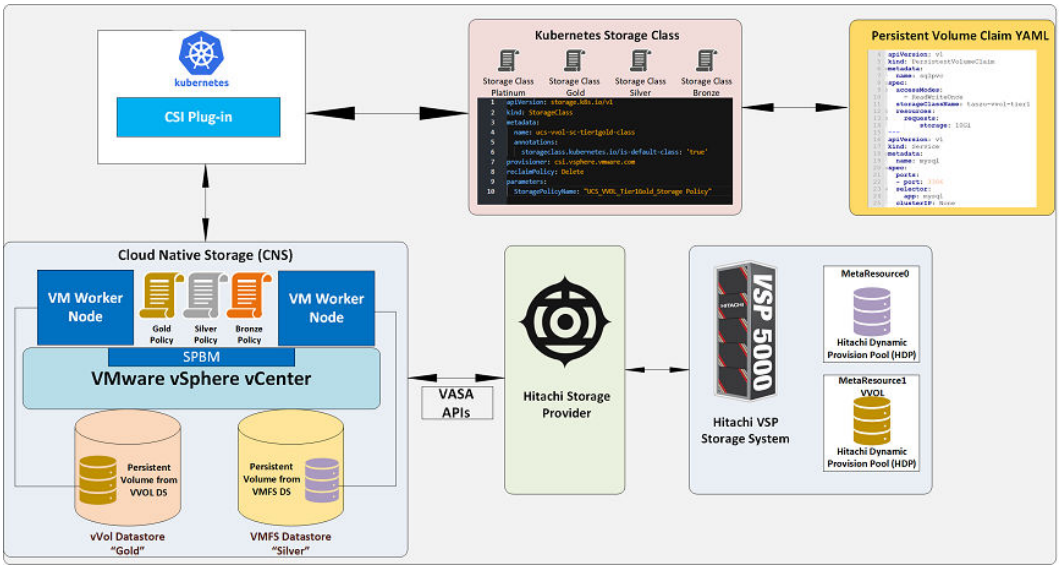
Hitachi storage policy-based management (SPBM) enables automated provisioning of virtual machines (VMs) and quicker adjustment to business changes. Virtual infrastructure (VI) administrators can make changes to policies to reflect changes in their business environment, dynamically matching storage policy requirements for VMs to available storage pools and services. The vVols solution reduces the operational burden between VI administrators and storage administrators with an efficient collaboration framework leading to faster and better VM and application services provisioning.

VASA makes this possible in two ways:

- VMware vSphere vVols
  - This function is the VASA component of VMware vVols that enables vVols to be used with supported Hitachi storage systems in a 1-to-1 mapping, enabling greater insight into virtual machine performance.
- VMware VMFS
  - VASA enables storage capability information and alert notifications related to VMFS file systems to be generated automatically and displayed in vCenter Server.

To use VMware vVols with Hitachi storage, install VASA. See https://knowledge.hitachivantara.com/Documents/Application_Optimized_Solutions/VMWare/VMware_vSphere_Virtual_Volumes_(vVols)_with_Hitachi_Virtual_Storage_Platform_Quick_Start_and_Reference_Guide for details. See https://knowledge.hitachivantara.com/Documents/Adapters_and_Drivers/Storage_Adapters_and_Drivers/VMware/Storage_Provider_for_VMware_vCenter_(VASA) to deploy this environment.

The following figure shows the relationship between VASA, CNS, CSI, StorageClasses and Persistent Volume Claim.



Hitachi Virtual Storage Platform operability with Kubernetes container platforms

See the following guides for RedHat OCP at https://www.hitachivantara.com/en-us/pdfd/architecture-guide/cisco-hitachi-adaptive-solutions-ci-with-red-hat-openshift-platform-implementation-guide.pdf and VMware Tanzu at https://www.hitachivantara.com/en-us/pdfd/architecture-guide/cisco-and-adaptive-solutions-with-vmware-tanzu-basic.pdf for platform-specific step-by-step configuration of VSP storage systems.

The following table shows Red Hat OCP integration with Hitachi Virtual Storage Platform.

Red Hat OpenShift Container Platform		
Deployment Type	**Storage Type**	**Hitachi Persistent Storage Provider Compatibility**
ESXi (all virtual workers)	iSCSI	Hitachi Storage Plug-in for Containers
	Fibre Channel or iSCSI – Cloud Native Storage (CNS)	VMware Container Storage Interface (vVol + VMFS)
Bare metal (all physical infrastructure)	Fibre Channel or iSCSI	Hitachi Storage Plug-in for Containers
Hybrid (mix of physical and virtual workers)	iSCSI	Hitachi Storage Plug-in for Containers (Virtual Only)
	Fibre Channel or iSCSI	Hitachi Storage Plug-in for Containers (Bare Metal Only)
	Fibre Channel or iSCSI with Cloud Native Storage (CNS)	VMware Container Storage Interface (vVol + VMFS)

The following table shows VMware Tanzu integration with Hitachi Virtual Storage Platform.

VMware Tanzu Container Platform		
Deployment Type	**Storage Type**	**Hitachi Persistent Storage Provider Compatibility**
ESXi (all virtual workers)	iSCSI	Hitachi Storage Plug-in for Containers
	Fibre Channel or iSCSI with Cloud Native Storage (CNS)	VMware Container Storage Interface (vVol + VMFS)
	vSAN	vCSI

The following table shows generic Kubernetes integration with Hitachi Virtual Storage Platform.

Generic Kubernetes Container Platform		
Deployment Type	**Storage Type**	**Hitachi Persistent Storage Provider Compatibility**
ESXi (all virtual workers)	iSCSI	Hitachi Storage Plug-in for Containers
	Fibre Channel or iSCSI with Cloud Native Storage (CNS)	Container Storage Interface (vVol + VMFS)
Bare Metal (all physical infrastructure)	Fibre Channel or iSCSI	Hitachi Storage Plug-in for Containers
Hybrid (mix of physical and virtual workers)	iSCSI	Hitachi Storage Plug-in for Containers (Virtual Only)
	Fibre Channel or iSCSI	Hitachi Storage Plug-in for Containers (Bare Metal Only)
	Fibre Channel or iSCSI with Cloud Native Storage (CNS)	Container Storage Interface (vVol + VMFS)

Conclusion

Cisco and Hitachi Adaptive Solutions plus Red Hat OCP, VMware Tanzu, or any native Kubernetes with Hitachi Virtual Storage Platform combine to create a powerful and flexible Kubernetes ecosystem. Hitachi technology such as Hitachi Storage Plug-in for Containers can be used to automate provisioning of persistent storage to stateful applications in conjunction with Hitachi Storage Plug-in for Prometheus to monitor VSP persistent volume performance. Additionally, Hitachi VASA plugins enable SPBM tags which can be leveraged via VMware CNS to provide persistent storage to Kubernetes clusters from VMware CSI.

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