Hitachi Storage Plug-in for Containers

Version 3.14.3

Quick Reference Guide

This Quick Reference Guide provides an implementation overview and describes the usage requirements, installation, and configuration of Storage Plug-in for Containers.

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Preface

Hitachi Storage Plug-in for Containers lets you create containers and run stateful applications inside those containers by using the Hitachi storage volumes as dynamically provisioned persistent volumes. This Quick Reference Guide provides an implementation overview and describes the usage requirements, installation, and configuration of Storage Plug-in for Containers.

Please read this document carefully to understand how to install and use the plug-in, and maintain a copy for your reference.

Product version

This document applies to Hitachi Storage Plug-in for Containers version 3.14.3.

Release notes

Read the release notes before installing and using this product. They may contain requirements or restrictions that are not fully described in this document or updates or corrections to this document. Release notes are available on the Hitachi Vantara documentation website: https://docs.hitachivantara.com.

Conventions for capacity values

Logical capacity units (for example, logical device capacity, cache memory capacity) are calculated based on the values that are outlined in the following table.

Logical capacity unit	Value
1 KiB	1,024 (2^{10}) bytes
1 MiB	1,024 KiB or $1{,}024^2$ bytes
1 GiB	1,024 MiB or $1{,}024^3$ bytes
1 TiB	1,024 GiB or $1{,}024^4$ bytes
1 PiB	1,024 TiB or $1{,}024^5$ bytes
1 EiB	1,024 PiB or $1{,}024^6$ bytes

Storage model abbreviations

This document uses the following abbreviations for storage models.

Abbreviation	Full name
VSP family	Hitachi Virtual Storage Platform family Collective name for the following storage models: ▪ VSP E series ▪ VSP F350, F370, F700, F900 ▪ VSP F400, F600, F800 ▪ VSP F1500 ▪ VSP G350, G370, G700, G900 ▪ VSP G200, G400, G600, G800 ▪ VSP G1000 ▪ VSP G1500 ▪ VSP N400, N600, N800 ▪ VSP 5000 series
VSP E series	Hitachi Virtual Storage Platform E series Collective name for the following storage models: ▪ Hitachi Virtual Storage Platform E590 ▪ Hitachi Virtual Storage Platform E790 ▪ Hitachi Virtual Storage Platform E990 ▪ Hitachi Virtual Storage Platform E1090 ▪ Hitachi Virtual Storage Platform E590H ▪ Hitachi Virtual Storage Platform E790H ▪ Hitachi Virtual Storage Platform E1090H
VSP F350	Hitachi Virtual Storage Platform F350
VSP F370	Hitachi Virtual Storage Platform F370

Abbreviation	Full name
VSP F700	Hitachi Virtual Storage Platform F700
VSP F900	Hitachi Virtual Storage Platform F900
VSP F400	Hitachi Virtual Storage Platform F400
VSP F600	Hitachi Virtual Storage Platform F600
VSP F800	Hitachi Virtual Storage Platform F800
VSP F1500	Hitachi Virtual Storage Platform F1500
VSP G350	Hitachi Virtual Storage Platform G350
VSP G370	Hitachi Virtual Storage Platform G370
VSP G700	Hitachi Virtual Storage Platform G700
VSP G900	Hitachi Virtual Storage Platform G900
VSP G200	Hitachi Virtual Storage Platform G200
VSP G400	Hitachi Virtual Storage Platform G400
VSP G600	Hitachi Virtual Storage Platform G600
VSP G800	Hitachi Virtual Storage Platform G800
VSP G1000	Hitachi Virtual Storage Platform G1000
VSP G1500	Hitachi Virtual Storage Platform G1500
VSP N400	Hitachi Virtual Storage Platform N400
VSP N600	Hitachi Virtual Storage Platform N600
VSP N800	Hitachi Virtual Storage Platform N800
VSP 5000 series	Hitachi Virtual Storage Platform 5000 series Collective name for the following storage models: ▪ Hitachi Virtual Storage Platform 5100 ▪ Hitachi Virtual Storage Platform 5200 ▪ Hitachi Virtual Storage Platform 5500 ▪ Hitachi Virtual Storage Platform 5600 ▪ Hitachi Virtual Storage Platform 5100H ▪ Hitachi Virtual Storage Platform 5200H

Abbreviation	Full name
	▪ Hitachi Virtual Storage Platform 5500H ▪ Hitachi Virtual Storage Platform 5600H
VSP One Block	Hitachi Virtual Storage Platform One Block Collective name for the following storage models: ▪ Hitachi Virtual Storage Platform One Block 24 ▪ Hitachi Virtual Storage Platform One Block 26 ▪ Hitachi Virtual Storage Platform One Block 28
VSP One B20	Hitachi Virtual Storage Platform One Block 20 Collective name for the following storage models: ▪ Hitachi Virtual Storage Platform One Block 24 ▪ Hitachi Virtual Storage Platform One Block 26 ▪ Hitachi Virtual Storage Platform One Block 28
VSP One SDS Block	Hitachi Virtual Storage Platform One SDS Block

Accessing product documentation

Product user documentation is available on: https://docs.hitachivantara.com. Check this site for the most current documentation, including important updates that may have been made after the release of the product.

Getting help

The Hitachi Vantara Support Website is the destination for technical support of products and solutions sold by Hitachi Vantara. To contact technical support, log on to the Hitachi Vantara Support Website for contact information: https://support.hitachivantara.com/en_us/contact-us.html.

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Comments

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Thank you!

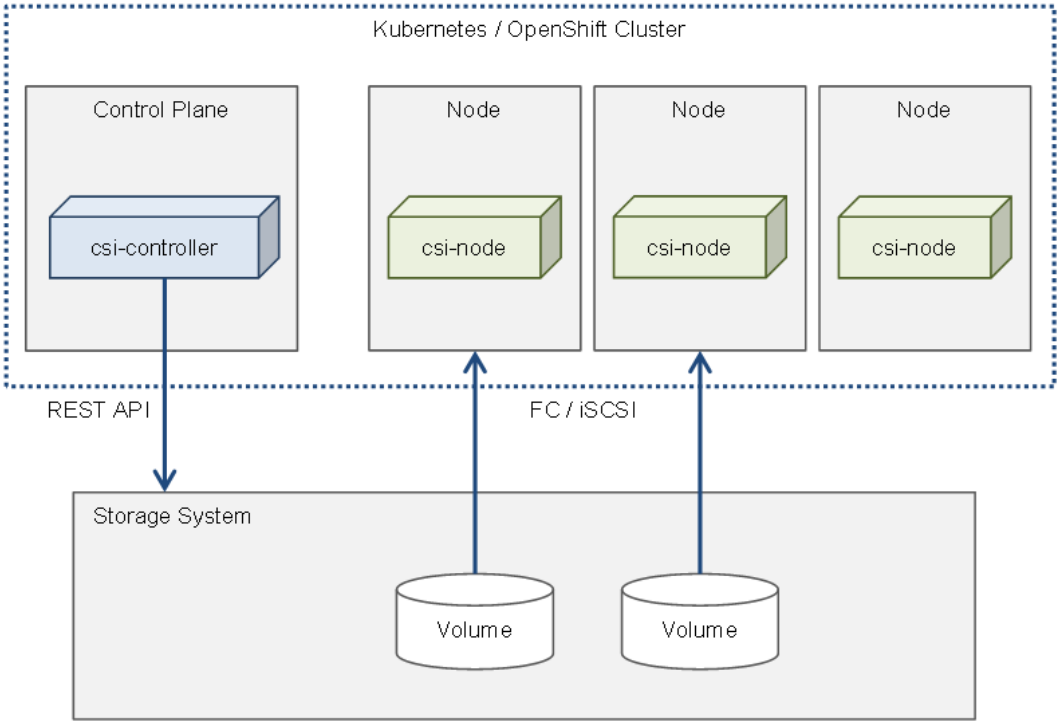
Chapter 1: Overview

Storage Plug-in for Containers is software for creating and managing persistent volumes for Hitachi storage systems in a Kubernetes environment. By using Storage Plug-in for Containers, you can use Hitachi storage volumes from stateful applications running on Kubernetes. For persistent volumes, in addition to creation and deletion, operations such as snapshots and clones are supported.

About Hitachi Storage Plug-in for Containers

Storage Plug-in for Containers integrates Kubernetes or OpenShift with Hitachi storage systems using Container Storage Interface (CSI).

The following diagram illustrates a container environment where Storage Plug-in for Containers is deployed.



The following table lists and describes the components of Storage Plug-in for Containers.

Component	Purpose
csi-controller	Implements the CSI controller service, which mainly uses the REST API for storage operations. This is deployed as Deployment and starts on a control plane. If the csi-controller cannot start on a control plane, it might start on a node.
csi-node	Implements the CSI node service, which primarily manages volumes on each node. This is deployed as DaemonSet, and all nodes must have this component.
Hitachi storage systems	Provides storage volumes for the containers.

About the environment setup tasks

Storage Plug-in for Containers enables dynamic operation of storage systems when containers are used. In order to use Storage Plug-in for Containers pre-installation tasks must be completed.

Procedure

1. Check and apply the requirements for the server (where you plan to install Storage Plug-in for Containers, Kubernetes, and OpenShift), Hitachi storage systems, Kubernetes, and OpenShift.
2. Execute pre-installation tasks.
   a. Set up the Kubernetes and OpenShift environment.
   b. Configure the Hitachi storage systems.
3. Install Storage Plug-in for Containers.

Requirements

Before you install Storage Plug-in for Containers, check that the system requirements meet the following minimum requirements.

Container orchestrators to be supported

Container orchestrator	Remarks
Red Hat OpenShift Container Platform	—

Container orchestrator	Remarks
Kubernetes	—
Rancher Kubernetes Engine 1 (RKE1) Rancher Kubernetes Engine 2 (RKE2)	If you use RKE1 or RKE2, in this manual, read "Kubernetes" as "RKE1" or "RKE2" and act accordingly.

For details on supported versions, see the Release Notes.

Server requirements

Component	Requirement
CPU	x86_64
Operating system	Refer to the release notes for details. **Note:** You can also use Red Hat Enterprise Linux CoreOS as a worker node of OpenShift environments.

Storage requirements

Storage requirements for VSP family and VSP One Block.

Component	Requirement
Model and SVOS	Refer to the release notes for details.
Interface	Fibre Channel, iSCSI, and NVMe over FC for bare metal servers. iSCSI for vSphere virtual machines.
Host group	Must be dedicated to Storage Plug-in for Containers. Do not use a host group used for Storage Plug-in for Containers for purposes other than Storage Plug-in for Containers.
User account	The built-in Storage administrator (View & Modify) user group. If you are using a customized user group, make sure it has the same roles as the built-in Storage Administrator (View & Modify) user group.

Component	Requirement
License	The following licenses are required: ▪ Dynamic Provisioning (HDP) ▪ Hitachi Thin Image (HTI)
SVP	Single and dual SVP configurations are supported.

Storage requirements for VSP One SDS Block.

Component	Requirement
Version	Refer to the release notes for details.
Interface	Fibre Channel and iSCSI for bare metal servers. iSCSI for vSphere virtual machines.
User account	▪ If multitenancy functionality is not used: The user must be assigned the Storage role. ▪ If multitenancy functionality is used: See Multitenancy functionality settings (on page 23) and set a user.

Network requirements

The network requirements for Storage Plug-in for Containers are as follows:

- Storage Plug-in for Containers uses the following ports. Use this information for reference when configuring the firewall.

Component	Port	Usage	Remarks
Storage	80 or 443	REST API connection	None

- Storage Plug-in for Containers does not support IPv6. Use IPv4.

Pre-installation tasks

Before you install Storage Plug-in for Containers, review and apply the server and storage pre-installation requirements.

Server pre-installation

The following table outlines the pre-installation tasks for each server component.

If you are using VSP One SDS Block, for information on the server settings, see the VSP One SDS Block manual.

Component	Tasks
Hypervisor	If you want to use virtual machines, set up the hypervisor. **Note:** Storage Plug-in for Containers is tested with VMware vSphere 7.0.
Fibre Channel	Verify that HBA is installed on nodes that implement a Fibre Channel connection with the storage system.
iSCSI	Verify that iSCSI initiator software is installed on nodes that implement an iSCSI connection with the storage system. If the software is not installed, refer to: https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/7/html/storage_administration_guide/osm-create-iscsi-initiator **Note:** Storage Plug-in for Containers does not support IQNs that include uppercase alphabetic characters.
NVMe over FC	NVMe over FC connections are supported by the following OSs. Check the following before specifying settings: ▪ Ubuntu 20.04, 22.04 ▪ Red Hat Enterprise Linux 9 ▪ Red Hat Enterprise Linux CoreOS (OpenShift 4.13 or later)

Component	Tasks
	Specify the following settings for a node that connects with the storage system through an NVMe over FC connection. The method for specifying settings differs depending on the OS. ▪ Ubuntu Using the following command, install the `nvme-cli` tool: `apt-get install nvme-cli` ▪ Red Hat Enterprise Linux • Broadcom (Emulex) Using the following website as reference, install the `nvme-cli` tool: https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/9/html/managing_storage_devices/configuring-nvme-over-fabrics-using-nvme-fc_managing-storage-devices • QLogic Using the following website as reference, install the `nvme-cli` tool and then reload the QLogic module (qla2xxx): https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/9/html/managing_storage_devices/configuring-nvme-over-fabrics-using-nvme-fc_managing-storage-devices ▪ Red Hat Enterprise Linux CoreOS You do not need to install the `nvme-cli` tool.

Component	Tasks
	Note: ▪ Do not change a host NQN while the host is running. However, if a change while the host is running is necessary, perform the drain operation on the relevant node, and then change the host NQN. After changing the host NQN, restart the host. ▪ When there are multiple nodes, make sure that no duplicate host NQN exists.
Multipath function	For Fibre Channel and iSCSI, use Device Mapper Multipath. For NVMe over FC, use Native NVMe Multipath. For details on multipath function settings, see Device Mapper Multipath settings (on page 17) or Native NVMe Multipath settings (on page 19).

Device Mapper Multipath settings

Enable Device Mapper Multipath and make sure that the `user_friendly_names` option is set to `yes`.

For example:

```
defaults {
        user_friendly_names yes
        find_multipaths yes
}
blacklist {
}
```

If you are using VSP One SDS Block, for information on settings specific to VSP One SDS Block, see the VSP One SDS Block manual, and check the sections describing the operating environment settings and the ALUA settings.

Note: The setting values might differ depending on the environment. Also see the documentation for your OS.

- Red Hat Enterprise Linux 7: https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/7/html/dm_multipath/mpio_setup
- Red Hat Enterprise Linux 8: https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/8/html/configuring_device_mapper_multipath/configuring-dm-multipath_configuring-device-mapper-multipath
- Ubuntu: https://ubuntu.com/server/docs/device-mapper-multipathing-introduction

For OpenShift, you will need to use the MachineConfig YAML file. For details, see the official documentation: https://docs.openshift.com/container-platform/latest/machine_configuration/index.html

For OpenShift, the following is an example of the procedure:

Procedure

1. Obtain `multipath-machineconfig-sample.yaml` from the provided sample files.

   Note: You can obtain the sample files from https://github.com/hitachi-vantara/csi-operator-hitachi. The sample files are stored in the `csi-operator-hitachi/hspc/<Storage-Plug-in-for-Containers-version>/sample` directory.

2. If necessary, change the multipath settings in `multipath-machineconfig-sample.yaml`.

   The following default multipath settings are specified in `multipath-sample.conf`. The character string obtained by encoding this file in base64 is specified in `multipath-machineconfig-sample.yaml`.

   ```
   defaults {
   user_friendly_names yes
   find_multipaths yes
   }
   blacklist {
   }
   ```

   a. Obtain `multipath-sample.conf` from the provided sample files.
   b. Edit `multipath-sample.conf` to change the multipath settings.
   c. Run the following command to obtain `multipath-sample.conf` encoded in base64:

      ```
      # cat multipath-sample.conf | base64 -w0
      ```

   d. Change the `spec.config.storage.files.contents.source` setting in `multipath-machineconfig-sample.yaml`.

The character string specified for `spec.config.storage.files.contents.source` corresponds to the multipath settings encoded in base64. Replace this character string with the base64-encoded character string obtained from `multipath-sample.conf`.

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  name: multipath-machineconfig-sample
  labels:
    machineconfiguration.openshift.io/role: worker
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
      - contents:
          source: data:text/plain;charset=utf-8;base64,
ZGVmYXVsdHMgewp1c2VyX2ZyaWVuZGx5X25hbWVzIHllcwpmaW5kX211bHRpcGF0aHMgeWVzCn0K
YmxhY2tsaXN0IHsKfQo=
          verification: {}
        filesystem: root
        mode: 400
        path: /etc/multipath.conf
```

3. Run the following command:

```
# oc apply -f multipath-machineconfig-sample.yaml
```

Note: MachineConfig applies to compute nodes only. After MachineConfig is created, all compute nodes are automatically restarted one by one.

4. `/etc/multipath.conf` is created on all compute nodes. On each compute node, open `/etc/multipath.conf` and verify that the settings have been applied.

Note: It might take time for the settings to be applied.

Native NVMe Multipath settings

The method for specifying Native NVMe Multipath settings differs depending on the OS.

Ubuntu

By default, Native NVMe Multipath is enabled. For this reason, there is no need to specify Native NVMe Multipath settings.

Red Hat Enterprise Linux

Using the following website as reference, enable Native NVMe Multipath:

https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/9/html/managing_storage_devices/enabling-multipathing-on-nvme-devices_managing-storage-devices

Red Hat Enterprise Linux CoreOS

By default, Native NVMe Multipath is enabled. For this reason, there is no need to specify Native NVMe Multipath settings.

Storage pre-installation for VSP family and VSP One Block

The following table outlines the pre-installation tasks to be completed for each storage component.

Component	Task
Program products	▪ Enable Dynamic Provisioning (HDP) license ▪ Enable Hitachi Thin Image (HTI) license
Pool	Create an HDP pool. Dynamic Tiering is not supported.
Fibre Channel connection	Use a Fibre Channel switch for communication between the storage and servers. Set the following parameters for storage ports using Storage Navigator: ▪ Connection Type: P-to-P ▪ Fabric: ON ▪ Security: Enabled Storage Plug-in for Containers automatically performs the following actions: ▪ Creates host groups for each host if there is no host group. If you want to use existing host groups, rename them according to the naming rule (see Host group and iSCSI target naming rules (on page 21)). ▪ Adds the WWNs for all of the HBA ports in each host to the host group created for each host. **Note:** Storage Plug-in for Containers will overwrite host mode options even if existing host groups have other host mode options.
iSCSI connection	Enable port security by Storage Navigator.

Component	Task
	Storage Plug-in for Containers automatically performs the following actions: ▪ Creates iSCSI targets for each host if there is no iSCSI target. If you want to use existing iSCSI targets, rename them according to the naming rule (see Host group and iSCSI target naming rules (on page 21)). ▪ Adds the IQN to the iSCSI target corresponding to each host that will join the Kubernetes cluster. ▪ Logs in to the iSCSI target on each host. If you want to use CHAP, do the following: ▪ Create an iSCSI target (see Host group and iSCSI target naming rules (on page 21)). ▪ Set CHAP for the port and iSCSI target. ▪ Log in to the iSCSI target with CHAP authentication. Run login from each host. **Note:** Storage Plug-in for Containers will overwrite host mode options even if existing iSCSI targets have other host mode options.
NVMe over FC connection	Create an NVM subsystem to manage the path between the host and storage system. The NVM subsystem must be dedicated to Storage Plug-in for Containers. Do not use the NVM subsystem used for Storage Plug-in for Containers for any purpose other than Storage Plug-in for Containers. 1. Create the NVM subsystem for the storage system. Enable the namespace security, and specify Linux as the host mode. 2. Set the operation mode of the Fibre Channel port to NVMe mode. 3. Disable LUN security on the Fibre Channel port. 4. Set an NVM subsystem port. For details about each of the above steps, see the *Provisioning Guide for Open Systems* or *Provisioning Guide*.

Host group and iSCSI target naming rules

Storage Plug-in for Containers automatically searches host groups and iSCSI targets based on the name.

If you want to use an already existing host group or iSCSI target, refer to either the naming rule of host groups or iSCSI targets depending on your storage connection:

Naming rule of host groups

Storage Plug-in for Containers searches host groups by the naming rule. If Storage Plug-in for Containers cannot find any host group in the port, it automatically creates the host group. If you already have host groups, you need to delete them or rename them according to the following naming rule:

"spc-<*wwn1*>-<*wwn2*>-<*wwn3*>"

Naming rule details:

- <*wwn1*>, <*wwn2*>, <*wwn3*> are the world wide name of each host.
- <*wwn1*>, <*wwn2*>, <*wwn3*> are sorted by name.
- If the host has more than three WWNs, Storage Plug-in for Containers sorts <*wwn1*>, <*wwn2*> ... <*wwnN*> and uses lower three names.
- If the host has only one or two WWNs, the names are "spc-<*wwn1*>" or "spc-<*wwn1*>-<*wwn2*>".

Naming rule of iSCSI targets

Storage Plug-in for Containers searches iSCSI targets by the naming rule. If Storage Plug-in for Containers cannot find any iSCSI target, it automatically creates the iSCSI target, "spc-<*hashed-IQN*>". If you already have iSCSI targets, you need to delete them or rename them according to the following naming rule: "spc-<*any-string*>"

Storage pre-installation for VSP One SDS Block

Component	Task
Fibre Channel connection	Use the Fibre Channel switch for communication between storage and servers.
Server resource	If you have already created a Server resource in VSP One SDS Block, verify the following: Storage Plug-in for Containers automatically performs the following actions: ▪ Finds an existing Server resource with the host WWN or IQN configured. ▪ If an existing Server resource is not found, it creates a new Server resource and configures it with a host WWN or IQN. ▪ Verifies and configures the Server resource to connect to the all compute ports.

Component	Task
	If you want to use CHAP, do the following: ▪ Set CHAP for the compute port. ▪ Log in to the iSCSI target with CHAP authentication. Run login from each host. **Note:** Do not add a WWN or IQN of multiple hosts to the same Server resource. Only one Server resource can be associated with a single host.

Multitenancy functionality settings

If you use the multitenancy functionality, set the items in the following table.

Note: An environment in which one Kubernetes/OpenShift cluster and one VSP One SDS Block are used has the following restrictions related to Virtual Private Storage (VPS):

- Multiple VPSs cannot be used.
- VPS and resources that do not belong to the VPS cannot be used at the same time.

Component	Task
VPS	Create VPS. For the maximum number of compute nodes set for VPS, set a number greater than the number of nodes that make up the Kubernetes/OpenShift cluster. For the maximum number of sessions, set at least 20.
User group	Create a user group that belongs to the created VPS. For the scope, set only the created VPS. For the role, set VpsStorage.
User	Create users and assign them to the user group you created in the preceding task. Do not assign the users to a user group other than the user group you created in the preceding task.

Chapter 2: Installation

This chapter describes how to install Storage Plug-in for Containers. The installation method depends on whether your environment is OpenShift or Kubernetes.

Installation on OpenShift

Storage Plug-in for Containers is easily deployed to OpenShift using the Operator, which can be installed from OperatorHub. To install Storage Plug-in for Containers, follow the steps below.

Note:

- If there is a previous version of Storage Plug-in for Containers, remove it before performing the installation procedure.
- If you want to install Storage Plug-in for Containers in an OpenShift Container Platform environment that does not have access to the internet, mirror the certified-operators catalog in advance. For details on the procedure, see https://docs.openshift.com/container-platform/latest/installing/disconnected_install/installing-mirroring-installation-images.html#olm-mirror-catalog_installing-mirroring-installation-images.

  For example, for OpenShift Container Platform version 4.10, the index image of the certified-operators catalog is registry.redhat.io/redhat/certified-operator-index:v4.10. For details, see https://docs.openshift.com/container-platform/latest/operators/understanding/olm-rh-catalogs.html.

Procedure

1. Access OperatorHub from the OpenShift web console.
2. Search Hitachi Storage Plug-in for Containers and install the Operator.

   Note: Select the following settings in Operator Subscription:

   - Installation mode: Select **A specific namespace on the cluster** and specify any namespace.
   - Update approval: Select **Manual** and approve the Install Plan. (see https://docs.openshift.com/).
3. Confirm the status of the Operator is **Succeeded**.
4. Confirm the status of the Operator Pod is **Running**.
5. Click **Create Instance** on the Operator Details.
6. Click **Create**. If you want to make an advanced configuration, refer to Configuration of Storage Plug-in for Containers instance (on page 26).

7. Confirm the status READY is **true** using the following command:

```
# oc get hspc -n <Storage-Plug-in-for-Containers-namespace>
NAME    READY    AGE
hspc    true     30s
```

Installation on Kubernetes

For Kubernetes, you can install Storage Plug-in for Containers using Operator. To install Storage Plug-in for Containers, perform the following procedure.

Note: If there is a previous version of Storage Plug-in for Containers, remove it before performing the installation procedure.

Procedure

1. Create a clone of https://github.com/hitachi-vantara/csi-operator-hitachi, and then move to the target Storage Plug-in for Containers version.

```
# git clone https://github.com/hitachi-vantara/csi-operator-hitachi
# cd csi-operator-hitach/hspc/<Storage-Plug-in-for-Containers-version>/operator
```

2. Create the namespace for the Operator:

```
# kubectl create -f hspc-operator-namespace.yaml
```

3. Create the Operator and confirm the Operator is running:

```
# kubectl create -f hspc-operator.yaml

# kubectl get deployment -n hspc-operator-system
NAME                              READY  UP-TO-DATE  AVAILABLE   AGE
hspc-operator-controller-manager  1/1    1           1           14s
```

4. If you want to change the Storage Plug-in for Containers settings, edit `hspc_v1_hspc.yaml`.

   On the namespace specified in `hspc_v1_hspc.yaml`, Storage Plug-in for Containers is created. Change the settings as necessary.

   If you want to make an advanced configuration, refer to Configuration of Storage Plug-in for Containers instance (on page 26).

5. Create a Storage Plug-in for Containers instance, and confirm that `READY` is `true`.

```
# kubectl create -f hspc_v1_hspc.yaml

# kubectl get hspc -n <Storage-Plug-in-for-Containers-namespace>
NAME READY AGE
hspc true 30s
```

For <*Storage-Plug-in-for-Containers-namespace*>, specify the namespace specified in `hspc_v1_hspc.yaml`.

Configuration of Storage Plug-in for Containers instance

You can configure Storage Plug-in for Containers by editing the `CustomResource` YAML file, which includes the following parameters:

Parameter	Description
`spec.imagePullSecrets`	Specify this parameter if a Secret is required to pull an image.
`spec.controller.containers.name`	Name of the Storage Plug-in for Containers that you want to configure in `hspc-csi-controller` pods. For example, `hspc-csi-driver`, `csi-provisioner`, and so on are the key to the container name inside the `hspc-csi-controller`. The **`kubectl describe deployment hspc-csi-controller -n <Storage-Plug-in-for-Containers-namespace>`** command is used to get the container names.
`spec.controller.containers.image`	The image name of `hspc-csi-controller`
`spec.controller.containers.imagePullPolicy`	The image pull policy of `hspc-csi-controller`. The default value is `IfNotPresent`.
`spec.controller.containers.env`	List of environment variables to set in `hspc-csi-controller` container. Refer to Environment variables (on page 28).
`spec.controller.containers.args`	Arguments to the entry point for `hspc-csi-controller`. This replaces all parameters at `spec.template.spec.containers.args` in a deployment of the container `hspc-csi-controller`.

Parameter	Description
`spec.controller.tolerations`	Specify the toleration of the Pod that runs `hspc-csi-controller`. The same format as Kubernetes is to be used. For details, see https://kubernetes.io/docs/concepts/scheduling-eviction/taint-and-toleration/.
`spec.controller.affinity.nodeAffinity`	Specify the node affinity of the Pod that runs `hspc-csi-controller`. The same format as Kubernetes is to be used. For details, see https://kubernetes.io/docs/tasks/configure-pod-container/assign-pods-nodes-using-node-affinity/.
`spec.node.containers.name`	Name of the container that you want to configure in `hspc-csi-node` pods. For example, `hspc-csi-driver`, `liveness-probe`, and so on are the key to the container name inside `hspc-csi-node`. The **`kubectl describe daemonset hspc-csi-node -n <Storage-Plug-in-for-Containers-namespace>`** command is used to get the container names.
`spec.node.containers.image`	The image name of `hspc-csi-node`
`spec.node.containers.imagePullPolicy`	The image pull policy of `hspc-csi-node`. The default value is `IfNotPresent`.
`spec.node.containers.env`	List of environment variables to set in `hspc-csi-node` container.
`spec.node.containers.args`	Arguments to the entry point for `hspc-csi-node`. This replaces all parameters at `spec.template.spec.containers.args` in a deployment of the container `hspc-csi-node`.
`spec.node.tolerations`	Specify the toleration of the Pod that runs `hspc-csi-node`. The same format as Kubernetes is to be used. For details, see https://kubernetes.io/docs/concepts/scheduling-eviction/taint-and-toleration/.

Parameter	Description
spec.node.affinity.nodeAffinity	Specify the node affinity of the Pod that runs hspc-csi-node. The same format as Kubernetes is to be used. For details, see https://kubernetes.io/docs/tasks/configure-pod-container/assign-pods-nodes-using-node-affinity/.

Environment variables

The following is the environment variable of hspc-csi-driver on hpsc-csi-controller:

Environment variable name	Description
SPC_VERIFY_CERTIFICATE	If true, the TLS certificate of the storage is checked in the HTTPS connection (Default: false).
TZ	Timezone for logging. For example, Asia/Tokyo (Default: UTC).

The following is an example to enable certificate verification of the hspc-csi-driver.

1. Check the current settings using the following command:

```
# kubectl get deployment -n <Storage-Plug-in-for-Containers-namespace> hspc-csi-controller -o yaml
<…>
    - name: hspc-csi-driver
      env:
      - name: CSI_ENDPOINT
        value: unix:///csi/csi-controller.sock
      - name: KUBE_NODE_NAME
        valueFrom:
          fieldRef:
            apiVersion: v1
            fieldPath: spec.nodeName
<…>
```

2. Add env: SPC_VERIFY_CERTIFICATE to Storage Plug-in for Containers manifests.

```
apiVersion: csi.hitachi.com/v1
kind: HSPC
metadata:
  name: hspc
```

```
  namespace: <Storage-Plug-in-for-Containers-namespace>
spec:
  controller:
    containers:
      - name: hspc-csi-driver
        env:
        - name: SPC_VERIFY_CERTIFICATE
          value: "true"
```

3. Uninstall and reinstall Storage Plug-in for Containers. For more information on how to uninstall and reinstall Storage Plug-in for Containers, see Installation (on page 24) and Uninstallation (on page 79).
4. Check the changes.

```
# kubectl get deployment -n <Storage-Plug-in-for-Containers-namespace> hspc-csi-
controller -o yaml
<…>
    - name: hspc-csi-driver
      env:
      - name: CSI_ENDPOINT
        value: unix:///csi/csi-controller.sock
      - name: KUBE_NODE_NAME
        valueFrom:
          fieldRef:
            apiVersion: v1
            fieldPath: spec.nodeName
      - name: SPC_VERIFY_CERTIFICATE
        value: "true"
<…>
```

Chapter 3: Usage

This chapter describes the settings and command examples for each component used in Storage Plug-in for Containers.

The procedures that follow are performed by using sample files.

Note: You can obtain the sample files from https://github.com/hitachi-vantara/csi-operator-hitachi. The sample files are stored in the `csi-operator-hitachi/hspc/<Storage-Plug-in-for-Containers-version>/sample` directory.

Secret settings

The Secret file contains the storage URL, user name, and password settings that are necessary for Storage Plug-in for Containers to work with your environment. The following sample provides information about the required parameters.

Parameter references for secret-sample.yaml

```
apiVersion: v1
kind: Secret
metadata:
  name: secret-sample              #(1)
type: Opaque
data:
  url: aHR0cDovLzE3Mi4xNi4xLjE=    #(2)
  user: VXNlcjAx                   #(3)
  password: UGFzc3dvcmQwMQ==       #(4)
```

Legend:

(1) Secret name

(2) base64-encoded storage URL

Use the IP address of the SVP for the following: VSP 5000 series, VSP F400, F600, F800, VSP F1500, VSP G200, G400, G600, G800, VSP G1000, VSP G1500, and VSP N400, N600, N800.

Use the IP address of the storage controller for the following: VSP E series, VSP F350, F370, F700, F900, and VSP G350, G370, G700, G900.

Use the service IP address for the following: VSP One B20.

Example:

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

(3) base64-encoded storage user name.

Example:

```
echo -n "User01" | base64
```

(4) base64-encoded storage password.

Example:

```
echo -n "Password01" | base64
```

StorageClass settings

The StorageClass file contains storage settings that are necessary for Storage Plug-in for Containers to work with your environment. The following sample provides information about the required parameters.

Note: After creating a StorageClass and PVC, re-creating StorageClass will not affect the existing PVCs.

StorageClass for VSP family and VSP One Block

Parameter references for the storage class YAML file

Example of the YAML file:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: sc-sample                        #(1)
  annotations:
    kubernetes.io/description: Hitachi Storage Plug-in for Containers
provisioner: hspc.csi.hitachi.com
reclaimPolicy: Delete
volumeBindingMode: Immediate
allowVolumeExpansion: true
parameters:
  serialNumber: "54321"                  #(2)
  poolID: "1"                            #(3)
  portID : CL1-A,CL2-A                   #(4)
  connectionType: fc                     #(5)
  storageEfficiency: "CompressionDeduplication"      #(6)
  storageEfficiencyMode: "PostProcess"               #(7)
  csi.storage.k8s.io/fstype: ext4                    #(8)
  csi.storage.k8s.io/node-publish-secret-name: "secret-sample"        #(9)
  csi.storage.k8s.io/node-publish-secret-namespace: "default"         #(10)
  csi.storage.k8s.io/provisioner-secret-name: "secret-sample"         #(9)
  csi.storage.k8s.io/provisioner-secret-namespace: "default"          #(10)
  csi.storage.k8s.io/controller-publish-secret-name: "secret-sample"  #(9)
  csi.storage.k8s.io/controller-publish-secret-namespace: "default"   #(10)
  csi.storage.k8s.io/node-stage-secret-name: "secret-sample"          #(9)
  csi.storage.k8s.io/node-stage-secret-namespace: "default"           #(10)
  csi.storage.k8s.io/controller-expand-secret-name: "secret-sample"   #(9)
  csi.storage.k8s.io/controller-expand-secret-namespace: "default"    #(10)
```

Legend:

(1) StorageClass name

(2) Storage serial number

(3) HDP pool ID

(4) Port ID. Use a comma separator for multipath. If an NVMe over FC connection is used, this specification is unnecessary.

(5) Connection type between storage and nodes. `fc`, `iscsi`, and `nvme-fc` are supported. If `connectionType` is not specified, `fc` is set.

Note: If an NVMe over FC connection is used, add `nvmSubsystemID`, and then specify a value.

(6) Activation of adaptive data reduction. `"Compression"`, `"CompressionDeduplication"`, and `"Disabled"` are supported. The default is `"Disabled"`, and If `"Disabled"` is specified, adaptive data reduction is disabled. For a storage system where the compression accelerator module is installed, if you specify `"Compression"` or `"CompressionDeduplication"` for `storageEfficiency`, the compression function using the compression accelerator module is automatically activated.

Note: For VSP One B20, `"Disabled"` is not supported. The default is `"CompressionDeduplication"`.

(7) Execution mode of adaptive data reduction. You can specify this parameter when `storageEfficiency` is `"Compression"` or `"CompressionDeduplication"`, and `"Inline"` and `"PostProcess"` are supported for the parameter. If `storageEfficiencyMode` is not specified, adaptive data reduction runs in the default execution mode, which depends on the storage system model. For details on the parameter, see the description of adaptive data reduction in the *Provisioning Guide for Open Systems* or *Provisioning Guide*.

Caution:

- If the LDEV was created with Storage Plug-in for Containers, do not change the parameters related to adaptive data reduction.
- Adaptive data reduction cannot be used together with the Stretched PVC function.

(8) Filesystem type. `ext4` and `xfs` are supported. If `csi.storage.k8s.io/fstype` is not specified, `ext4` is set.

(9) Secret name

(10) Secret namespace

Storage Class for VSP One SDS Block

Parameter references for sc-sample-vsp-one-sds-block.yaml

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: sc-sample-vsp-one-sds-block                                          #(1)
  annotations:
    kubernetes.io/description: Hitachi Storage Plug-in for Containers
provisioner: hspc.csi.hitachi.com
reclaimPolicy: Delete
volumeBindingMode: Immediate
allowVolumeExpansion: true
parameters:
  storageType: vsp-one-sds-block                                             #(2)
  connectionType: fc                                                 #(3)
  storageEfficiency: Disabled                                        #(4)
  csi.storage.k8s.io/fstype: ext4                                    #(5)
  csi.storage.k8s.io/node-publish-secret-name: "secret-sample"       #(6)
  csi.storage.k8s.io/node-publish-secret-namespace: "default"        #(7)
  csi.storage.k8s.io/provisioner-secret-name: "secret-sample"        #(6)
  csi.storage.k8s.io/provisioner-secret-namespace: "default"         #(7)
  csi.storage.k8s.io/controller-publish-secret-name: "secret-sample" #(6)
  csi.storage.k8s.io/controller-publish-secret-namespace: "default"  #(7)
  csi.storage.k8s.io/node-stage-secret-name: "secret-sample"         #(6)
  csi.storage.k8s.io/node-stage-secret-namespace: "default"          #(7)
  csi.storage.k8s.io/controller-expand-secret-name: "secret-sample"  #(6)
  csi.storage.k8s.io/controller-expand-secret-namespace: "default"   #(7)
```

Legend:

(1) StorageClass name

(2) Storage type. This parameter must be set to `vsp-one-sds-block` when using VSP One SDS Block.

(3) Connection type between storage and nodes. `fc` and `iscsi` are supported. If `connectionType` is not specified, `fc` is set.

(4) The setting of the data reduction function for volumes. `Compression` and `Disabled` are supported. The default is `Disabled`, and if `Disabled` is specified, the data reduction function is disabled. If you are using the multitenancy functionality, you cannot set this parameter. For multitenancy functionality, the data reduction function settings for volumes comply with the VPS settings.

(5) Filesystem type. `ext4` and `xfs` are supported. If `csi.storage.k8s.io/fstype` is not specified, `ext4` is set.

(6) Secret name

(7) Secret namespace

PersistentVolumeClaim settings

In this section, you will configure PersistentVolumeClaim settings, which are required by Storage Plug-in for Containers to dynamically create a new volume for a storage system.

The PersistentVolumeClaim file contains volume information that is used by Storage Plug-in for Containers to create PersistentVolumes. The following sample provides information about the required parameters.

Note:

- If you want to use the existing volume of the storage system as PersistentVolumeClaim, see Static provisioning (on page 52).
- If you will use PersistentVolumeClaim to be configured in this section and the static provisioning function at the same time, a static PV created by following the procedure described in Creating a PV (on page 53) must be properly associated with a PVC by performing the procedure described in Creating a PVC (on page 61). If you have not performed the procedure described in Creating a PVC (on page 61), perform the following procedure before configuring the PersistentVolumeClaim settings in this section.

  1. Check PVs for which association has not been completed.

     ```
     kubectl get pv
     ```

     PVs whose `STATUS` is `Available` have not been associated.

  2. For PVs for which association has not been completed, check whether `claimRef` is specified.

     ```
     kubectl get <PV-name> -o yaml
     ```

  3. If there are any PVs for which `claimRef` is not specified, perform either of the following procedures for each PV.
     - Re-create the static PV, specify `claimRef`, and then perform the procedure described in Creating a PVC (on page 61).
     - If you do not need the PV, delete it.

If you configure PersistentVolumeClaim settings as described in this section when there is a PV for which `claimRef` is not specified, no PV will be dynamically created by Storage Plug-in for Containers, and a PVC might be associated with the static PV whose association is not complete.

Parameter references for pvc-sample.yaml

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-sample                #(1)
spec:
  accessModes:
  - ReadWriteOnce                 #(2)
  resources:
    requests:
      storage: 1Gi                #(3)
  storageClassName: sc-sample     #(4)
```

Legend:

(1) PersistentVolumeClaim name

(2) Specify `ReadWriteOnce` or `ReadOnlyMany`. To use ReadOnlyMany, see ReadOnlyMany (on page 47).

(3) Volume size

(4) StorageClass name

Usage restrictions for a PersistentVolumeClaim

- If a failure occurs when creating a PersistentVolumeClaim, a PersistentVolumeClaim object will be created without the PersistentVolume. In this case, delete the PersistentVolumeClaim object using the `kubectl delete pvc <PVC-name>` command.
- If a failure occurs when deleting a PersistentVolumeClaim, a PersistentVolumeClaim object will be deleted but the PersistentVolume object will remain and any storage asset associated with the PersistentVolume object may also remain. In this case, see Viewing the volume properties of PersistentVolume (on page 82) and obtain the volume ID of the storage. Delete the PersistentVolume using the `kubectl delete pv <PV-name>` command. Also, delete the storage asset (LDEV). For details, see the user guide for the storage system in your environment.

Pod settings

The Pod file contains volume information. Storage Plug-in for Containers mount volumes based on this information.

Parameter references for pod-sample.yaml

```
apiVersion: v1
kind: Pod
metadata:
  name: pod-sample            #(1)
spec:
```

```
containers:
  - name: my-busybox
    image: busybox
    volumeMounts:
    - mountPath: "/data"    #(2)
      name: sample-volume
    command: ["sleep", "1000000"]
    imagePullPolicy: IfNotPresent
volumes:
  - name: sample-volume
    persistentVolumeClaim:
      claimName: pvc-sample  #(3)
```

Legend:

(1) Pod name

(2) Path (path where the volume is mounted inside a container)

(3) PersistentVolumeClaim name

Command examples

Following are examples of creating and deleting a Secret, StorageClass, PersistentVolumeClaim, and Pod using commands in practice.

Note: If your environment is OpenShift, replace Kubernetes Command Line Interface (CLI) with OpenShift CLI. For more information about OpenShift CLI, refer to the OpenShift CLI reference.

Create a Secret, StorageClass, PersistentVolumeClaim, and Pod

```
# kubectl create -f secret-sample.yaml
secret/secret-sample created

# kubectl get secret
NAME            TYPE     DATA   AGE
secret-sample   Opaque   3      34s

# kubectl create -f sc-sample.yaml
storageclass.storage.k8s.io/sc-sample created

# kubectl get sc
NAME        PROVISIONER            AGE
sc-sample   hspc.csi.hitachi.com   21s

# kubectl create -f pvc-sample.yaml
persistentvolumeclaim/pvc-sample created

# kubectl get pvc
NAME         STATUS   VOLUME                                     CAPACITY   ACCESS
MODES   STORAGECLASS   AGE
pvc-sample   Bound    pvc-cf8c6089-0386-4c39-8037-e1520a986a7d   1Gi
RWO            sc-sample      28s

# kubectl create -f pod-sample.yaml
pod/pod-sample created

# kubectl get pod
NAME         READY   STATUS    RESTARTS   AGE
pod-sample   1/1     Running   0          20s
```

Caution: If the LDEV was created with Storage Plug-in for Containers, do not change the nickname.

Confirm a PersistentVolume information created by Storage Plug-in for Containers

```
# kubectl get pv
NAME                                       CAPACITY   ACCESS MODES   RECLAIM
POLICY   STATUS   CLAIM                STORAGECLASS   REASON   AGE
pvc-3796f902-ed64-4636-9d25-e73e28e556f2   1Gi        RWO
Delete           Bound    default/pvc-sample   sc-sample               19h

# kubectl describe pv pvc-3796f902-ed64-4636-9d25-e73e28e556f2
Name:            pvc-3796f902-ed64-4636-9d25-e73e28e556f2
Labels:          <none>
Annotations:     pv.kubernetes.io/provisioned-by: hspc.csi.hitachi.com
                 volume.kubernetes.io/provisioner-deletion-secret-name: secret-
sample
                 volume.kubernetes.io/provisioner-deletion-secret-namespace: default
Finalizers:      [kubernetes.io/pv-protection]
StorageClass:    sc-sample
Status:          Bound
Claim:           default/pvc-sample
Reclaim Policy:  Delete
Access Modes:    RWO
VolumeMode:      Filesystem
Capacity:        1Gi
Node Affinity:   <none>
Message:
Source:
    Type:              CSI (a Container Storage Interface (CSI) volume source)
    Driver:            hspc.csi.hitachi.com
    FSType:            ext4
    VolumeHandle:      01--scsi--900000070010--914--spc-ecdf100f22
    ReadOnly:          false
    VolumeAttributes:      connectionType=fc
                           hostModeOption=
                           ldevIDDec=914
                           ldevIDHex=03:92
                           nickname=spc-ecdf100f22
                           ports=CL5-C
                           size=1Gi
                           storage.kubernetes.io/
csiProvisionerIdentity=1685522390822-8081-hspc.csi.hitachi.com
Events:                <none>
```

Delete a Secret, StorageClass, PersistentVolumeClaim, and Pod

```
# kubectl get pod
NAME         READY   STATUS    RESTARTS   AGE
pod-sample   1/1     Running   0          30s

# kubectl delete pod pod-sample
pod "pod-sample" deleted

# kubectl get pvc
NAME         STATUS   VOLUME                                     CAPACITY   ACCESS
MODES   STORAGECLASS   AGE
pvc-sample   Bound    pvc-cf8c6089-0386-4c39-8037-e1520a986a7d   1Gi
RWO            sc-sample      46s

# kubectl delete pvc pvc-sample
persistentvolumeclaim "pvc-sample" deleted

# kubectl get sc
NAME        PROVISIONER        AGE
sc-sample   hspc.csi.hitachi.com   53s

# kubectl delete sc sc-sample
storageclass.storage.k8s.io "sc-sample" deleted

# kubectl get secret
NAME            TYPE     DATA   AGE
secret-sample   Opaque   3      74s

# kubectl delete secret secret-sample
secret "secret-sample" deleted
```

Volume snapshot

This feature can create a snapshot that is a point-in-time image of a volume. A snapshot can be used to duplicate a previous state of an existing volume.

Note:

- If the volume is expanded, confirm for completion before executing this feature. See Volume expansion (on page 44) for more details.
- Flush the data before creating a snapshot for data consistency. For example, temporarily remove the Pod.
- This feature is not supported in VSP One B20 and VSP One SDS Block.

Before you begin

This feature requires the following resources:

- StorageClass
- PersistentVolumeClaim

If your environment is Kubernetes, install Snapshot CRDs and Snapshot Controller per cluster (see https://github.com/kubernetes-csi/external-snapshotter). For Snapshot CRDs, use v1.

Note: If Snapshot Alpha or Beta CRDs are present in your environment, remove them before installing Snapshot v1 CRDs.

Parameter references for volumesnapshotclass-sample.yaml

```
apiVersion: snapshot.storage.k8s.io/v1
kind: VolumeSnapshotClass
metadata:
  name: snapshotclass-sample    #(1)
driver: hspc.csi.hitachi.com
deletionPolicy: Delete
parameters:
  poolID: "1"                    #(2)
  csi.storage.k8s.io/snapshotter-secret-name: "secret-sample" #(3)
  csi.storage.k8s.io/snapshotter-secret-namespace: "default"  #(4)
```

Legend:

(1) VolumeSnapshotClass name

(2) Same poolID as the StorageClass

(3) Same Secret name as the StorageClass

(4) Same Secret namespace as the StorageClass

Parameter references for volumesnapshot-sample.yaml

```
apiVersion: snapshot.storage.k8s.io/v1
kind: VolumeSnapshot
metadata:
  name: snapshot-sample                                  #(1)
spec:
  volumeSnapshotClassName: snapshotclass-sample          #(2)
  source:
    persistentVolumeClaimName: pvc-sample                #(3)
```

Legend:

(1) VolumeSnapshot name

(2) VolumeSnapshotClass name

(3) PersistentVolumeClaim name from which the snapshot is obtained

Parameter references for pvc-from-snapshot-sample.yaml

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-from-snapshot-sample    #(1)
spec:
  dataSource:
    name: snapshot-sample           #(2)
    kind: VolumeSnapshot
    apiGroup: snapshot.storage.k8s.io
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi                  #(3)
  storageClassName: sc-sample       #(4)
```

Legend:

(1) PersistentVolumeClaim name

(2) VolumeSnapshot name

(3) Specify the size of the source volume. Obtain the size by using the `kubectl get pv <PV-name> -o yaml` command, which is displayed in **size**.

Note: If the volume is expanded or it is a statically provisioned PersistentVolume, obtain the size by using the `kubectl get pv <PV-name>` command. The size is displayed in **CAPACITY**.

(4) Specify the same StorageClass name as the one used for dataSource.

Command examples

- Create a VolumeSnapshotClass:

```
# kubectl create -f volumesnapshotclass-sample.yaml
```

- Create a VolumeSnapshot:

```
# kubectl create -f volumesnapshot-sample.yaml
```

- Verify that `readyToUse` is true. If it is true, the creation of VolumeSnapshot is complete.

```
# kubectl get volumesnapshot -o yaml
```

> **Note:** If `readyToUse` is false, confirm the cause and solution by following the steps:
>
> 1. Obtain the `boundVolumeSnapshotContentName` by using the command: **`kubectl get volumesnapshot -o yaml`**
> 2. Confirm the error message by using the command: **`kubectl describe volumesnapshotcontent <VolumeSnapshotContentName>`**

- Create a PersistentVolumeClaim from a snapshot:

```
# kubectl create -f pvc-from-snapshot-sample.yaml
```

Volume cloning

This feature can create a duplicate as a clone of an existing volume. A clone can be consumed in the same way as any standard volume.

> **Note:**
>
> - If the volume is expanded, confirm for completion before executing this feature. Refer to Volume expansion (on page 44) for details.
> - Flush the data before cloning for data consistency. For example, temporarily remove the Pod.
> - This feature is not supported in VSP One B20 and VSP One SDS Block.

Before you begin

This feature requires the following resources:

- StorageClass
- PersistentVolumeClaim

Parameter references for pvc-from-pvc-sample.yaml

This YAML file is a manifest file for creating a clone from an existing volume "pvc-sample".

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-from-pvc-sample      #(1)
spec:
  dataSource:
    name: pvc-sample             #(2)
    kind: PersistentVolumeClaim
    apiGroup: ""
```

```
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi                #(3)
  storageClassName: sc-sample     #(4)
```

Legend:

(1) PersistentVolumeClaim name of clone

(2) PersistentVolumeClaim name of source

(3) Specify the size of the source volume. Obtain the size by using the `kubectl get pv <PV-name> -o yaml` command, which is displayed in **size**.

Note: If the volume is expanded or it is a statically provisioned PersistentVolume, obtain the size by using the `kubectl get pv <PV-name>` command, which is displayed in **CAPACITY**.

(4) Specify the same StorageClass name as the one used for dataSource.

Command examples

- Create a PersistentVolumeClaim for a clone:

```
# kubectl create -f pvc-from-pvc-sample.yaml
```

Volume expansion

This feature can expand the capacity of an existing volume. There is no need to delete and recreate the Pod for volume expansion.

Caution:

- Confirm completion of volume expansion with the `kubectl get pvc` command, which is displayed in **CAPACITY**. Do not shut down the OS or drain the node before volume expansion completes.
- In NVMe over FC, volume expansion in the state in which the PVC is attached to a host is not supported. Expand a volume in the state in which the PVC is detached from the host.

Before you begin

This feature requires the following resources:

- StorageClass
- PersistentVolumeClaim

Note: Volume expansion has the following restrictions:

- The minimum additional size for volume expansion is 1 GiB.
- The maximum additional size for volume expansion is 7 TiB or a value that does not exceed the warning threshold of pool capacity. If you add more than 7 TiB, execute the command again.
- Volume capacity cannot be reduced.
- While `allowVolumeExpansion` of StorageClass is set to `false`, a PersistentVolume created with this setting cannot be expanded.
- The size obtained by the `kubectl get pv <PV-name> -o yaml` command is not updated after the volume is expanded. If the volume is expanded, obtain the size by using the `kubectl get pv <PV-name>` command, which is displayed in **CAPACITY**.

Command examples

- Expand the capacity of an existing volume pvc-sample to 5GiB:

```
# kubectl patch pvc pvc-sample --patch \
'{"spec":{"resources":{"requests":{"storage": "5Gi"}}}}'
```

- Confirm the completion of volume expansion by looking at **CAPACITY**:

```
# kubectl get pv <PV-name>
NAME           CAPACITY     ACCESS MODES      RECLAIM POLICY
STATUS CLAIM                STORAGECLASS      REASON AGE
<PV-name>      5Gi          RWO               Delete
Bound default/pvc-sample    sc-sample               35s
```

Caution: If you want to change the size of an LDEV created with Storage Plug-in for Containers, use the `kubectl` command instead of using the storage system management software to change the size of the LDEV.

Raw block volume

Kubernetes supports raw block volumes in addition to filesystem volumes. This section describes how to apply a raw block volume.

Before you begin

This feature requires the StorageClass.

Parameter references for pvc-sample-block.yaml

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-sample-block    #(1)
```

```
spec:
  accessModes:
  - ReadWriteOnce    #(2)
  volumeMode: Block
  resources:
    requests:
      storage: 1Gi    #(3)
  storageClassName: sc-sample    #(4)
```

Legend:

(1) PersistentVolumeClaim name

(2) Specify `ReadWriteOnce` or `ReadWriteMany`.

(3) Volume size

(4) StorageClass name

Parameter references for pod-sample-block.yaml

```
apiVersion: v1
kind: Pod
metadata:
  name: pod-sample-block               #(1)
spec:
  containers:
    - name: my-busybox
      image: busybox
      volumeDevices:
      - devicePath: "/block"    #(2)
        name: sample-volume
      command: ["sleep", "1000000"]
      imagePullPolicy: IfNotPresent
  volumes:
    - name: sample-volume
      persistentVolumeClaim:
        claimName: pvc-sample-block    #(3)
```

Legend:

(1) Pod name

(2) Path (path where the volume is mounted in the container)

(3) PersistentVolumeClaim name

Command examples

- Create a PersistentVolumeClaim for a raw block volume:

```
# kubectl create -f pvc-sample-block.yaml
```

- Create a Pod for a raw block volume:

```
# kubectl create -f pod-sample-block.yaml
```

ReadOnlyMany

You can mount a volume on one or many nodes in your Kubernetes cluster and perform read-only operations.

To create a PersistentVolumeClaim with ReadOnlyMany, you must create the PersistentVolumeClaim from an existing PVC.

Use the PersistentVolumeClaim manifest file used in the Volume cloning (on page 43) section and specify ReadOnlyMany, as shown in the following example.

Note: This feature is not supported in VSP One B20 and VSP One SDS Block.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-rox-sample
spec:
  dataSource:
    name: pvc-sample
    kind: PersistentVolumeClaim
    apiGroup: ""
  accessModes:
  - ReadOnlyMany # Specify "ReadOnlyMany" here.
  resources:
    requests:
      storage: 1Gi
  storageClassName: sc-sample
```

Resource partitioning

By using this function, you can partition storage system resources for each Kubernetes cluster.

The following are examples of resource partitioning:

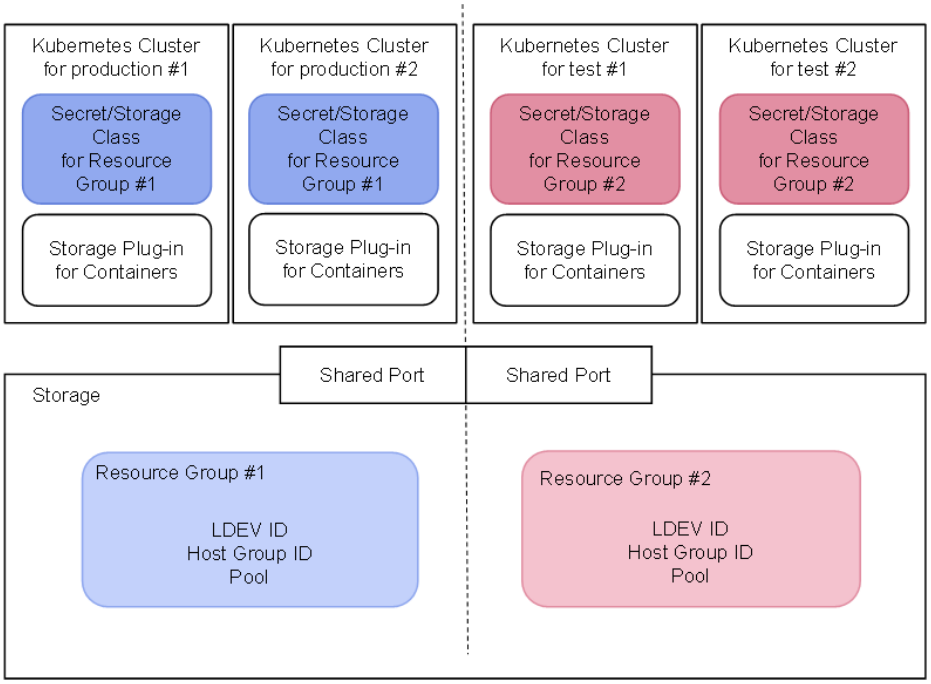
- You can restrict the range of LDEV IDs added to a resource group for a specific Kubernetes cluster.
- You can isolate the impacts between Kubernetes clusters.

Note: Resource partitioning is not supported for VSP One SDS Block.

Before you use the resource partitioning, the storage system settings, Secret and StorageClass settings, are required.

Supported configurations

The following are examples of configurations in which storage system resources can be partitioned.



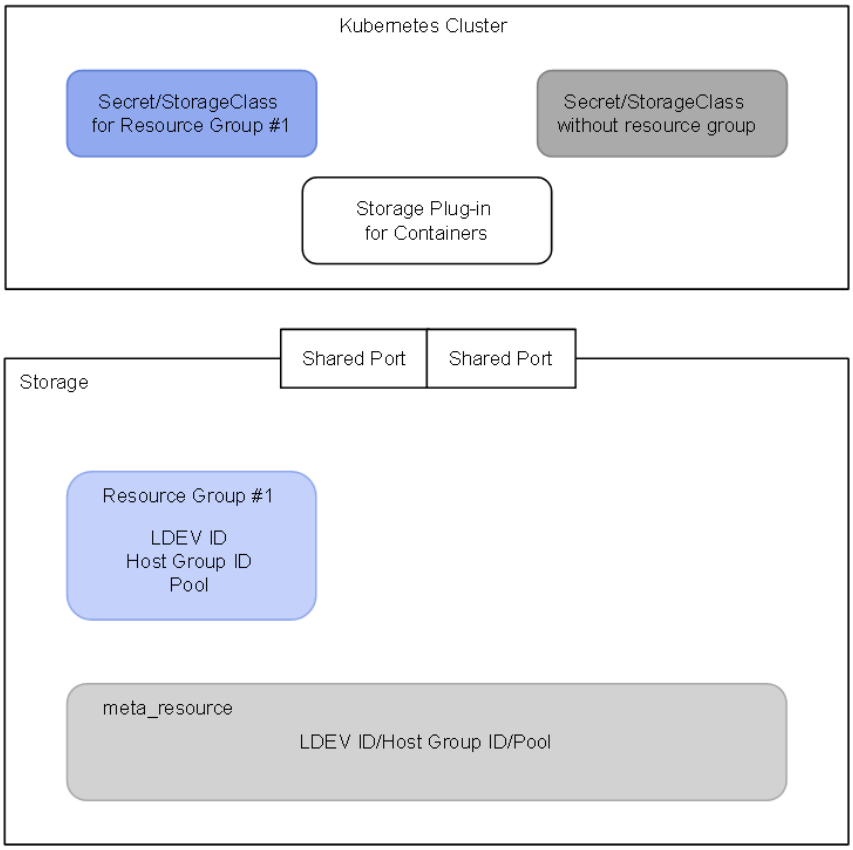
Unsupported configurations

The following are examples of configurations that are not supported.

Example 1

You cannot include both the following configurations in the same Kubernetes cluster.

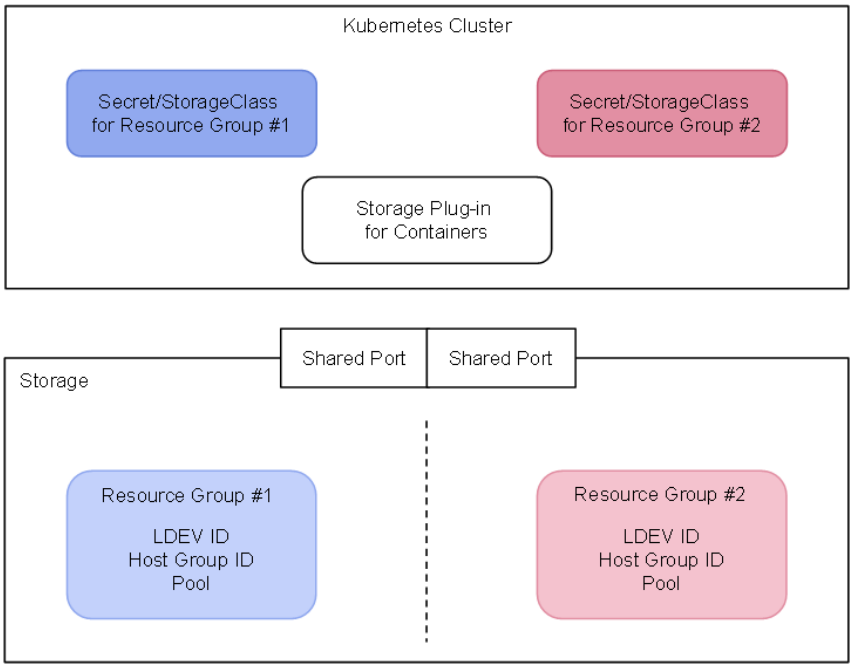
- StorageClass and Secret are configured for a resource group.
- StorageClass and Secret are temporarily configured for use with meta resource.



Example 2

If multiple resource groups are configured for a single storage system, each of those resource groups cannot correspond to a resource group in the same Kubernetes cluster.

Only one resource group (containing storageClass and Secret) per storage system can be configured for a Kubernetes cluster.



Storage system requirements and settings

Set your storage system to meet the following requirements:

Storage system resources	Descriptions
Resource group	You cannot use multiple resource groups for a single Kubernetes cluster. Virtual storage machines are not supported.
Storage system user group and Storage system user	Storage system users must have access only to the resource group that you created. The storage system user must not have access to other resource groups.
Pool	Create a pool from pool volumes with the resource group that you have created.
LDEV	Allocate the necessary number of unused LDEV IDs to the resource group. If you enable the adaptive data reduction function, a deduplication system data volume is created. Register the LDEV ID required to allocate this volume to each resource group. For details about the number of LDEV IDs that need to be registered, see the user guide for the storage system in your environment.

Storage system resources	Descriptions
Host Group	For each port of a storage system defined in StorageClass, prepare the same number of host group IDs as the number of hosts. For example, if the number of hosts is 3 and the number of ports is 2, a total of 6 host group IDs are required. For each storage system port, allocate the prepared host group IDs to the resource groups.
NVM subsystem	If NVMe over FC is used, assign the NVM subsystem to the resource group.
Port	If NVMe over FC is used, assign the storage system port to the resource group.

Secret settings

Specify the resource group ID of the storage system.

Example of Secret settings:

```
apiVersion: v1
kind: Secret
metadata:
  name: secret-sample
type: Opaque
data:
  url: aHR0cDovLzE3Mi4xNi4xLjE=
  user: VXNlcjAx
  password: UGFzc3dvcmQwMQ==
stringData:
  resourceGroupID: "1"    # Specify resource group ID
```

StorageClass settings

If you use iSCSI as a storage system connection, specify the port IP address in number order. If you use Fibre Channel or NVMe over FC as a storage system connection, no additional setting is required for StorageClass.

Examples of StorageClass settings:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: sc-sample
provisioner: hspc.csi.hitachi.com
reclaimPolicy: Delete
volumeBindingMode: Immediate
allowVolumeExpansion: true
parameters:
```

```
  serialNumber: "54321"
  poolID: "1"
  portID : CL1-A,CL2-A
  connectionType: iscsi
  portIP: "192.168.10.10, 192.168.10.11"    # Specify iSCSI Port IP Addresses.
<...>
```

Static provisioning

This function allows existing volumes in a storage system to be used as PVCs by a container orchestrator. By using this function, you can perform operations on existing volumes in the same way as PVCs dynamically provisioned by using Storage Plug-in for Containers.

Requirements for using static provisioning

The requirements for using static provisioning are as follows:

Make sure that the volume meets the following requirements:

Requirements for VSP family and VSP One Block

- The LDEV has the HDP attribute.

  For VSP family, the LDEV does not have the DRS attribute.

  For VSP One Block, the LDEV has the DRS attribute.

  Tip: The DRS attribute indicates the data reduction shared volume.

- The format of the nickname is `spc-<10-digit-hexadecimal-number>`.

  <10-digit-hexadecimal-number> needs to be a unique value for each LDEV.

  If the nickname is the same as that of another LDEV, the functions supported by Storage Plug-in for Containers might not work properly.

  You can also use a command to generate a unique character string for a nickname. The following is an example command:

  ```
  # echo spc-$(cat /dev/urandom | tr -dc a-f0-9 | head -c 10)
  ```

- The LDEV is not mapped to a port.
- No pairs are formed.

For other requirements, see Requirements (on page 12).

If the LDEV is assigned to a specific resource group, also see the storage system requirements in Resource partitioning (on page 47).

Note: The following restrictions apply to the use of static provisioning:

- It is not supported for stretched PVCs.
- Static provisioning cannot be used together with Replication Plug-in for Containers.

Requirements for VSP One SDS Block

Refer to the *VSP One SDS Block Storage Administrator Guide* and check the following requirements.

- `naaId` can be obtained as volume information.

  For volumes created for VSP One SDS Block v1.11 or earlier versions, `naaId` cannot be obtained. Therefore, these volumes are not supported.

- `volumeType` is `Normal`.
- `name` and `nickname` have the same value, and their format is `spc-<`*`10-digit-hexadecimal-number`*`>`.

  You can also use a command to generate a unique character string for `name`. The following is an example command:

```
# echo spc-$(cat /dev/urandom | tr -dc a-f0-9 | head -c 10)
```

- The volume is not connected to a computer node.

For other requirements, see Requirements (on page 12).

If the volume is assigned to a specific VPS, also see Multitenancy functionality settings (on page 23).

Creating Secret and StorageClass

Create the Secret and StorageClass to be specified when creating a PV and PVC.

For details about the settings in the YAML files for Secret and StorageClass, see Secret settings (on page 30) and StorageClass settings (on page 31). If you are using VSP family or VSP One Block and the volume is assigned to a specific resource group, also see the descriptions of Secret settings and StorageClass settings in Resource partitioning (on page 47).

For the parameters of StorageClass, specify values based on the status of the target volume. If the values specified for the parameters do not match the actual volume status, the functions supported by Storage Plug-in for Containers might not work properly.

Creating a PV

Create a PV to be associated with a PVC.

Note:

- You can create only one PV for one volume.

  If you create more than one PV for one volume, the functions supported by Storage Plug-in for Containers might not work properly.

- If values specified for the parameters of the PV are incorrect, an unexpected error message might be displayed.

Procedure

1. Create a YAML file.

   For the parameters of the PV, specify values based on the status of the target volume and the settings of the created StorageClass. If the values specified for the parameters do not match the actual volume status, the functions supported by Storage Plug-in for Containers might not work properly.

   Example of the YAML file for VSP family and VSP One Block:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: static-pv
  annotations:
    pv.kubernetes.io/provisioned-by: hspc.csi.hitachi.com
spec:
  persistentVolumeReclaimPolicy: Delete
  accessModes:
  - ReadWriteOnce
  capacity:
    storage: 1Gi
  volumeMode: Filesystem
  csi:
    fsType: ext4
    volumeAttributes:
      connectionType: fc
      ports: CL1-A, CL2-A
    volumeHandle: 01--scsi--900000070010--50000--spc-c3d46c5a71
    driver: hspc.csi.hitachi.com
    controllerExpandSecretRef:
      name: secret-sample
      namespace: default
    controllerPublishSecretRef:
      name: secret-sample
      namespace: default
  storageClassName: sc-sample
  claimRef:
    name: static-pvc
    namespace: default
```

   Parameters for VSP family and VSP One Block:

Parameter	Description	Required or optional
`metadata.name`	Specify the PV name.	Required
`metadata.annotations.pv.kubernetes.io/provisioned-by`	Specify `hspc.csi.hitachi.com`.	Required if `Delete` is specified for `persistentVolumeReclaimPolicy`
`spec.persistentVolumeReclaimPolicy`	Specify the reclaim policy. If you specify `Retain`, the PV and LDEV will not be deleted even when the PVC is deleted. Instead, the PV will be in the released state, so if you want to reuse the LDEV, you will need to re-create the PV. For details, see https://kubernetes.io/docs/concepts/storage/persistent-volumes/#retain. If you specify `Delete`, the PV and LDEV will be deleted when the PVC is deleted. The default value is `Retain`.	Optional
`spec.accessModes`	Specify the access mode. For details about supported access modes, see PersistentVolumeClaim settings (on page 35).	Required
`spec.capacity.storage`	Specify the LDEV size.	Required
`spec.volumeMode`	Specify `Filesystem` or `Block`. If the target LDEV was used as a raw block volume, be sure to specify `Block`. If the LDEV was used as a raw block volume and you specify `Filesystem`, it will be formatted as a file system and the existing data will be deleted. The default value is `Filesystem`.	Optional
`spec.csi.fsType`	Specify the file system type of the target LDEV. The default value is `ext4`.	Optional

Parameter	Description	Required or optional
	If you specify `Block` for `volumeMode`, this parameter is disabled. For details about supported file system types, see StorageClass settings (on page 31).	
`spec.csi.volumeAttributes.connectionType`	Specify the type of connection between the storage system and the node. For details about supported connection types, see StorageClass settings (on page 31).	Required
`spec.csi.volumeAttributes.ports`	Specify the storage port ID. For multipath configurations, use commas to delimit the storage port IDs.	Required if `fc` or `iscsi` is specified for `connectionType`
`spec.csi.volumeAttributes.portIPs`	Specify the storage port IP address. For multipath configurations, use commas to delimit the storage port IP addresses.	Required if `iscsi` is specified for `connectionType` and the LDEV is assigned to a specific resource group
`spec.csi.volumeAttributes.nvmSubsystemID`	Specify the NVM subsystem ID of the storage system.	Required if `nvme-fc` is specified for `connectionType`
`spec.csi.volumeHandle`	Specify the value in the following format: `01--<IO-protocol>--<storage-device-ID>--<LDEV-ID>--<LDEV-nickname>`	Required

Parameter	Description	Required or optional
	<IO-protocol> Specify the value as follows: ▪ If `fc` or `iscsi` is specified for `connectionType`: `scsi` ▪ If `nvme-fc` is specified for `connectionType`: `nvme` ***<storage-device-ID>*** Check this value by referring to the *REST API Reference Guide* for each storage model. The storage device ID is a 12-digit value and the format is as follows: *<6-digit-fixed-value-for-each-storage-model><6-digit-serial-number>* For example, the fixed value for VSP 5100 is `900000`. ***<LDEV-ID>*** Check these values by using the storage system management software. Specify a value by using a decimal number. ***<LDEV-nickname>*** Check these values by using the storage system management software.	
`spec.csi.driver`	Specify `hspc.csi.hitachi.com`.	Required
`spec.csi.controllerExpandSecretRef.name`	Specify the name of the Secret.	Required
`spec.csi.controllerExpandSecretRef.namespace`	Specify the namespace of the Secret.	Required

Parameter	Description	Required or optional
`spec.csi.controllerPublishSecretRef.name`	Specify the name of the Secret.	Required
`spec.csi.controllerPublishSecretRef.namespace`	Specify the namespace of the Secret.	Required
`spec.storageClassName`	Specify the StorageClass name.	Required
`spec.claimRef.name`	Specify the PVC name to be created in Creating a PVC (on page 61).	Required If you do not specify this parameter, the PV might be associated with an unintended PVC and the Storage Plug-in for Containers functions might not work properly.
`spec.claimRef.namespace`	Specify the namespace of the PVC to be created in Creating a PVC (on page 61).	Required

Example of the YAML file for VSP One SDS Block:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: static-pv
  annotations:
    pv.kubernetes.io/provisioned-by: hspc.csi.hitachi.com
spec:
  persistentVolumeReclaimPolicy: Delete
  accessModes:
  - ReadWriteOnce
  capacity:
    storage: 1Gi
  volumeMode: Filesystem
  csi:
    fsType: ext4
    volumeAttributes:
      connectionType: fc
    volumeHandle: 60060e81166020006016602000000004f--spc-909b93359a--4026f840-e15e-
4410-a37f-3862072c10ba
    driver: hspc.csi.hitachi.com
```

```
  controllerExpandSecretRef:
    name: secret-sample
    namespace: default
  controllerPublishSecretRef:
    name: secret-sample
    namespace: default
storageClassName: sc-sample-vsp-one-sds-block
claimRef:
  name: static-pvc
  namespace: default
```

Parameters for VSP One SDS Block:

Parameter	Description	Required or optional
`metadata.name`	Specify the PV name.	Required
`metadata.annotations.pv.kubernetes.io/provisioned-by`	Specify `hspc.csi.hitachi.com`.	Required if `Delete` is specified for `persistentVolumeReclaimPolicy`
`spec.persistentVolumeReclaimPolicy`	Specify the reclaim policy. If you specify `Retain`, the PV and volume will not be deleted even when the PVC is deleted. Instead, the PV will be in the released state, so if you want to reuse the volume, you will need to re-create the PV. For details, see https://kubernetes.io/docs/concepts/storage/persistent-volumes/#retain. If you specify `Delete`, the PV and volume will be deleted when the PVC is deleted. The default value is `Retain`.	Optional
`spec.accessModes`	Specify the access mode. For details about supported access modes, see PersistentVolumeClaim settings (on page 35).	Required
`spec.capacity.storage`	Specify the volume size.	Required
`spec.volumeMode`	Specify `Filesystem` or `Block`.	Optional

Parameter	Description	Required or optional
	If the target volume was used as a raw block volume, be sure to specify `Block`. If the volume was used as a raw block volume and you specify `Filesystem`, it will be formatted as a file system and the existing data will be deleted. The default value is `Filesystem`.	
`spec.csi.fsType`	Specify the file system type of the target volume. The default value is `ext4`. If you specify `Block` for `volumeMode`, this parameter is disabled. For details about supported file system types, see StorageClass settings (on page 31).	Optional
`spec.csi.volumeAttributes.connectionType`	Specify the type of connection between the storage system and the node. For details about supported connection types, see StorageClass settings (on page 31).	Required
`spec.csi.volumeHandle`	Specify the value in the following format: `<volume-naaId>--<volume-name>--<volume-id>` ***<volume-naaId>*** `naaId` of the target volume ***<volume-name>*** `name` of the target volume ***<volume-id>*** `id` of the target volume	Required

Parameter	Description	Required or optional
	For details about how to check `naaId`, `name`, and `id`, see the *VSP One SDS Block Storage Administrator Guide*.	
`spec.csi.driver`	Specify `hspc.csi.hitachi.com`.	Required
`spec.csi.controllerExpandSecretRef.name`	Specify the name of the Secret.	Required
`spec.csi.controllerExpandSecretRef.namespace`	Specify the namespace of the Secret.	Required
`spec.csi.controllerPublishSecretRef.name`	Specify the name of the Secret.	Required
`spec.csi.controllerPublishSecretRef.namespace`	Specify the namespace of the Secret.	Required
`spec.storageClassName`	Specify the StorageClass name.	Required
`spec.claimRef.name`	Specify the PVC name to be created in Creating a PVC (on page 61).	Required If you do not specify this parameter, the PV might be associated with an unintended PVC and the Storage Plug-in for Containers functions might not work properly.
`spec.claimRef.namespace`	Specify the namespace of the PVC to be created in Creating a PVC (on page 61).	Required

2. Deploy the YAML file.

```
# kubectl apply -f <YAML-file-name>
```

Creating a PVC

Create a PVC so that Storage Plug-in for Containers functions can be used.

Procedure

1. Create a YAML file.

   Example of the YAML file:

   The following shows examples for VSP family or VSP One Block.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: static-pvc
  namespace: default
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi
  storageClassName: sc-sample
  volumeMode: Filesystem
  volumeName: static-pv
```

   Parameters:

Parameter	Description	Required or optional
`metadata.name`	Specify the PVC name.	Required
`metadata.namespace`	Specify the namespace of the PVC.	Optional
`spec.accessModes`	Specify the same value as the value of `accessModes` for the PV.	Required
`spec.resources.requests.storage`	Specify the same value as the value of `capacity.storage` for the PV.	Required
`spec.storageClassName`	Specify the same value as the value of `storageClassName` for the PV.	Required
`spec.volumeName`	Specify the PV name.	Required

Parameter	Description	Required or optional
		If you do not specify this parameter, the PVC might be associated with an unintended PV and the Storage Plug-in for Containers functions might not work properly.
`spec.volumeMode`	If you specified `volumeMode` for the PV, specify the same value for this parameter as you did for the PV. The default value is `Filesystem`.	Required if you specified `Block` for `volumeMode` of the PV

2. Deploy the YAML file.

```
# kubectl apply -f <YAML-file-name>
```

3. Confirm that STATUS of the PVC is Bound.
   When STATUS of the PVC is Bound, you can use the functions supported by Storage Plug-in for Containers.

Troubleshooting when using static provisioning

A VolumeAttachment remains after you delete the Pod

If there are mistakes in the format or values of parameters in the YAML file for the PV, the creation of the Pod will fail. If you delete this Pod, a VolumeAttachment might remain.

The following are examples of failed attempts to create a Pod:

- Incorrect format of `volumeHandle` (error code: `0x0000c002`)
- Insufficient permissions for LDEV (error code: `0x00001007`)
- `controllerPublishSecretRef` is not specified (error code: `0x0000c00f`)

To delete a VolumeAttachment, run the following command:

```
# kubectl patch volumeattachments <VolumeAttachment-name> --type merge -p
'{"metadata":{"finalizers":null}}'
```

The PV remains after you delete the PVC

If there are mistakes in the format or values of parameters in the YAML file for the PV, even if you specify `Delete` for `persistentVolumeReclaimPolicy`, the PV might remain after you delete the PVC.

The following shows examples of a PV remaining after a PVC is deleted:

- Incorrect format of `volumeHandle` (error code: `0x0000c002`)
- Insufficient permissions for LDEV (error code: `0x00001007`)

To delete the PV, perform the following procedure:

1. If you need to delete the volume, use the `volumeHandle` information to check the target volume.

   ```
   # kubectl get pv <PV-name> -o yaml
   ```

2. Delete the PV.

   ```
   # kubectl delete pv <PV-name>
   ```

3. If you need to delete the volume, use the management software for the storage system to delete it.

The volume remains after you delete the PVC

In the following cases, if you specify `Delete` for `persistentVolumeReclaimPolicy`, the PV will be deleted after the PVC is deleted, but the volume will not be deleted.

VSP family and VSP One Block:

For the LDEV specified by <*LDEV-ID*> of `volumeHandle`, an incorrect value is specified for <*LDEV-nickname*>.

VSP One SDS Block:

- For the volume specified by <*volume-id*> of `volumeHandle`, an incorrect value is specified for <*volume-naaId*> or <*volume-name*>.
- For the volume specified by <*volume-id*> of `volumeHandle`, user permissions specified in the Secret are insufficient.

To delete the volume, use the management software for the storage system to delete it.

Chapter 4: Technology preview

This chapter describes a Technology Preview feature that is included with the software code.

Use of this feature is only recommended in a test environment as it is not covered under any Hitachi Vantara LLC support plans, may not be functionally complete, and is not intended for production use.

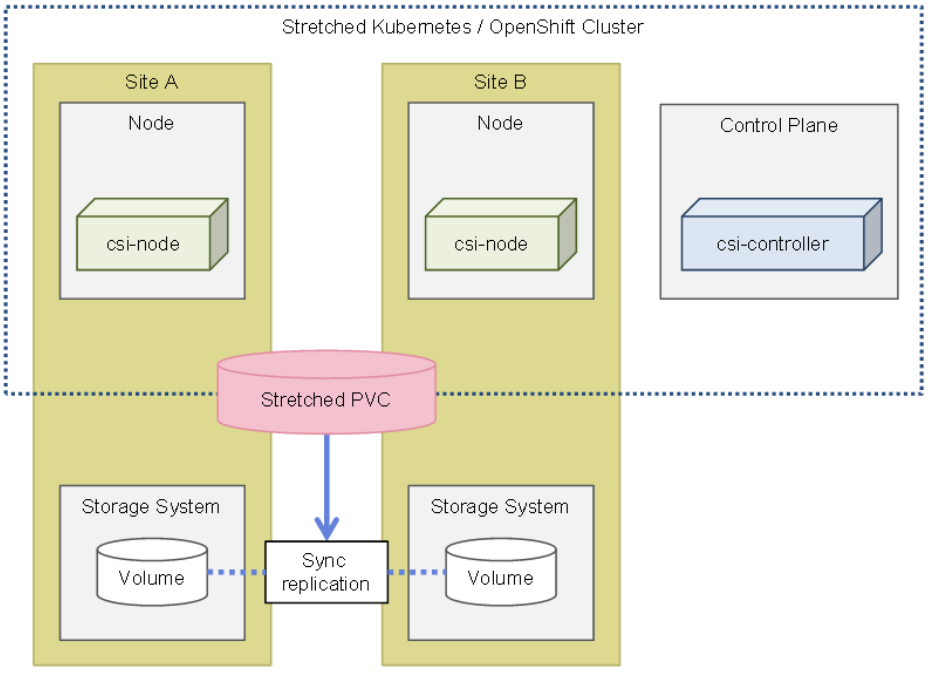
For full information about Technology Preview, review the release notes.

Stretched PVC

The Stretched PersistentVolumeClaim (PVC) feature automates the provisioning of synchronous replication between the storage system at each site in a single Kubernetes or OpenShift cluster that spans two sites. By using this feature, you can build a high-availability cluster that includes storage systems at two sites.

The provisioning of synchronous replication for conventional systems requires the storage system administrator, cluster administrator, and user to cooperate closely. By using the Stretched PVC feature, the cluster administrator and user can perform the provisioning of synchronous replication by themselves by using the command line tool for Kubernetes or OpenShift.

The following figure gives an overview of a cluster environment in which Stretched PVC is installed.



Requirements for using the Stretched PVC feature

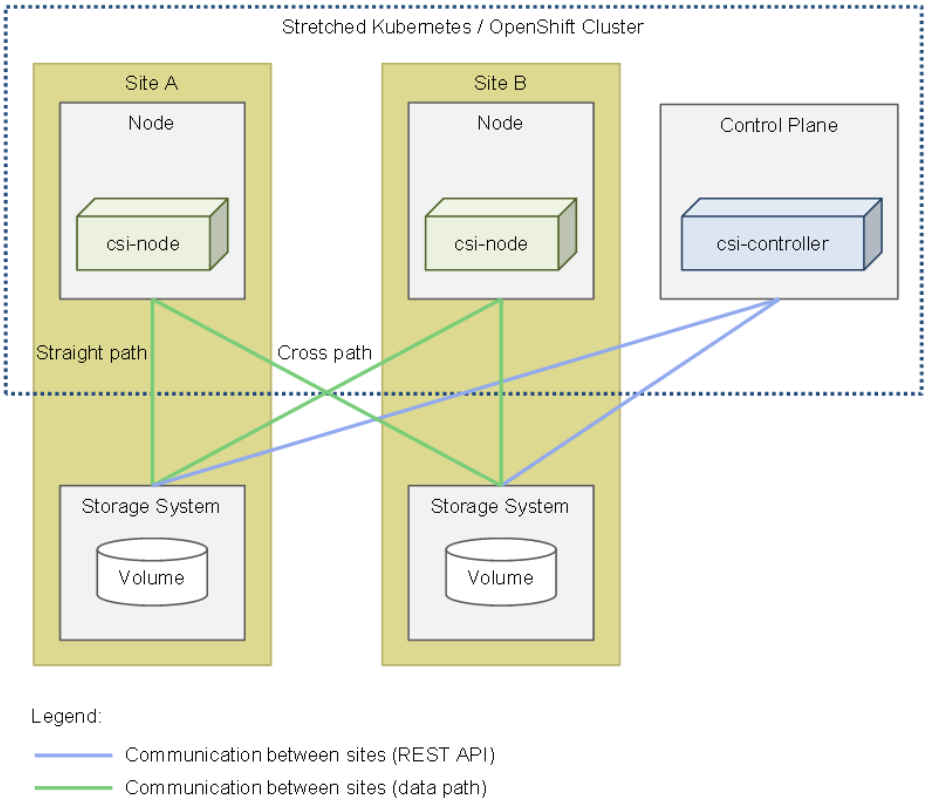
The Stretched PVC feature automates replication provisioning. Note that this feature includes neither the management and monitoring of the replication status, nor the management and monitoring of the status of the primary and secondary sites.

Requirements for all systems

The following table shows the system-wide requirements for using Stretched PVC.

Item	Description
Cluster configuration	Configure a single Kubernetes or OpenShift cluster (stretched cluster) that spans two sites. Then, allocate one storage system to each site.
Communication between sites (REST API)	Specify settings so that Storage Plug-in for Containers can communicate with the storage systems at the primary site and at the secondary site by using the REST API.
Communication between sites (data path)	Specify settings so that each node can perform data communication with the storage systems at the primary site and at the secondary site. Only Fibre Channel is supported for communication between nodes and storage systems.

The following is an overview of connecting the server and storage systems in a stretched cluster.



Requirements and settings for storage systems

Check the following requirements and settings for both the primary site and secondary site. For details, see the *Global-Active Device User Guide*.

Item	Description
Storage system models	The following storage systems are supported: ▪ VSP E series ▪ VSP 5000 series ▪ VSP F350, F370, F700, F900 ▪ VSP G350, G370, G700, G900
License	Apply the required license by referring to the *Global-Active Device User Guide*.

Item	Description
Virtual storage machines	For each storage system, create one virtual storage machine. The virtual storage machine must meet the following requirements: ▪ At the primary site and the secondary site, specify the same serial number and model for the virtual storage machines. Note that a virtual storage machine is also required at the primary site. ▪ For the model of the virtual storage machines, specify any storage system model supported by the Stretched PVC feature. ▪ Use the virtual storage machines only for Storage Plug-in for Containers. Do not use the virtual storage machines for other purposes. Note the following when using the same combination of storage systems from multiple clusters: ▪ For each cluster, use the same storage system users and virtual storage machines. ▪ Make sure that the combination of the storage system set for the primary site and the storage system set for the secondary site for each cluster matches each other.
Users and user groups	Create a user group that has access permissions only for the resource group of the created virtual storage machine. In addition, create users to which only the created user group is assigned.
Pool	Create a pool from the pool volumes in the created virtual storage machines.
LDEV	Assign the required number of unused LDEV IDs to the virtual storage machines. For the assigned LDEVs, change the virtual LDEV ID to unassigned (65534).
Host groups	For each port that you want to use, assign the required number of unused host group IDs for the virtual storage machines. The number of host group IDs must be at least the total number of hosts + 1.
Remote paths	Create remote paths. The same path group ID must be used for both the primary site and the secondary site.
Quorum disks	Create quorum disks. The same quorum disk ID must be used for both the primary site and the secondary site.

Using a regular PVC in a stretched cluster

To use a regular PVC instead of Stretched PVC in a stretched cluster, specify settings in advance by referring to Resource partitioning (on page 47). Note the items listed in the following table when specifying settings in advance:

Item	Description
Resource group	Create a resource group. However, do not create a resource group from a virtual storage machine.
Host groups	Use ports that are not used by Stretched PVCs.

When connecting to a Pod, if you want to control the site to which the Pod will be deployed, use the Node Affinity or Node Selector feature of Kubernetes and OpenShift.

When using Stretched PVC together with other features

The following table shows whether Stretched PVC can be used together with other features:

Feature	Can be used with Stretched PVC?
Volume snapshot	Yes (For details about how to use it, see Creating a clone from a Stretched PVC (on page 73).)
Volume cloning	Yes (For details about how to use it, see Creating a clone from a Stretched PVC (on page 73).)
Volume expansion	No
Raw block volume	Yes
ReadOnlyMany	No
Adaptive data reduction	No

Note: Do not use the Stretched PVC feature and Replication Plug-in for Containers together in the same Kubernetes cluster.

Creating a Stretched PVC

You can create a Secret and StorageClass specifically for a Stretched PVC, and then use the created Secret and StorageClass to create a Stretched PVC. You can also use the created Stretched PVC in the same way as a regular PVC.

When Storage Plug-in for Containers receives the Secret and StorageClass specifically for the Stretched PVC, Storage Plug-in for Containers creates volumes at the specified primary site and secondary site and generates a global-active device pair. The volumes created at the primary site and secondary site and the global-active device pair are to be deleted when the Stretched PVC is deleted. Use Storage Navigator to manage the status of the global-active device pair in the period between the creation and deletion of the Stretched PVC.

To create a Stretched PVC:

Procedure

1. Create a Secret specifically for the Stretched PVC. A sample (`secret-sample-stretched.yaml`) can be found in the yaml directory.

```
apiVersion: v1
kind: Secret
metadata:
  name: secret-sample-stretched
type: Opaque
stringData:
  primarySerial: "11111"                  #(1)
  primaryURL : http://172.16.0.1          #(2)
  primaryUser : primary-user              #(3)
  primaryPassword : primary-password      #(4)
  secondarySerial: "22222"                #(5)
  secondaryURL : http://172.16.0.2        #(6)
  secondaryUser : secondary-user          #(7)
  secondaryPassword : secondary-password  #(8)
```

   Legend:

   (1) Serial number of the storage system at the primary site

   (2) URL of the REST API of the storage system at the primary site

   (3) User of the storage system at the primary site

   (4) Password for the storage system at the primary site

   (5) Serial number of the storage system at the secondary site

   (6) URL of the REST API of the storage system at the secondary site

   (7) User of the storage system at the secondary site

   (8) Password for the storage system at the secondary site

2. Create a StorageClass specifically for the Stretched PVC. A sample (`sc-sample-stretched.yaml`) can be found in the yaml directory.

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: sc-sample-stretched
  annotations:
```

```
    kubernetes.io/description: Hitachi Storage Plug-in for Containers
provisioner: hspc.csi.hitachi.com
reclaimPolicy: Delete
volumeBindingMode: Immediate
allowVolumeExpansion: false
parameters:
  connectionType: fc
  replicationType: stretched              #(1)
  quorumID: "30"                          #(2)
  primaryPoolID: "10"                     #(3)
  primaryPortID: CL1-A,CL2-A              #(4)
  secondaryPoolID: "20"                   #(5)
  secondaryPortID: CL1-F                  #(6)
  csi.storage.k8s.io/node-publish-secret-name: "secret-sample-stretched"
  csi.storage.k8s.io/node-publish-secret-namespace: "default"
  csi.storage.k8s.io/provisioner-secret-name: "secret-sample-stretched"
  csi.storage.k8s.io/provisioner-secret-namespace: "default"
  csi.storage.k8s.io/controller-publish-secret-name: "secret-sample-stretched"
  csi.storage.k8s.io/controller-publish-secret-namespace: "default"
  csi.storage.k8s.io/node-stage-secret-name: "secret-sample-stretched"
  csi.storage.k8s.io/node-stage-secret-namespace: "default"
```

Legend:

(1) Parameter indicating that the replication type is Stretched PVC

(2) ID of the Quorum disk

(3) Pool ID of the storage system at the primary site

(4) Port ID of the storage system at the primary site

(5) Pool ID of the storage system at the secondary site

(6) Port ID of the storage system at the secondary site

3. Create a PVC by specifying the created StorageClass.
4. Display the created PVC to make sure that STATUS is Bound.

Note: Creating a Stretched PVC takes more time than creating a regular PVC.

Checking information on Stretched PVCs

A PV is created after a Stretched PVC is created. Therefore, by running `kubectl describe pv <PV-name>` and checking `spec.csi.volumeAttributes`, you can check the resources on the storage systems created by Storage Plug-in for Containers. You can also use this information for troubleshooting.

The following table lists the items displayed in `spec.csi.volumeAttributes`.

Item	Description
nickname	Nickname of the created LDEV (the same for both the primary site and the secondary site)
primarySerial	Serial number of the primary site
primaryVolumeID	ID of the LDEV created at the primary site
secondarySerial	Serial number of the secondary site
secondaryVolumeID	ID of the LDEV created at the secondary site

Deleting a Stretched PVC

You can delete a Stretched PVC in the same way as deleting a regular PVC. When a Stretched PVC is deleted, the global-active device pair and the volumes at the primary and secondary sites are also deleted.

Note:

- Deleting a Stretched PVC takes more time than deleting a regular PVC.
- If the Stretched PVC cannot be deleted, take action in accordance with the error message. If the problem persists, see Forcibly deleting a Stretched PVC (on page 72).

Forcibly deleting a Stretched PVC

To delete a Stretched PVC, the storage systems at the primary site and secondary site must be running normally. If a failure occurs on the storage system at either site or on the global-active device pair, deletion of the Stretched PVC will fail. To delete a Stretched PVC in this situation, perform the following steps:

Procedure

1. Check information about the resources created at the primary and secondary sites by referring to Checking information on Stretched PVCs (on page 71).
2. Delete the PVC and PV.
3. Based on the information you checked in step 1, use Storage Navigator to delete the global-active device pair, volumes, and the associated LUNs. In addition, change the virtual LDEV IDs of the deleted volumes to unassigned (65534).

Connecting a Stretched PVC to a Pod

Similar to a regular PVC, a Stretched PVC can be used from a Pod.

When you create a Pod, the following message is output to the log of Storage Plug-in for Containers. The log displays the serial number of the storage system that successfully connected to the Pod. Generally, both the storage system at the primary site and the one at the secondary site will be used. However, depending on the status of the storage systems, only one of these storage systems (either the one at the primary site or the one at the secondary site) might be used.

```
[INFO]storages used for publish : [11111 22222]
```

Creating a clone from a Stretched PVC

You can replicate Stretched PVC data to a regular PVC by creating a volume snapshot from the Stretched PVC and running a clone from the volume snapshot.

Before you begin

Before creating the clone data for a Stretched PVC, configure the storage system for a regular PVC. For details, see the explanations related to using a regular PVC in a stretched cluster, in Requirements for using the Stretched PVC feature (on page 66). When configuring, be careful of the items written in the following table.

Item	Description
Storage system	For the storage system, specify either a primary site or a secondary site.
Storage system user	For the storage system user, assign both the resource group for the virtual storage machine used for a Stretched PVC and the resource group used for a regular PVC. Do not assign other resource groups.
LDEV	Assign the necessary number of LDEV IDs to the resource group used for a regular PVC. The assigned IDs must use sequential numbers. If the numbers are not sequential, the operations might not work correctly.

Procedure

1. To run a clone from the volume snapshot, create a Secret. When creating it, use the following sample for reference and refer to Secret settings (on page 30).

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

```
stringData:
  startLdevID: "100"     #(1)
  endLdevID: "200"       #(2)
  resourceGroupID: "5"   #(3)
```

Legend:

(1) Specify in decimal notation the smallest number out of the LDEV IDs assigned for a regular PVC.

(2) Specify in decimal notation the largest number out of the LDEV IDs assigned for a regular PVC.

(3) Specify the ID of the resource group used for a regular PVC.

2. Create a VolumeSnapshotClass. When creating it, use the following sample for reference and refer to Volume snapshot (on page 40).

```
apiVersion: snapshot.storage.k8s.io/v1
kind: VolumeSnapshotClass
metadata:
  name: snapshotclass-regular-from-stretched-sample
driver: hspc.csi.hitachi.com
deletionPolicy: Delete
parameters:
 poolID: "1"
 serialNumber: "12345"            #(1)
 csi.storage.k8s.io/snapshotter-secret-name: "secret-regular-from-stretched-
sample"                          #(2)
 csi.storage.k8s.io/snapshotter-secret-namespace: "default"
```

Legend:

(1) Specify the serial number of the storage system to be used.

(2) Specify the Secret you created in step 1.

3. Create a volume snapshot. For details, see Volume snapshot (on page 40).
4. Create the StorageClass used for a regular PVC. Create it by using the Secret you created in step 1. For details, see StorageClass settings (on page 31) and Resource partitioning (on page 47).
5. Create a PVC from the volume snapshot. For details, see Volume snapshot (on page 40).

Failover

If a failure occurs on a storage system or at a site, allocate the Pod to a different site at your discretion. A Stretched PVC can continue to operate by using the volumes of the storage system that is running normally.

Troubleshooting

Creating a Stretched PVC

If processing to create a Stretched PVC does not finish (the status does not change to Bound), run `kubectl describe pvc <PVC-name>` to check the error details. In addition, if the following error message appears, this indicates that volumes have already been created on the storage system. If you delete the PVC before the status of the PVC changes to Bound, the volumes will remain on the storage system without being deleted. After the PVC is deleted, use Storage Navigator to delete the volumes and the associated LUNs. In addition, change the virtual LDEV IDs of the deleted volumes to unassigned (65534).

```
failed to provision volume with StorageClass  ... : volumes created : [{id:100
serial:11111} {id:200 serial:22222}]
```

Pair status

If a failure occurs in a storage system, the global-active device pairs configuring the Stretched PVC might have an abnormal status. If an error occurs when you are using the Stretched PVC or a Pod connected to the Stretched PVC becomes unavailable, refer to the Global-Active Device User Guide and perform recovery for the storage system failure and the pair status. If recovery from the failure is difficult, by referring to Creating a clone from a Stretched PVC (on page 73) and creating a volume clone of either the primary or secondary storage system, you can continue to use the clone as the regular PVC.

Host failure

If a host fails, the status of the Pod run by the relevant host becomes Terminating and the Pod has an abnormal state. If you want to use this Pod with a normal host where the failure did not occur, do the following.

1. Forcibly delete the Pod.

   ```
   kubectl delete pod <Pod-name> --grace-period=0 --force
   ```

2. Delete the VolumeAttachment related to the Stretched PVC that the Pod was using.

   ```
   kubectl delete volumeattachment <VolumeAttachment-name>
   ```

Chapter 5: Upgrade

This chapter describes how to upgrade Storage Plug-in for Containers. The upgrade method you use depends on whether your environment is OpenShift or Kubernetes.

Note:

- If alpha versions of VolumeSnapshotClass and VolumeSnapshot are present in your environment, remove them before upgrading Storage Plug-in for Containers.
- If you are using an old version of OpenShift or Kubernetes, the latest Storage Plug-in for Containers might not operate. If you want to use the latest Storage Plug-in for Containers, upgrade OpenShift or Kubernetes first.
- Before upgrading Storage Plug-in for Containers, back up the settings configured in Configuration of Storage Plug-in for Containers instance (on page 26). The settings that are backed up might also be used for the new version of Storage Plug-in for Containers. If you do not have the `hspc_v1_hspc.yaml` file that was used when configuring the settings, run `kubectl get hspc -A -o yaml` to obtain the configured settings.

Upgrade on OpenShift

For OpenShift, you can upgrade Storage Plug-in for Containers using OpenShift web console.

Procedure

1. Delete HSPC on the Storage Plug-in for Containers tab for Operator Details.
2. Uninstall the Operator of Storage Plug-in for Containers.
3. Install new Storage Plug-in for Containers. See Installation on OpenShift (on page 24).

Upgrade on Kubernetes

For Kubernetes, you can upgrade Storage Plug-in for Containers by following the steps below.

Procedure

1. Delete Storage Plug-in for Containers and the Operator by using the previous version package:

```
# kubectl delete -f hspc_v1_hspc.yaml
# kubectl delete -f hspc-operator.yaml
```

2. Install new Storage Plug-in for Containers. See the topic Installation on Kubernetes (on page 25).

Chapter 6: Re-creation

This chapter describes how to re-create Storage Plug-in for Containers. The re-creation method depends on whether your environment is OpenShift or Kubernetes. To re-create Storage Plug-in for Containers, delete Storage Plug-in for Containers, and then create it again.

Deleting Storage Plug-in for Containers

OpenShift

Access the OpenShift web console, and delete the Storage Plug-in for Containers instance.

Kubernetes

Run the following command to delete the Storage Plug-in for Containers instance:

```
# kubectl delete hspc -n <Storage-Plug-in-for-Containers-namespace> hspc
```

For <*Storage-Plug-in-for-Containers-namespace*>, specify the namespace specified in `hspc_v1_hspc.yaml`.

Re-creating Storage Plug-in for Containers

OpenShift

Access the OpenShift web console, and create a Storage Plug-in for Containers instance.

For details, see Installation on OpenShift (on page 24).

Kubernetes

Run the following command to create a Storage Plug-in for Containers instance:

```
# kubectl create -f hspc_v1_hspc.yaml
```

For details, see Installation on Kubernetes (on page 25).

Chapter 7: Uninstallation

This chapter describes how to uninstall Storage Plug-in for Containers. This step includes removing any PersistentVolumeClaims, PersistentVolumes, StorageClasses, Storage Plug-in for Containers, and other elements. The uninstallation method you use depends on whether your environment is OpenShift or Kubernetes.

Uninstallation on OpenShift

For OpenShift, you can uninstall Storage Plug-in for Containers using OpenShift web console.

Procedure

1. Delete all Pods which are using the volumes created by Storage Plug-in for Containers.
2. Delete the VolumeSnapshotClass, VolumeSnapshot, PersistentVolumeClaim, the StorageClass, and the Secret that were created in relation to Storage Plug-in for Containers.
3. Delete HSPC on the Hitachi Storage Plug-in for Containers tab of the Operator Details.
4. Uninstall the Operator of Storage Plug-in for Containers.

Uninstallation on Kubernetes

For Kubernetes, you can uninstall Storage Plug-in for Containers by following the steps below.

Procedure

1. Delete all Pods which are using the volumes created by Storage Plug-in for Containers.
2. Delete the VolumeSnapshotClass, VolumeSnapshot, PersistentVolumeClaim, the StorageClass, and the Secret that were created in relation to Storage Plug-in for Containers.
3. Delete Storage Plug-in for Containers and the resources for the Operator:

```
# kubectl delete -f hspc_v1_hspc.yaml
# kubectl delete -f hspc-operator.yaml
# kubectl delete -f hspc-operator-namespace.yaml
```

4. If you created a Secret to pull an image, delete the Secret.

Chapter 8: Troubleshooting

When troubleshooting, you must understand what information to collect when an error occurs, the cases where an error occurs, and what action to take in each case.

Collecting information for troubleshooting

If a failure occurs in Storage Plug-in for Containers, collect the following information. Provide the collected information to customer support when you make an inquiry.

Information needed when contacting support

You can provide the following information for Storage Plug-in for Containers and the storage system to customer support for advanced troubleshooting.

Information	Procedure
Command execution logs	Retrieve the command that you ran and the result of running that command.
Result of running the `kubectl describe` command for the operation target resource	Run the following command for the resource you operated. `# kubectl describe <resource> -n <Storage-Plug-in-for-Containers-namespace> <resource-name>`
Cluster information	Run the following command: `# kubectl cluster-info dump -A > dump.txt`
Pod information	Retrieve the command that you ran in step 1 of Collecting logs for Storage Plug-in for Containers (on page 81) and the result of running that command.
Operator logs	See Collecting logs for Storage Plug-in for Containers (on page 81).
CSI controller logs	See Collecting logs for Storage Plug-in for Containers (on page 81).

Information	Procedure
CSI node logs	See Collecting logs for Storage Plug-in for Containers (on page 81).
PVC-related manifests	Get the YAML files for StorageClass, Secret, and PersistentVolumeClaim.
Snapshot-related manifests	Get the YAML files for VolumeSnapshotClass, Secret, and VolumeSnapshot.
Snapshot-related logs	Collect the snapshot controller logs that you installed in the Volume snapshot (on page 40) chapter.
Application manifests	Get the YAML files for applications that uses Storage Plug-in for Containers PVCs.
Storage logs	See Collecting storage system information for VSP family and VSP One Block (on page 82) or Collecting storage system information for VSP One SDS Block (on page 82).

Collecting logs for Storage Plug-in for Containers

You can retrieve logs for your running containers using the `kubectl logs` command. To collect Storage Plug-in for Containers logs, you need to collect logs from the Operator, CSI controller, and CSI node.

Note: If necessary, set up cluster-level logging to save logs:
https://kubernetes.io/docs/concepts/cluster-administration/logging/

1. Before retrieving logs, run the following command to check the Pod name.

```
# kubectl get pod -A -o wide
```

2. Run the following command to retrieve logs.
   - Operator

     ```
     # kubectl logs -n <Storage-Plug-in-for-Containers-namespace> hspc-operator-controller-manager-<id>
     ```

   - CSI controller

     ```
     # kubectl logs -n <Storage-Plug-in-for-Containers-namespace> hspc-csi-controller-<id> -c hspc-csi-driver
     ```

   - CSI node

     ```
     # kubectl logs -n <Storage-Plug-in-for-Containers-namespace> hspc-csi-node-<id> -c hspc-csi-driver
     ```

     Note: You will see multiple CSI node Pods because this is deployed as a DaemonSet. Collect logs from all these Pods.

3. Perform the following procedure to retrieve the directories as old logs might be rotated and removed from the retrieved logs.
   a. Check the target node.

      From the result of step 1, find the line where the value of `NAME` includes `hspc-csi-controller`, and check the value of `NODE` in the same line.

   b. Retrieve the directories stored under `/var/log/pods` for the node you checked in step a.

Collecting storage system information for VSP family and VSP One Block

If you are using an SVP, collect the regular dump files.

If you are not using an SVP, collect system dumps using the maintenance utility. For details about how to collect the dump files of storage systems, see the *System Administrator Guide*.

Collecting storage system information for VSP One SDS Block

Collect the dump files. For the procedure on collecting dump files, contact customer support.

Viewing the volume properties of PersistentVolume

When a volume is dynamically created by Storage Plug-in for Containers, information about the created volume is set in the `spec.csi.volumeAttributes` of the PersistentVolume.

You can view these properties using the `kubectl get pv <PV-name> -o yaml` command.

These properties are mainly used for internal purposes. The following tables describe some properties that can be helpful when troubleshooting.

Volume properties for VSP family and VSP One Block.

Property	Description
ldevIDDec	Decimal LDEV ID
ldevIDHex	Hexadecimal LDEV ID
size	Capacity of the volume **Note:** Capacity shown here is the original capacity used when creating the volume.

Volume properties for VSP One SDS Block.

Property	Description
volumeID	ID of the volume created in VSP One SDS Block
size	Capacity of the volume **Note:** Capacity shown here is the original capacity used when creating the volume.

Notes on forcibly deleting a Pod

If you forcibly delete a Pod from a specific node, the deleted Pod and the information on the PVC associated with the Pod might remain on the relevant node, and an unexpected error might occur.

To properly delete this information, you must restart the relevant node before using the node again.

Creating and deleting PersistentVolumeClaim simultaneously

When PersistentVolumeClaims are created or deleted simultaneously, the storage might get overloaded and cause errors `0x0000100b`, `0x0000100f`, `0x0000101a`, or `0x0000f007`. This problem can be reduced by specifying the `--worker-threads` argument to the `csi-`

`provisioner` container. This argument limits the number of simultaneously running create and delete operations. The default value is 20.

The following example shows how to reduce the number of `--worker-threads` to 10. For the YAML configuration, refer to Configuration of Storage Plug-in for Containers instance (on page 26).

```
apiVersion: csi.hitachi.com/v1
kind: HSPC
metadata:
  name: hspc
  namespace: <Storage-Plug-in-for-Containers-namespace>
spec:
  controller:
    containers:
      - name: csi-provisioner
        args:
        - --csi-address=/csi/csi-controller.sock
        - --timeout=300s
        - --v=5
        - --worker-threads=10
        - --default-fstype=ext4
```

If the problem persists, contact technical support.

Host group settings

If you encounter error `0x00001023`, you must modify the host group in the storage. Storage Plug-in for Containers searches the host group named "spc-<*wwn1*>-<*wwn2*>-<*wwn3*>", based on the naming rules (see Host group and iSCSI target naming rules (on page 21)). The error was likely generated because the host group's name may not follow the "spc-<*wwn1*>-<*wwn2*>-<*wwn3*>" naming format. To resolve the issue, delete the host group shown in the error message and rename the host group that has host WWNs.

1. Delete Storage Plug-in for Containers.

   For details, see Deleting Storage Plug-in for Containers (on page 78).

2. Delete the host group that is specified in the error message.
3. Search host groups that have WWNs for each host, and delete them or rename them to "spc-<*wwn1*>-<*wwn2*>-<*wwn3*>".
4. Create Storage Plug-in for Containers.

   For details, see Re-creating Storage Plug-in for Containers (on page 78).

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