



Red Hat OpenShift Data Foundation 4.10

Planning your deployment

Important considerations when deploying Red Hat OpenShift Data Foundation 4.10

Red Hat OpenShift Data Foundation 4.10 Planning your deployment

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Abstract

Read this document for important considerations when planning your Red Hat OpenShift Data Foundation deployment.

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MAKING OPEN SOURCE MORE INCLUSIVE

Red Hat is committed to replacing problematic language in our code, documentation, and web properties. We are beginning with these four terms: master, slave, blacklist, and whitelist. Because of the enormity of this endeavor, these changes will be implemented gradually over several upcoming releases. For more details, see [our CTO Chris Wright's message](#).

PROVIDING FEEDBACK ON RED HAT DOCUMENTATION

We appreciate your input on our documentation. Do let us know how we can make it better.

To give feedback, create a Bugzilla ticket:

1. Go to the [Bugzilla](#) website.
2. In the **Component** section, choose **documentation**.
3. Fill in the **Description** field with your suggestion for improvement. Include a link to the relevant part(s) of documentation.
4. Click **Submit Bug**.

CHAPTER 1. INTRODUCTION TO OPENSIFT DATA FOUNDATION

Red Hat OpenShift Data Foundation is a highly integrated collection of cloud storage and data services for Red Hat OpenShift Container Platform. It is available as part of the Red Hat OpenShift Container Platform Service Catalog, packaged as an operator to facilitate simple deployment and management.

Red Hat OpenShift Data Foundation services are primarily made available to applications by way of storage classes that represent the following components:

- Block storage devices, catering primarily to database workloads. Prime examples include Red Hat OpenShift Container Platform logging and monitoring, and PostgreSQL.
- Shared and distributed file system, catering primarily to software development, messaging, and data aggregation workloads. Examples include Jenkins build sources and artifacts, Wordpress uploaded content, Red Hat OpenShift Container Platform registry, and messaging using JBoss AMQ.
- Multicloud object storage, featuring a lightweight S3 API endpoint that can abstract the storage and retrieval of data from multiple cloud object stores.
- On premises object storage, featuring a robust S3 API endpoint that scales to tens of petabytes and billions of objects, primarily targeting data intensive applications. Examples include the storage and access of row, columnar, and semi-structured data with applications like Spark, Presto, Red Hat AMQ Streams (Kafka), and even machine learning frameworks like TensorFlow and Pytorch.



NOTE

Running PostgreSQL workload on CephFS persistent volume is not supported and it is recommended to use RADOS Block Device (RBD) volume.

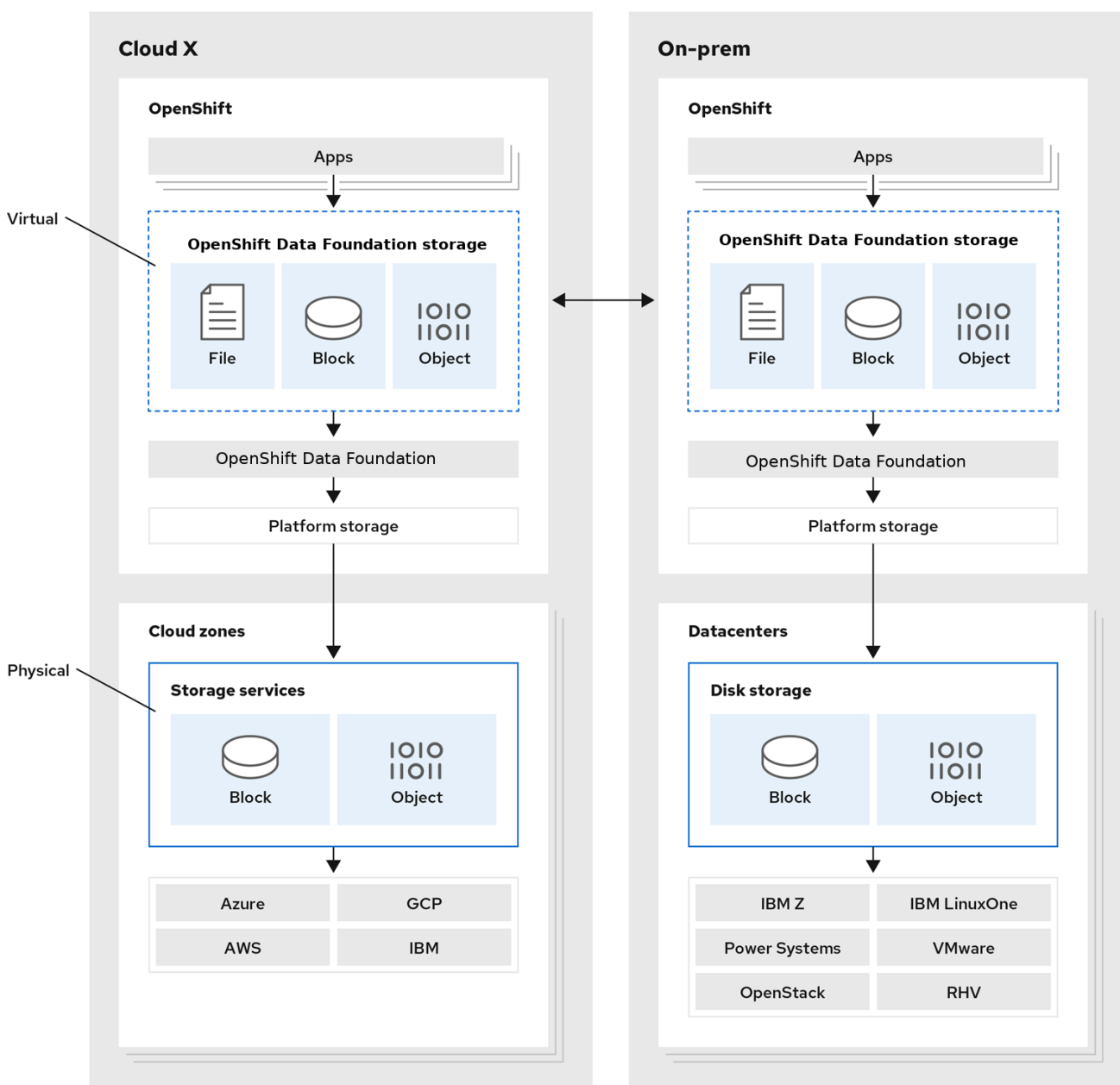
Red Hat OpenShift Data Foundation version 4.x integrates a collection of software projects, including:

- Ceph, providing block storage, a shared and distributed file system, and on-premises object storage
- Ceph CSI, to manage provisioning and lifecycle of persistent volumes and claims
- NooBaa, providing a Multicloud Object Gateway
- OpenShift Data Foundation, Rook-Ceph, and NooBaa operators to initialize and manage OpenShift Data Foundation services.

CHAPTER 2. ARCHITECTURE OF OPENSIFT DATA FOUNDATION

Red Hat OpenShift Data Foundation provides services for, and can run internally from Red Hat OpenShift Container Platform.

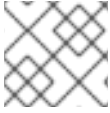
Figure 2.1. Red Hat OpenShift Data Foundation architecture



171_OpenShift_1221

Red Hat OpenShift Data Foundation supports deployment into Red Hat OpenShift Container Platform clusters deployed on Installer Provisioned Infrastructure or User Provisioned Infrastructure. For details about these two approaches, see [OpenShift Container Platform - Installation process](#). To know more about interoperability of components for the Red Hat OpenShift Data Foundation and Red Hat OpenShift Container Platform, see the [Red Hat OpenShift Data Foundation Supportability and Interoperability Checker](#).

For information about the architecture and lifecycle of OpenShift Container Platform, see [OpenShift Container Platform architecture](#).

**NOTE**

For IBM Power refer [OpenShift Container Platform - Installation process](#).

2.1. ABOUT OPERATORS

Red Hat OpenShift Data Foundation comprises three main operators, which codify administrative tasks and custom resources so that task and resource characteristics can be easily automated. Administrators define the desired end state of the cluster, and the OpenShift Data Foundation operators ensure the cluster is either in that state, or approaching that state, with minimal administrator intervention.

OpenShift Data Foundation operator

A meta-operator that codifies and enforces the recommendations and requirements of a supported Red Hat OpenShift Data Foundation deployment by drawing on other operators in specific, tested ways. This operator provides the storage cluster resource that wraps resources provided by the Rook-Ceph and NooBaa operators.

Rook-Ceph operator

This operator automates the packaging, deployment, management, upgrading, and scaling of persistent storage and file, block, and object services. It creates block and file storage classes for all environments, and creates an object storage class and services object bucket claims made against it in on-premises environments.

Additionally, for internal mode clusters, it provides the Ceph cluster resource, which manages the deployments and services representing the following:

- Object storage daemons (OSDs)
- Monitors (MONs)
- Manager (MGR)
- Metadata servers (MDS)
- Object gateways (RGW) on-premises only

MCG operator

This operator automates the packaging, deployment, management, upgrading, and scaling of the Multicloud Object Gateway object service. It creates an object storage class and services object bucket claims made against it.

Additionally, it provides the NooBaa cluster resource, which manages the deployments and services for NooBaa core, database, and endpoint.

2.2. STORAGE CLUSTER DEPLOYMENT APPROACHES

Flexibility is a core tenet of Red Hat OpenShift Data Foundation, as evidenced by its growing list of operating modalities. This section provides you with information that will help you to select the most appropriate approach for your environments.

Red Hat OpenShift Data Foundation can be deployed either entirely within OpenShift Container Platform (Internal approach) or to make available the services from a cluster running outside of OpenShift Container Platform (External approach).

2.2.1. Internal approach

Deployment of Red Hat OpenShift Data Foundation entirely within Red Hat OpenShift Container Platform has all the benefits of operator based deployment and management. Internal-attached device approach in the graphical user interface can be used to deploy Red Hat OpenShift Data Foundation in internal mode using the local storage operator and local storage devices.

Ease of deployment and management are the highlights of running OpenShift Data Foundation services internally on OpenShift Container Platform. There are two different deployment modalities available when Red Hat OpenShift Data Foundation is running entirely within Red Hat OpenShift Container Platform:

- Simple
- Optimized

Simple deployment

Red Hat OpenShift Data Foundation services run co-resident with applications, managed by operators in Red Hat OpenShift Container Platform.

A simple deployment is best for situations where

- Storage requirements are not clear
- Red Hat OpenShift Data Foundation services will run co-resident with applications
- Creating a node instance of a specific size is difficult (bare metal)

In order for Red Hat OpenShift Data Foundation to run co-resident with applications, they must have local storage devices, or portable storage devices attached to them dynamically, like EBS volumes on EC2, or vSphere Virtual Volumes on VMware, or SAN volumes dynamically provisioned by PowerVC.

Optimized deployment

Red Hat OpenShift Data Foundation services run on dedicated infrastructure nodes managed by Red Hat OpenShift Container Platform.

An optimized approach is best for situations when:

- Storage requirements are clear
- Red Hat OpenShift Data Foundation services run on dedicated infrastructure nodes
- Creating a node instance of a specific size is easy (Cloud, Virtualized environment, etc.)

2.2.2. External approach

Red Hat OpenShift Data Foundation exposes the Red Hat Ceph Storage services running outside of the OpenShift Container Platform cluster as storage classes.

The external approach is best used when:

- Storage requirements are significant (600+ storage devices)
- Multiple OpenShift Container Platform clusters need to consume storage services from a common external cluster.

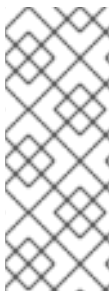
- Another team (SRE, Storage, etc.) needs to manage the external cluster providing storage services. Possibly pre-existing.

2.3. NODE TYPES

Nodes run the container runtime, as well as services, to ensure that containers are running, and maintain network communication and separation between pods. In OpenShift Data Foundation, there are three types of nodes.

Table 2.1. Types of nodes

Node Type	Description
Master	These nodes run processes that expose the Kubernetes API, watch and schedule newly created pods, maintain node health and quantity, and control interaction with underlying cloud providers.
Infrastructure (Infra)	<p>Infra nodes run cluster level infrastructure services such as logging, metrics, registry, and routing. These are optional in OpenShift Container Platform clusters. In order to separate OpenShift Data Foundation layer workload from applications, it is recommended to use infra nodes for OpenShift Data Foundation in virtualized and cloud environments.</p> <p>To create Infra nodes, you can provision new nodes labeled as infra. See How to use dedicated worker nodes for Red Hat OpenShift Data Foundation?</p>
Worker	<p>Worker nodes are also known as application nodes since they run applications.</p> <p>When OpenShift Data Foundation is deployed in internal mode, a minimal cluster of 3 worker nodes is required, where the nodes are recommended to be spread across three different racks, or availability zones, to ensure availability. In order for OpenShift Data Foundation to run on worker nodes, they must either have local storage devices, or portable storage devices attached to them dynamically.</p> <p>When it is deployed in external mode, it runs on multiple nodes to allow rescheduling by K8S on available nodes in case of a failure.</p>



NOTE

OpenShift Data Foundation requires the same number of subscriptions as OpenShift Container Platform. However, if OpenShift Data Foundation is running on infra nodes, OpenShift does not require OpenShift Container Platform subscription for these nodes. Therefore, the OpenShift Data Foundation control plane does not require additional OpenShift Container Platform and OpenShift Data Foundation subscriptions. For more information, see [Chapter 6, Subscriptions](#).

CHAPTER 3. INTERNAL STORAGE SERVICES

Red Hat OpenShift Data Foundation service is available for consumption internally to the Red Hat OpenShift Container Platform running on the following infrastructure:

- Amazon Web Services
- Bare metal
- VMware vSphere
- Microsoft Azure
- Google Cloud [Technology Preview]
- Red Hat Virtualization 4.4.x or higher (IPI)
- Red Hat OpenStack 13 or higher (IPI) [Technology Preview]
- IBM Power
- IBM Z and LinuxONE

Creation of an internal cluster resource will result in the internal provisioning of the OpenShift Data Foundation base services, and make additional storage classes available to applications.

CHAPTER 4. EXTERNAL STORAGE SERVICES

Red Hat OpenShift Data Foundation can use IBM FlashSystems or make services from an external Red Hat Ceph Storage cluster available for consumption through OpenShift Container Platform clusters running on the following platforms:

- VMware vSphere
- Bare Metal
- Red Hat OpenStack platform (Technology Preview)
- IBM Power
- IBM Z infrastructure

The OpenShift Data Foundation operators create and manage services to satisfy persistent volume and object bucket claims against external services. External cluster can serve Block, File and Object storage classes for applications running on OpenShift Container Platform. External clusters are not deployed or managed by operators.

CHAPTER 5. SECURITY CONSIDERATIONS

5.1. FIPS-140-2

The Federal Information Processing Standard Publication 140-2 (FIPS-140-2) is a standard defining a set of security requirements for the use of cryptographic modules. This standard is mandated by law for US government agencies and contractors and is also referenced in other international and industry specific standards.

Red Hat OpenShift Data Foundation is now using FIPS validated cryptographic modules as delivered by Red Hat Enterprise Linux OS/CoreOS (RHCOS).

The cryptography modules are currently being processed by Cryptographic Module Validation Program (CMVP) and their state can be seen at [Modules in Process List](#). For more up-to-date information, see the [knowledge base article](#).



NOTE

FIPS mode must be enabled on the OpenShift Container Platform, prior to installing OpenShift Data Foundation. OpenShift Container Platform must run on RHCOS nodes, as OpenShift Data Foundation deployment on RHEL 7 is not supported for this feature.

For more information, see [installing a cluster in FIPS mode](#) and [support for FIPS cryptography](#).

5.2. PROXY ENVIRONMENT

A proxy environment is a production environment that denies direct access to the internet and provides an available HTTP or HTTPS proxy instead. Red Hat OpenShift Container Platform is configured to use a proxy by modifying the proxy object for existing clusters or by configuring the proxy settings in the `install-config.yaml` file for new clusters.

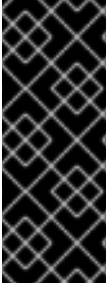
Red Hat supports deployment of OpenShift Data Foundation in proxy environments when OpenShift Container Platform has been configured according to [configuring the cluster-wide proxy](#).

5.3. DATA ENCRYPTION OPTIONS

Encryption lets you encode your data to make it impossible to read without the required encryption keys. This mechanism protects the confidentiality of your data in the event of a physical security breach that results in a physical media to escape your custody. The per-PV encryption also provides access protection from other namespaces inside the same OpenShift Container Platform cluster. Data is encrypted when it is written to the disk, and decrypted when it is read from the disk. Working with encrypted data might incur a small penalty to performance.

Encryption is only supported for new clusters deployed using Red Hat OpenShift Data Foundation 4.6 or higher. An existing encrypted cluster that is not using an external Key Management System (KMS) cannot be migrated to use an external KMS.

Currently, HashiCorp Vault is the only supported KMS for Cluster-wide and Persistent Volume encryptions. With OpenShift Data Foundation 4.7.0 and 4.7.1, only HashiCorp Vault Key/Value (KV) secret engine API, version 1 is supported. Starting with OpenShift Data Foundation 4.7.2, HashiCorp Vault KV secret engine API, versions 1 and 2 are supported.



IMPORTANT

- KMS is required for Persistent Volume (PV) encryption, and is optional for cluster-wide encryption.
- To start with, Storage class encryption requires a valid Red Hat OpenShift Data Foundation Advanced subscription. For more information, see the [knowledgebase article on OpenShift Data Foundation subscriptions](#).

Red Hat works with the technology partners to provide this documentation as a service to the customers. However, Red Hat does not provide support for the Hashicorp product. For technical assistance with this product, contact [Hashicorp](#).

5.3.1. Cluster-wide encryption

Red Hat OpenShift Data Foundation supports cluster-wide encryption (encryption-at-rest) for all the disks and Multicloud Object Gateway operations in the storage cluster. OpenShift Data Foundation uses Linux Unified Key System (LUKS) version 2 based encryption with a key size of 512 bits and the **aes-xts-plain64** cipher where each device has a different encryption key. The keys are stored using a Kubernetes secret or an external KMS. Both methods are mutually exclusive and you can not migrate between methods.

Encryption is disabled by default. You can enable encryption for the cluster at the time of deployment. See the deployment guides for more information.

Cluster wide encryption is supported in OpenShift Data Foundation 4.6 without Key Management System (KMS), while starting with OpenShift Data Foundation 4.7, it supports with and without KMS.



NOTE

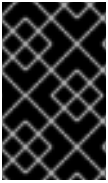
Requires a valid Red Hat OpenShift Data Foundation Advanced subscription. To know how subscriptions for OpenShift Data Foundation work, see [knowledgebase article on OpenShift Data Foundation subscriptions](#).

Cluster wide encryption with HashiCorp Vault KMS provides two authentication methods:

- **Token:** This method allows authentication using vault tokens. A kubernetes secret containing the vault token is created in the openshift-storage namespace and is used for authentication. If this authentication method is selected then the administrator has to provide the vault token that provides access to the backend path in Vault, where the encryption keys are stored.
- **Kubernetes:** This method allows authentication with vault using serviceaccounts. If this authentication method is selected then the administrator has to provide the name of the role configured in Vault that provides access to the backend path, where the encryption keys are stored. The value of this role is then added to the **ocs-kms-connection-details** config map. This method is available from OpenShift Data Foundation 4.10. Currently, HashiCorp Vault is the only supported KMS. With OpenShift Data Foundation 4.7.0 and 4.7.1, only HashiCorp Vault KV secret engine, API version 1 is supported. Starting with OpenShift Data Foundation 4.7.2, HashiCorp Vault KV secret engine API, versions 1 and 2 are supported.

**NOTE**

OpenShift Data Foundation on IBM Cloud platform supports Hyper Protect Crypto Services (HPCS) Key Management Services (KMS) as the encryption solution in addition to HashiCorp Vault KMS.

**IMPORTANT**

Red Hat works with the technology partners to provide this documentation as a service to the customers. However, Red Hat does not provide support for the Hashicorp product. For technical assistance with this product, contact [Hashicorp](#).

5.3.2. Storage class encryption

You can encrypt persistent volumes (block only) with storage class encryption using an external Key Management System (KMS) to store device encryption keys. Persistent volume encryption is only available for RADOS Block Device (RBD) persistent volumes. See [how to create a storage class with persistent volume encryption](#).

Storage class encryption is supported in OpenShift Data Foundation 4.7 or higher.

**NOTE**

Requires a valid Red Hat OpenShift Data Foundation Advanced subscription. To know how subscriptions for OpenShift Data Foundation work, see [knowledgebase article on OpenShift Data Foundation subscriptions](#).

CHAPTER 6. SUBSCRIPTIONS

6.1. SUBSCRIPTION OFFERINGS

Red Hat OpenShift Data Foundation subscription is based on “core-pairs,” similar to Red Hat OpenShift Container Platform. The Red Hat OpenShift Data Foundation 2-core subscription is based on the number of logical cores on the CPUs in the system where OpenShift Container Platform runs.

As with OpenShift Container Platform:

- OpenShift Data Foundation subscriptions are stackable to cover larger hosts.
- Cores can be distributed across as many virtual machines (VMs) as needed. For example, ten 2-core subscriptions will provide 20 cores and in case of IBM Power a 2-core subscription at SMT level of 8 will provide 2 cores or 16 vCPUs that can be used across any number of VMs.
- OpenShift Data Foundation subscriptions are available with Premium or Standard support.

6.2. DISASTER RECOVERY SUBSCRIPTIONS

Disaster Recovery features supported by Red Hat OpenShift Data Foundation require all of the following prerequisites in order to successfully implement a Disaster Recovery solution:

- A valid Red Hat OpenShift Data Foundation Advanced entitlement
- A valid Red Hat Advanced Cluster Management for Kubernetes subscription

Any Red Hat OpenShift Data Foundation Cluster containing PVs participating in active replication either as a source or destination requires OpenShift Data Foundation Advanced entitlement. This subscription should be active on both source and destination clusters.

To know how subscriptions for OpenShift Data Foundation work, see [knowledgebase article on OpenShift Data Foundation subscriptions](#).

6.3. CORES VERSUS VCPUS AND HYPERTHREADING

Making a determination about whether or not a particular system consumes one or more cores is currently dependent on whether or not that system has hyperthreading available. Hyperthreading is only a feature of Intel CPUs. Visit the Red Hat Customer Portal to determine whether a particular system supports hyperthreading.

For systems where hyperthreading is enabled and where one hyperthread equates to one visible system core, the [calculation of cores](#) is a ratio of 2 cores to 4 vCPUs. Therefore, a 2-core subscription covers 4 vCPUs in a hyperthreaded system. A large virtual machine (VM) might have 8 vCPUs, equating to 4 subscription cores. As subscriptions come in 2-core units, you will need two 2-core subscriptions to cover these 4 cores or 8 vCPUs.

Where hyperthreading is not enabled, and where each visible system core correlates directly to an underlying physical core, the calculation of cores is a ratio of 2 cores to 2 vCPUs.

6.3.1. Cores versus vCPUs and simultaneous multithreading (SMT) for IBM Power

Making a determination about whether or not a particular system consumes one or more cores is currently dependent on the level of simultaneous multithreading configured (SMT). IBM Power provides

simultaneous multithreading levels of 1, 2, 4 or 8 for each core which correspond to the number of vCPUs as in the table below.

Table 6.1. Different SMT levels and their corresponding vCPUs

SMT level	SMT=1	SMT=2	SMT=4	SMT=8
1 Core	# vCPUs=1	# vCPUs=2	# vCPUs=4	# vCPUs=8
2 Cores	# vCPUs=2	# vCPUs=4	# vCPUs=8	# vCPUs=16
4 Cores	# vCPUs=4	# vCPUs=8	# vCPUs=16	# vCPUs=32

For systems where SMT is configured the calculation for the number of cores required for subscription purposes depends on the SMT level. Therefore, a 2-core subscription corresponds to 2 vCPUs on SMT level of 1, and to 4 vCPUs on SMT level of 2, and to 8 vCPUs on SMT level of 4 and to 16 vCPUs on SMT level of 8 as seen in the table above. A large virtual machine (VM) might have 16 vCPUs, which at a SMT level 8 will require a 2 core subscription based on dividing the # of vCPUs by the SMT level (16 vCPUs / 8 for SMT=8 = 2). As subscriptions come in 2-core units, you will need one 2-core subscription to cover these 2 cores or 16 vCPUs.

6.4. SPLITTING CORES

Systems that require an odd number of cores need to consume a full 2-core subscription. For example, a system that is calculated to require only 1 core will end up consuming a full 2-core subscription once it is registered and subscribed.

When a single virtual machine (VM) with 2 vCPUs uses hyperthreading resulting in 1 calculated vCPU, a full 2-core subscription is required; a single 2-core subscription may not be split across two VMs with 2 vCPUs using hyperthreading. See section [Cores versus vCPUs and hyperthreading](#) for more information.

It is recommended that virtual instances be sized so that they require an even number of cores.

6.4.1. Shared Processor Pools for IBM Power

IBM Power have a notion of shared processor pools. The processors in a shared processor pool can be shared across the nodes in the cluster. The aggregate compute capacity required for a Red Hat OpenShift Data Foundation should be a multiple of core-pairs.

6.5. SUBSCRIPTION REQUIREMENTS

Red Hat OpenShift Data Foundation components can run on either OpenShift Container Platform worker or infrastructure nodes, for which you can use either Red Hat CoreOS (RHCOS) or Red Hat Enterprise Linux (RHEL) 8.4 as the host operating system. RHEL 7 is now deprecated. OpenShift Data Foundation subscriptions are required for every OpenShift Container Platform subscribed core with a ratio of 1:1.

When using infrastructure nodes, the rule to subscribe all OpenShift worker node cores for OpenShift Data Foundation applies even though they don't need any OpenShift Container Platform or any OpenShift Data Foundation subscriptions. You can use labels to state whether a node is a worker or an infrastructure node.

For more information, see [How to use dedicated worker nodes for Red Hat OpenShift Data Foundation](#) in the [Managing and Allocating Storage Resources](#) guide.

CHAPTER 7. INFRASTRUCTURE REQUIREMENTS

7.1. PLATFORM REQUIREMENTS

Red Hat OpenShift Data Foundation 4.10 is supported only on OpenShift Container Platform version 4.10 and its next minor versions.

Bug fixes for previous version of Red Hat OpenShift Data Foundation will be released as bug fix versions. For details, see [Red Hat OpenShift Container Platform Life Cycle Policy](#) .

For external cluster subscription requirements, see this [Red Hat Knowledgebase article](#) .

For a complete list of supported platform versions, see the [Red Hat OpenShift Data Foundation and Red Hat OpenShift Container Platform interoperability matrix](#).

7.1.1. Amazon EC2

Supports internal Red Hat OpenShift Data Foundation clusters only.

An Internal cluster must meet both, [storage device requirements](#) and have a storage class providing

- EBS storage via the aws-ebs provisioner

OpenShift Data Foundation version 4.10 now supports the gp2 and gp3 CSI drivers introduced by AWS. These drivers provide improved storage expansion capabilities (gp2 CSI compared to gp2 in-tree) and a reduced monthly price-point (gp3). You can now select the new drivers when selecting your Storage Class in OpenShift Data Foundation 4.10 (gp2 is the default).

7.1.2. Bare Metal

Supports internal clusters and consuming external clusters.

An Internal cluster must meet both, [storage device requirements](#) and have a storage class providing local SSD (NVMe/SATA/SAS, SAN) via the Local Storage Operator.

7.1.3. VMware vSphere

Supports internal clusters and consuming external clusters.

Recommended versions:

- vSphere 6.7, Update 2 or later
- vSphere 7.0 or later

See [VMware vSphere infrastructure requirements](#) for details.



NOTE

If VMware ESXi does not recognize its devices as flash, mark them as flash devices. Before Red Hat OpenShift Data Foundation deployment, refer to [Mark Storage Devices as Flash](#).

Additionally, an Internal cluster must meet both, [storage device requirements](#) and have a storage class providing either

- vSAN or VMFS datastore via the vsphere-volume provisioner
- VMDK, RDM, or DirectPath storage devices via the Local Storage Operator.

7.1.4. Microsoft Azure

Supports internal Red Hat OpenShift Data Foundation clusters only.

An Internal cluster must meet both, [storage device requirements](#) and have a storage class providing

- Azure disk via the azure-disk provisioner

7.1.5. Google Cloud [Technology Preview]

Supports internal Red Hat OpenShift Data Foundation clusters only.

An Internal cluster must meet both, [storage device requirements](#) and have a storage class providing

- GCE Persistent Disk via the gce-pd provisioner

7.1.6. Red Hat Virtualization Platform

Supports internal Red Hat OpenShift Data Foundation clusters only.

An Internal cluster must meet both, [storage device requirements](#) and have a storage class providing local SSD (NVMe/SATA/SAS, SAN) via the Local Storage Operator.

7.1.7. Red Hat OpenStack Platform [Technology Preview]

Supports internal Red Hat OpenShift Data Foundation clusters and consuming external clusters.

An Internal cluster must meet both, [storage device requirements](#) and have a storage class providing

- standard disk via the Cinder provisioner

7.1.8. IBM Power

Supports internal Red Hat OpenShift Data Foundation clusters and consuming external clusters.

An Internal cluster must meet both, [storage device requirements](#) and have a storage class providing local SSD (NVMe/SATA/SAS, SAN) via the Local Storage Operator.

7.1.9. IBM Z and LinuxONE

Supports internal Red Hat OpenShift Data Foundation clusters only.

An Internal cluster must meet both, [storage device requirements](#) and have a storage class providing local SSD (NVMe/SATA/SAS, SAN) via the Local Storage Operator.

7.2. EXTERNAL MODE REQUIREMENT

7.2.1. Red Hat Ceph Storage

To check the supportability and interoperability of Red Hat Ceph Storage (RHCS) with Red Hat OpenShift Data Foundation in external mode, go to the lab [Red Hat OpenShift Data Foundation Supportability and Interoperability Checker](#).

1. Select **Service Type** as **ODF as Self-Managed Service**.
2. Select appropriate **Version** from the drop down.
3. On Versions tab, click **Supported RHCS Compatibility** tab.

For instructions regarding how to install a RHCS cluster, see the [Installation guide](#).

7.2.2. IBM FlashSystem

To use IBM FlashSystem as a pluggable external storage on other providers, you need to first deploy it before you can deploy OpenShift Data Foundation, which would use the IBM FlashSystem storage class as a backing storage.

For the latest supported FlashSystem products and versions, see Reference > Red Hat OpenShift Data Foundation support summary within your Spectrum Virtualize family product documentation on [IBM Documentation](#).

For instructions on how to deploy OpenShift Data Foundation, see [Creating an OpenShift Data Foundation Cluster for external IBM FlashSystem storage](#).

7.3. RESOURCE REQUIREMENTS

Red Hat OpenShift Data Foundation services consist of an initial set of base services, and can be extended with additional device sets. All of these Red Hat OpenShift Data Foundation services pods are scheduled by kubernetes on OpenShift Container Platform nodes according to [resource requirements](#). Expanding the cluster in multiples of three, one node in each failure domain, is an easy way to satisfy [pod placement rules](#).



IMPORTANT

These requirements relate to OpenShift Data Foundation services only, and not to any other services, operators or workloads that are running on these nodes.

Table 7.1. Aggregate available resource requirements for Red Hat OpenShift Data Foundation only

Deployment Mode	Base services	Additional device Set
Internal	<ul style="list-style-type: none"> ● 30 CPU (logical) ● 72 GiB memory ● 3 storage devices 	<ul style="list-style-type: none"> ● 6 CPU (logical) ● 15 GiB memory ● 3 storage devices

Deployment Mode	Base services	Additional device Set
External	<ul style="list-style-type: none"> • 4 CPU (logical) • 16 GiB memory 	Not applicable

Example: For a 3 node cluster in an internal mode deployment with a single device set, a minimum of $3 \times 10 = 30$ units of CPU are required.

For more information, see [Chapter 6, Subscriptions](#) and [CPU units](#).

For additional guidance with designing your Red Hat OpenShift Data Foundation cluster, see the [ODF Sizing Tool](#).

CPU units

In this section, 1 CPU Unit maps to the Kubernetes concept of 1 CPU unit.

- 1 unit of CPU is equivalent to 1 core for non-hyperthreaded CPUs.
- 2 units of CPU are equivalent to 1 core for hyperthreaded CPUs.
- Red Hat OpenShift Data Foundation core-based subscriptions always come in pairs (2 cores).

Table 7.2. Aggregate minimum resource requirements for IBM Power

Deployment Mode	Base services
Internal	<ul style="list-style-type: none"> • 48 CPU (logical) • 192 GiB memory • 3 storage devices, each with additional 500GB of disk
External	<ul style="list-style-type: none"> • 24 CPU (logical) • 48 GiB memory

Example: For a 3 node cluster in an internal-attached devices mode deployment, a minimum of $3 \times 16 = 48$ units of CPU and $3 \times 64 = 192$ GB of memory is required.

7.3.1. Resource requirements for IBM Z and LinuxONE infrastructure

Red Hat OpenShift Data Foundation services consist of an initial set of base services, and can be extended with additional device sets.

All of these Red Hat OpenShift Data Foundation services pods are scheduled by kubernetes on OpenShift Container Platform nodes according to the [resource requirements](#).

Expanding the cluster in multiples of three, one node in each failure domain, is an easy way to satisfy the [pod placement rules](#).

Table 7.3. Aggregate available resource requirements for Red Hat OpenShift Data Foundation only (IBM Z and LinuxONE)

Deployment Mode	Base services	Additional device Set	IBM Z and LinuxONE minimum hardware requirements
Internal	<ul style="list-style-type: none"> ● 30 CPU (logical) <ul style="list-style-type: none"> ○ 3 nodes with 10 CPUs (logical) each ● 72 GiB memory ● 3 storage devices 	<ul style="list-style-type: none"> ● 6 CPU (logical) ● 15 GiB memory ● 3 storage devices 	1 IFL
External	<ul style="list-style-type: none"> ● 4 CPU (logical) ● 16 GiB memory 	Not applicable	Not applicable

CPU

Is the number of virtual cores defined in the hypervisor, IBM z/VM, Kernel Virtual Machine (KVM), or both.

IFL (Integrated Facility for Linux)

Is the physical core for IBM Z and LinuxONE.

Minimum system environment

- In order to operate a minimal cluster with 1 logical partition (LPAR), one additional IFL is required on top of the 6 IFLs. OpenShift Container Platform consumes these IFLs .

7.3.2. Minimum deployment resource requirements

An OpenShift Data Foundation cluster will be deployed with minimum configuration when the standard deployment resource requirement is not met.



IMPORTANT

These requirements relate to OpenShift Data Foundation services only, and not to any other services, operators or workloads that are running on these nodes.

Table 7.4. Aggregate resource requirements for OpenShift Data Foundation only

Deployment Mode	Base services
Internal	<ul style="list-style-type: none"> ● 24 CPU (logical) ● 72 GiB memory ● 3 storage devices

If you want to add additional device sets, we recommend converting your minimum deployment to standard deployment.

7.3.3. Compact deployment resource requirements

Red Hat OpenShift Data Foundation can be installed on a three-node OpenShift compact bare metal cluster, where all the workloads run on three strong master nodes. There are no worker or storage nodes.



IMPORTANT

These requirements relate to OpenShift Data Foundation services only, and not to any other services, operators or workloads that are running on these nodes.

Table 7.5. Aggregate resource requirements for OpenShift Data Foundation only

Deployment Mode	Base services	Additional device Set
Internal	<ul style="list-style-type: none"> ● 24 CPU (logical) ● 72 GiB memory ● 3 storage devices 	<ul style="list-style-type: none"> ● 6 CPU (logical) ● 15 GiB memory ● 3 storage devices


To configure OpenShift Container Platform on a compact bare metal cluster, see [Configuring a three-node cluster](#) and [Delivering a Three-node Architecture for Edge Deployments](#).

7.3.4. Resource requirements for MCG only deployment

An OpenShift Data Foundation cluster deployed only with the Multicloud Object Gateway (MCG) component provides the flexibility in deployment and helps to reduce the resource consumption.

Table 7.6. Aggregate resource requirements for MCG only deployment

Deployment Mode	Core	Database (DB)	Endpoint
-----------------	------	---------------	----------

Deployment Mode	Core	Database (DB)	Endpoint
Internal	<ul style="list-style-type: none"> • 1 CPU • 4 GiB memory 	<ul style="list-style-type: none"> • 0.5 CPU • 4 GiB memory 	<ul style="list-style-type: none"> • 1 CPU • 2 GiB memory  <p>NOTE The default auto scale is between n1 - 2.</p>

7.4. POD PLACEMENT RULES

Kubernetes is responsible for pod placement based on declarative placement rules. The Red Hat OpenShift Data Foundation base service placement rules for Internal cluster can be summarized as follows:

- Nodes are labeled with the **cluster.ocs.openshift.io/openshift-storage** key
- Nodes are sorted into pseudo failure domains if none exist
- Components requiring high availability are spread across failure domains
- A storage device must be accessible in each failure domain

This leads to the requirement that there be at least three nodes, and that nodes be in three distinct rack or zone failure domains in the case of pre-existing [topology labels](#).

For additional device sets, there must be a storage device, and sufficient resources for the pod consuming it, in each of the three failure domains. Manual placement rules can be used to override default placement rules, but generally this approach is only suitable for bare metal deployments.

7.5. STORAGE DEVICE REQUIREMENTS

Use this section to understand the different storage capacity requirements that you can consider when planning internal mode deployments and upgrades. We generally recommend 9 devices or less per node. This recommendation ensures both that nodes stay below cloud provider dynamic storage device attachment limits, and to limit the recovery time after node failures with local storage devices. Expanding the cluster in multiples of three, one node in each failure domain, is an easy way to satisfy [pod placement rules](#).



NOTE

You can expand the storage capacity only in the increment of the capacity selected at the time of installation.

7.5.1. Dynamic storage devices

Red Hat OpenShift Data Foundation permits the selection of either 0.5 TiB, 2 TiB or 4 TiB capacities as the request size for dynamic storage device sizes. The number of dynamic storage devices that can run per node is a function of the node size, underlying provisioner limits and [resource requirements](#).

7.5.2. Local storage devices

For local storage deployment, any disk size of 4 TiB or less can be used, and all disks should be of the same size and type. The number of local storage devices that can run per node is a function of the node size and [resource requirements](#). Expanding the cluster in multiples of three, one node in each failure domain, is an easy way to satisfy [pod placement rules](#).



NOTE

Disk partitioning is not supported.

7.5.3. Capacity planning

Always ensure that available storage capacity stays ahead of consumption. Recovery is difficult if available storage capacity is completely exhausted, and requires more intervention than simply adding capacity or deleting or migrating content.

Capacity alerts are issued when cluster storage capacity reaches 75% (near-full) and 85% (full) of total capacity. Always address capacity warnings promptly, and review your storage regularly to ensure that you do not run out of storage space. When you get to 75% (near-full), either free up space or expand the cluster. When you get the 85% (full) alert, it indicates that you have run out of storage space completely and cannot free up space using standard commands. At this point, contact [Red Hat Customer Support](#).

The following tables show example node configurations for Red Hat OpenShift Data Foundation with dynamic storage devices.

Table 7.7. Example initial configurations with 3 nodes

Storage Device size	Storage Devices per node	Total capacity	Usable storage capacity
0.5 TiB	1	1.5 TiB	0.5 TiB
2 TiB	1	6 TiB	2 TiB
4 TiB	1	12 TiB	4 TiB

Table 7.8. Example of expanded configurations with 30 nodes (N)

Storage Device size (D)	Storage Devices per node (M)	Total capacity (D * M * N)	Usable storage capacity (D*M*N/3)
0.5 TiB	3	45 TiB	15 TiB
2 TiB	6	360 TiB	120 TiB

Storage Device size (D)	Storage Devices per node (M)	Total capacity (D * M * N)	Usable storage capacity (D*M*N/3)
4 TiB	9	1080 TiB	360 TiB

7.6. MULTI NETWORK PLUG-IN (MULTUS) SUPPORT [TECHNOLOGY PREVIEW]

By default, Red Hat OpenShift Data Foundation is configured to use the Red Hat OpenShift Software Defined Network (SDN). In this default configuration the SDN carries the following types of traffic:

- Pod to pod traffic
- Pod to OpenShift Data Foundation traffic, known as the OpenShift Data Foundation public network traffic
- OpenShift Data Foundation replication and rebalancing, known as the OpenShift Data Foundation cluster network traffic

However, OpenShift Data Foundation 4.8 and later supports as a Technology Preview the ability to use Multus to improve security and performance by isolating the different types of network traffic.



IMPORTANT

Multus support is a Technology Preview feature that is only supported and has been tested on bare metal and VMWare deployments. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information, see [Technology Preview Features Support Scope](#).

7.6.1. Understanding multiple networks

In Kubernetes, container networking is delegated to networking plug-ins that implement the Container Network Interface (CNI).

OpenShift Container Platform uses the Multus CNI plug-in to allow chaining of CNI plug-ins. During cluster installation, you configure your *default* pod network. The default network handles all ordinary network traffic for the cluster. You can define an *additional network* based on the available CNI plug-ins and attach one or more of these networks to your pods. You can define more than one additional network for your cluster, depending on your needs. This gives you flexibility when you configure pods that deliver network functionality, such as switching or routing.

7.6.1.1. Usage scenarios for an additional network

You can use an additional network in situations where network isolation is needed, including data plane and control plane separation. Isolating network traffic is useful for the following performance and security reasons:

Performance

You can send traffic on two different planes in order to manage how much traffic is along each plane.

Security

You can send sensitive traffic onto a network plane that is managed specifically for security considerations, and you can separate private data that must not be shared between tenants or customers.

All of the pods in the cluster still use the cluster-wide default network to maintain connectivity across the cluster. Every pod has an **eth0** interface that is attached to the cluster-wide pod network. You can view the interfaces for a pod by using the **oc exec -it <pod_name> -- ip a** command. If you add additional network interfaces that use Multus CNI, they are named **net1**, **net2**, ..., **netN**.

To attach additional network interfaces to a pod, you must create configurations that define how the interfaces are attached. You specify each interface by using a **NetworkAttachmentDefinition** custom resource (CR). A CNI configuration inside each of these CRs defines how that interface is created.

7.6.2. Segregating storage traffic using Multus

In order to use Multus, before deployment of the OpenShift Data Foundation cluster you must create network attachment definitions (NADs) that later will be attached to the cluster. For more information, see:

- [Creating network attachment definitions](#) for bare metal
- [Creating network attachment definitions](#) for VMware

Using Multus, the following configurations are possible depending on your hardware setup or your VMWare instance network setup:

- Nodes with a dual network interface recommended configuration
 - Segregated storage traffic
 - Configure one interface for OpenShift SDN (pod to pod traffic)
 - Configure one interface for all OpenShift Data Foundation traffic
- Nodes with a triple network interface recommended configuration
 - Full traffic segregation
 - Configure one interface for OpenShift SDN (pod to pod traffic)
 - Configure one interface for all pod to OpenShift Data Foundation traffic (OpenShift Data Foundation public traffic)
 - Configure one interface for all OpenShift Data Foundation replication and rebalancing traffic (OpenShift Data Foundation cluster traffic)

7.6.3. Recommended network configuration and requirements for a Multus configuration

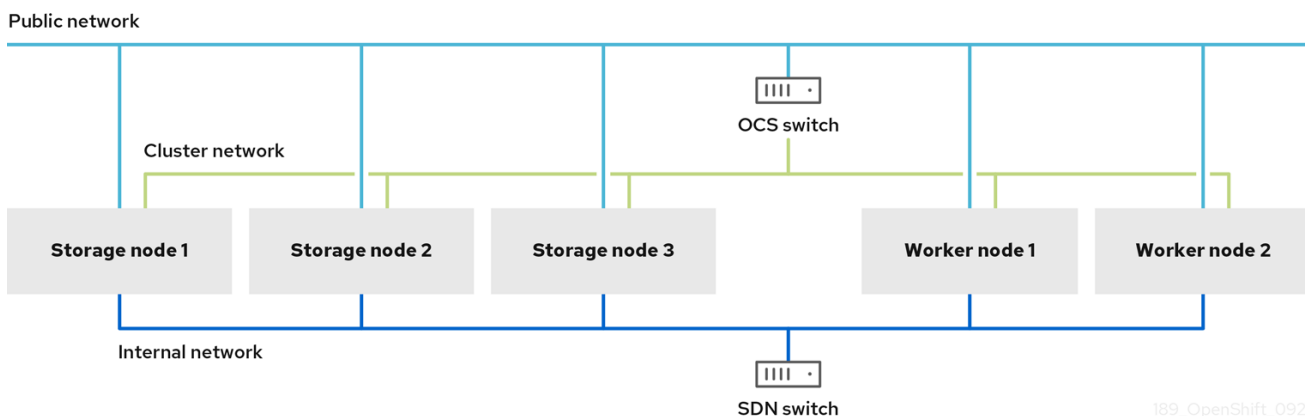
If you decide to leverage a Multus configuration, the following prerequisites must be met:

- All the nodes used to deploy OpenShift Data Foundation must have the same network interface configuration to guarantee a fully functional Multus configuration. The network interfaces

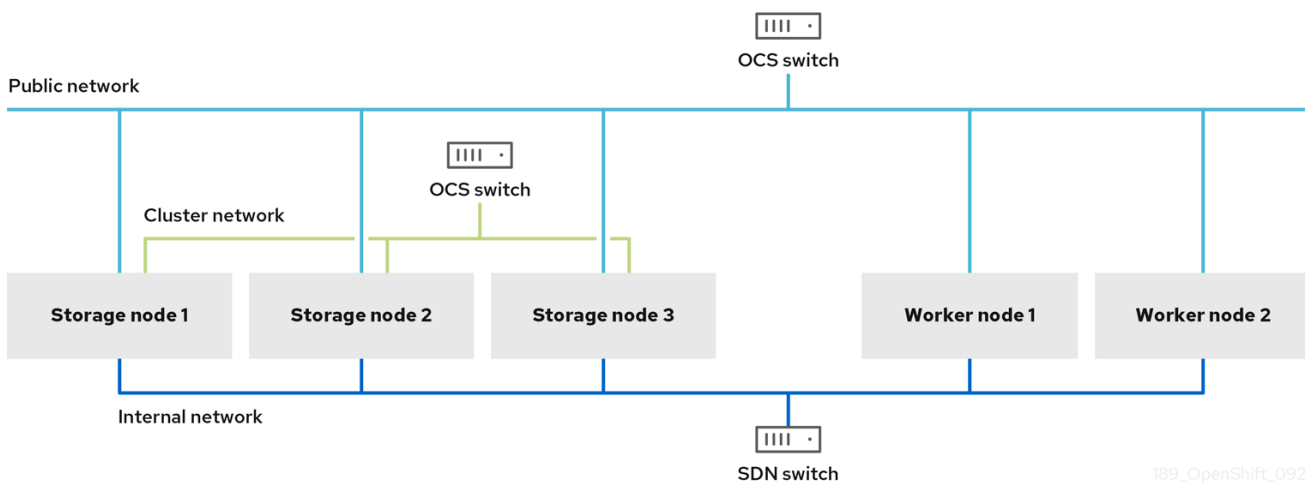
names on all nodes must be the same and connected to the same underlying switching mechanism for the Multus public network and the Multus cluster network.

- All the Worker nodes used to deploy applications that leverage OpenShift Data Foundation for persistent storage must have the same network interface configuration to guarantee a fully functional Multus configuration. One of the two interfaces must be the same interface name as that used to configure the Multus public network on the Storage nodes. All Worker network interfaces must be connected to the same underlying switching mechanism as that used for the Storage node's Multus public network.

Dual network interface segregated configuration schematic example:



Triple network interface full segregated configuration schematic example:



NOTE

Only the Storage nodes where OpenShift Data Foundation OSDs are running require access to the OpenShift Data Foundation cluster network configured via Multus.

See [Creating Multus networks](#) for the necessary steps to configure a Multus based configuration on bare metal.

See [Creating Multus networks](#) for the necessary steps to configure a Multus based configuration on VMware.

CHAPTER 8. DISASTER RECOVERY

Disaster Recovery (DR) helps an organization to recover and resume business critical functions or normal operations when there are disruptions or disasters. OpenShift Data Foundation provides High Availability (HA) & DR solutions for stateful apps which are broadly categorized into three broad categories:

- **Regional-DR:** Cross Region protection with minimal potential data loss [Developer Preview]
- **Metro-DR:** Single Region and cross data center protection with no data loss [Developer Preview]
- **Stretched Cluster - Arbiter:** Single OpenShift Data Foundation cluster is stretched between two different locations to provide the storage infrastructure with disaster recovery capabilities [Technology Preview]

8.1. REGIONAL-DR [DEVELOPER PREVIEW]

Regional-DR is composed of Red Hat Advanced Cluster Management for Kubernetes (RHACM) and OpenShift Data Foundation components to provide application and data mobility across OpenShift Container Platform clusters. It is built on Asynchronous data replication and hence could have a potential data loss but provides the protection against a broad set of failures.

Red Hat OpenShift Data Foundation is backed by Ceph as the storage provider, whose lifecycle is managed by Rook and it's enhanced with the ability to:

- Enable pools for mirroring.
- Automatically mirror images across RBD pools.
- Provides csi-addons to manage per Persistent Volume Claim mirroring.

This release of Regional-DR supports Multi-Cluster configuration that is deployed across different regions and data centers. For example, a 2-way replication across two managed clusters located in two different regions or data centers. This solution is entitled with Red Hat Advanced Cluster Management (RHACM) and OpenShift Data Foundation Advanced SKUs and related bundles.

Prerequisites

Disaster Recovery features supported by Red Hat OpenShift Data Foundation require all of the following prerequisites in order to successfully implement a Disaster Recovery solution:

- A valid Red Hat OpenShift Data Foundation Advanced entitlement
- A valid Red Hat Advanced Cluster Management for Kubernetes subscription

To know how subscriptions for OpenShift Data Foundation work, see [knowledgebase article on OpenShift Data Foundation subscriptions](#).

For detailed requirements, see [Regional-DR requirements](#) and [RHACM requirements](#).



IMPORTANT

This is a Developer Preview feature and is subject to Developer Preview support limitations. Developer Preview releases are not intended to be run in production environments and are not supported through the Red Hat Customer Portal case management system. If you need assistance with Developer Preview features, reach out to the ocs-devpreview@redhat.com mailing list and a member of the Red Hat Development Team will assist you as quickly as possible based on their availability and work schedules.

8.2. METRO-DR [DEVELOPER PREVIEW]

Metro-DR is composed of Red Hat Advanced Cluster Management for Kubernetes (RHACM), Red Hat Ceph Storage and OpenShift Data Foundation components to provide application and data mobility across OpenShift Container Platform clusters.

This release of Metro-DR solution provides volume persistent data and metadata replication across sites that are geographically dispersed. In the public cloud these would be similar to protecting from an Availability Zone failure. Metro-DR ensures business continuity during the unavailability of a data center with no data loss. This solution is entitled with Red Hat Advanced Cluster Management (RHACM) and OpenShift Data Foundation Advanced SKUs and related bundles.

Prerequisites

Disaster Recovery features supported by Red Hat OpenShift Data Foundation require all of the following prerequisites in order to successfully implement a Disaster Recovery solution:

- A valid Red Hat OpenShift Data Foundation Advanced entitlement
- A valid Red Hat Advanced Cluster Management for Kubernetes subscription

To know how subscriptions for OpenShift Data Foundation work, see [knowledgebase article on OpenShift Data Foundation subscriptions](#).

For detailed requirements, see [Metro-DR requirements](#), [deployment requirements for Red Hat Ceph Storage stretch cluster with arbiter](#) and [RHACM requirements](#).



IMPORTANT

This is a Developer Preview feature and is subject to Developer Preview support limitations. Developer Preview releases are not intended to be run in production environments and are not supported through the Red Hat Customer Portal case management system. If you need assistance with Developer Preview features, reach out to the ocs-devpreview@redhat.com mailing list and a member of the Red Hat Development Team will assist you as quickly as possible based on their availability and work schedules.

8.3. STRETCHED CLUSTER - ARBITER [TECHNOLOGY PREVIEW]

In this case, a single cluster is stretched across two zones with a third zone as the location for the arbiter. This is a Technology Preview feature that is currently intended for deployment in the OpenShift Container Platform on-premises and in the same data center. This solution is not recommended for deployments stretching over multiple data centers. Instead, consider Metro-DR as your first option for no data loss DR solution deployed over multiple data centers with low latency networks.



NOTE

This solution is designed to be deployed where latencies do not exceed 10 milliseconds round-trip time (RTT) between locations of the two zones residing in the main on-premise data centres. Contact [Red Hat Customer Support](#) if you are planning to deploy with higher latencies.

To use the Arbiter stretch cluster,

- You must have a minimum of five nodes across three zones, where:
 - Two nodes per zone are used for each data-center zone, and one additional zone with one node is used for arbiter zone (the arbiter can be on a master node).
- All the nodes must be manually labeled with the zone labels prior to cluster creation. For example, the zones can be labeled as:
 - **topology.kubernetes.io/zone=arbiter** (master or worker node)
 - **topology.kubernetes.io/zone=datacenter1** (minimum two worker nodes)
 - **topology.kubernetes.io/zone=datacenter2** (minimum two worker nodes)

For more information, see [Knowledgebase article](#) on Configuring OpenShift Data Foundation for stretch cluster.

For more information, see:

- [Configuring OpenShift Data Foundation for stretch cluster](#) .
- [Recovering a stretch cluster](#) .



IMPORTANT

Stretch cluster is a Technology Preview features and is subject to Technology Preview support limitations. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information, see [Technology Preview Features Support Scope](#) .

CHAPTER 9. DISCONNECTED ENVIRONMENT

Disconnected environment is a network restricted environment where Operator Lifecycle Manager (OLM) cannot access the default Operator Hub and image registries, which require Internet connectivity.

Red Hat supports deployment of OpenShift Data Foundation in disconnected environments where OpenShift Container Platform is installed in restricted networks.

To install OpenShift Data Foundation in a disconnected environment, refer to the steps in the [Using Operator Lifecycle Manager on restricted networks](#) chapter of Operators guide in OpenShift Container Platform documentation.



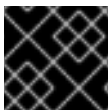
NOTE

When you install OpenShift Data Foundation in a restricted network environment, apply a custom Network Time Protocol (NTP) configuration to the nodes, because by default, internet connectivity is assumed in OpenShift Container Platform and chronyd is configured to use [*.rhel.pool.ntp.org](#) servers. See [Red Hat Knowledgebase article](#) and [Configuring chrony time service](#) for more details.

Packages to include for OpenShift Data Foundation

At the time of pruning **redhat-operator** index image, include the following list of packages for OpenShift Data Foundation deployment:

- **ocs-operator**
- **odf-operator**
- **mcg-operator**
- **odf-csi-addons-operator**
- **odf-lvm-operator** [This is currently a **Technology Preview** feature and not supported for disconnected installations]
- (optional)**local-storage-operator** (only for local storage deployments)
- (optional)**odf-multicluster-orchestrator** (only for Regional disaster recovery configuration)



IMPORTANT

CatalogSource must be named as **redhat-operators**.

CHAPTER 10. SUPPORTED AND UNSUPPORTED FEATURES FOR IBM POWER AND IBM Z INFRASTRUCTURE

Table 10.1. List of supported and unsupported features on IBM Power and IBM Z infrastructure

Features	IBM Power	IBM Z infrastructure
Compact deployment	Unsupported	Unsupported
Dynamic storage devices	Unsupported	Supported
Stretched Cluster - Arbiter	Unsupported	Unsupported
FIPS	Unsupported	Unsupported
Ability to view pool compression metrics	Supported	Unsupported
Automated scaling of Multicloud Object Gateway endpoint pods	Supported	Unsupported
Alerts to control overprovision	Supported	Unsupported
Alerts when Ceph Monitor runs out of space	Supported	Unsupported
Deployment of standalone Multicloud Object Gateway component	Supported	Unsupported
Extended OpenShift Data Foundation control plane which allows pluggable external storage such as IBM Flashsystem	Unsupported	Unsupported
IPV6 support	Unsupported	Unsupported
Multus	Unsupported	Unsupported
Multicloud Object Gateway bucket replication	Supported	Unsupported
Quota support for object data	Supported	Unsupported
Minimum deployment	Unsupported	Unsupported
Regional-DR with Red Hat Advanced Cluster Management (RHACM)	Unsupported	Unsupported

Features	IBM Power	IBM Z infrastructure
Metro-DR multiple clusters with Red Hat Advanced Cluster Management (RHACM)	Unsupported	Unsupported
Single Node solution for Radio Access Network (RAN)	Unsupported	Unsupported

CHAPTER 11. NEXT STEPS

To start deploying your OpenShift Data Foundation, you can use the internal mode within OpenShift Container Platform or use external mode to make available services from a cluster running outside of OpenShift Container Platform.

Depending on your requirement, go to the respective deployment guides.

Internal mode

- [Deploying OpenShift Data Foundation using Amazon web services](#)
- [Deploying OpenShift Data Foundation using Bare Metal](#)
- [Deploying OpenShift Data Foundation using VMWare vSphere](#)
- [Deploying OpenShift Data Foundation using Microsoft Azure](#)
- [Deploying OpenShift Data Foundation using Google Cloud \[Technology Preview\]](#)
- [Deploying OpenShift Data Foundation using Red Hat OpenStack Platform \[Technology Preview\]](#)
- [Deploying OpenShift Data Foundation using Red Hat Virtualization Platform](#)
- [Deploying OpenShift Data Foundation on IBM Power](#)
- [Deploying OpenShift Data Foundation on IBM Z Infrastructure](#)

External mode

- [Deploying OpenShift Data Foundation in external mode](#)