Red Hat OpenShift Service on AWS 4

Nodes

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Abstract

This document provides instructions for configuring and managing the nodes, Pods, and containers in your cluster. It also provides information on configuring Pod scheduling and placement, using jobs and DaemonSets to automate tasks, and other tasks to ensure an efficient cluster.

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CHAPTER 1. OVERVIEW OF NODES

1.1. ABOUT NODES

A node is a virtual or bare-metal machine in a Kubernetes cluster. Worker nodes host your application containers, grouped as pods. The control plane nodes run services that are required to control the Kubernetes cluster. In Red Hat OpenShift Service on AWS, the control plane nodes contain more than just the Kubernetes services for managing the Red Hat OpenShift Service on AWS cluster.

Having stable and healthy nodes in a cluster is fundamental to the smooth functioning of your hosted application. In Red Hat OpenShift Service on AWS, you can access, manage, and monitor a node through the **Node** object representing the node. Using the OpenShift CLI (**oc**) or the web console, you can perform the following operations on a node.

The following components of a node are responsible for maintaining the running of pods and providing the Kubernetes runtime environment.

Container runtime

The container runtime is responsible for running containers. Kubernetes offers several runtimes such as containerd, cri-o, rktlet, and Docker.

Kubelet

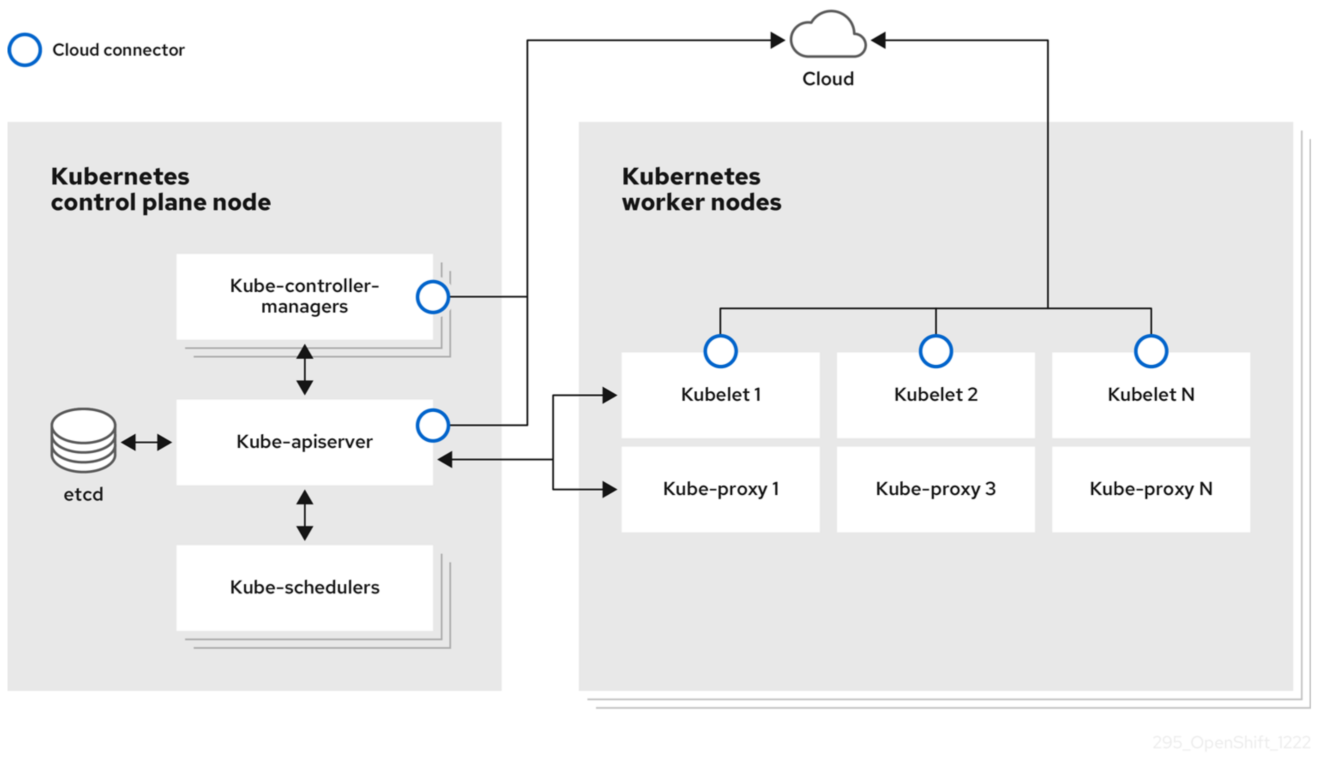
Kubelet runs on nodes and reads the container manifests. It ensures that the defined containers have started and are running. The kubelet process maintains the state of work and the node server. Kubelet manages network rules and port forwarding. The kubelet manages containers that are created by Kubernetes only.

Kube-proxy

Kube-proxy runs on every node in the cluster and maintains the network traffic between the Kubernetes resources. A Kube-proxy ensures that the networking environment is isolated and accessible.

DNS

Cluster DNS is a DNS server which serves DNS records for Kubernetes services. Containers started by Kubernetes automatically include this DNS server in their DNS searches.



Read operations

The read operations allow an administrator or a developer to get information about nodes in an Red Hat OpenShift Service on AWS cluster.

- List all the nodes in a cluster .
- Get information about a node, such as memory and CPU usage, health, status, and age.
- List pods running on a node .

Enhancement operations

Red Hat OpenShift Service on AWS allows you to do more than just access and manage nodes; as an administrator, you can perform the following tasks on nodes to make the cluster more efficient, application-friendly, and to provide a better environment for your developers.

- Manage node-level tuning for high-performance applications that require some level of kernel tuning by using the Node Tuning Operator.
- Run background tasks on nodes automatically with daemon sets . You can create and use daemon sets to create shared storage, run a logging pod on every node, or deploy a monitoring agent on all nodes.

1.2. ABOUT PODS

A pod is one or more containers deployed together on a node. As a cluster administrator, you can define a pod, assign it to run on a healthy node that is ready for scheduling, and manage. A pod runs as long as the containers are running. You cannot change a pod once it is defined and is running. Some operations you can perform when working with pods are:

Read operations

As an administrator, you can get information about pods in a project through the following tasks:

- List pods associated with a project , including information such as the number of replicas and restarts, current status, and age.
- View pod usage statistics such as CPU, memory, and storage consumption.

Management operations
The following list of tasks provides an overview of how an administrator can manage pods in an Red Hat OpenShift Service on AWS cluster.

- Control scheduling of pods using the advanced scheduling features available in Red Hat OpenShift Service on AWS:
  - Node-to-pod binding rules such as pod affinity, node affinity, and anti-affinity.
  - Node labels and selectors.
  - Taints and tolerations.
  - Pod topology spread constraints.
- Configure how pods behave after a restart using pod controllers and restart policies .
- Limit both egress and ingress traffic on a pod .
- Add and remove volumes to and from any object that has a pod template . A volume is a mounted file system available to all the containers in a pod. Container storage is ephemeral; you can use volumes to persist container data.

Enhancement operations
You can work with pods more easily and efficiently with the help of various tools and features available in Red Hat OpenShift Service on AWS. The following operations involve using those tools and features to better manage pods.

- Secrets: Some applications need sensitive information, such as passwords and usernames. An administrator can use the **Secret** object to provide sensitive data to pods using the **Secret** object.

1.3. ABOUT CONTAINERS

A container is the basic unit of an Red Hat OpenShift Service on AWS application, which comprises the application code packaged along with its dependencies, libraries, and binaries. Containers provide consistency across environments and multiple deployment targets: physical servers, virtual machines (VMs), and private or public cloud.

Linux container technologies are lightweight mechanisms for isolating running processes and limiting access to only designated resources. As an administrator, You can perform various tasks on a Linux container, such as:

- Copy files to and from a container .
- Allow containers to consume API objects.
- Execute remote commands in a container .
- Use port forwarding to access applications in a container .

Red Hat OpenShift Service on AWS provides specialized containers called Init containers. Init containers run before application containers and can contain utilities or setup scripts not present in an application image. You can use an Init container to perform tasks before the rest of a pod is deployed.

Apart from performing specific tasks on nodes, pods, and containers, you can work with the overall Red Hat OpenShift Service on AWS cluster to keep the cluster efficient and the application pods highly available.

1.4. GLOSSARY OF COMMON TERMS FOR RED HAT OPENSHIFT SERVICE ON AWS NODES

This glossary defines common terms that are used in the *node* content.

Container

It is a lightweight and executable image that comprises software and all its dependencies. Containers virtualize the operating system, as a result, you can run containers anywhere from a data center to a public or private cloud to even a developer's laptop.

Daemon set

Ensures that a replica of the pod runs on eligible nodes in an Red Hat OpenShift Service on AWS cluster.

egress

The process of data sharing externally through a network's outbound traffic from a pod.

garbage collection

The process of cleaning up cluster resources, such as terminated containers and images that are not referenced by any running pods.

Ingress

Incoming traffic to a pod.

Job

A process that runs to completion. A job creates one or more pod objects and ensures that the specified pods are successfully completed.

Labels

You can use labels, which are key-value pairs, to organise and select subsets of objects, such as a pod.

Node

A worker machine in the Red Hat OpenShift Service on AWS cluster. A node can be either be a virtual machine (VM) or a physical machine.

Node Tuning Operator

You can use the Node Tuning Operator to manage node-level tuning by using the TuneD daemon. It ensures custom tuning specifications are passed to all containerized TuneD daemons running in the cluster in the format that the daemons understand. The daemons run on all nodes in the cluster, one per node.

Self Node Remediation Operator

The Operator runs on the cluster nodes and identifies and reboots nodes that are unhealthy.

Pod

One or more containers with shared resources, such as volume and IP addresses, running in your Red Hat OpenShift Service on AWS cluster. A pod is the smallest compute unit defined, deployed, and managed.

Toleration

Indicates that the pod is allowed (but not required) to be scheduled on nodes or node groups with matching taints. You can use tolerations to enable the scheduler to schedule pods with matching taints.

Taint

A core object that comprises a key,value, and effect. Taints and tolerations work together to ensure that pods are not scheduled on irrelevant nodes.

CHAPTER 2. WORKING WITH PODS

2.1. USING PODS

A *pod* is one or more containers deployed together on one host, and the smallest compute unit that can be defined, deployed, and managed.

2.1.1. Understanding pods

Pods are the rough equivalent of a machine instance (physical or virtual) to a Container. Each pod is allocated its own internal IP address, therefore owning its entire port space, and containers within pods can share their local storage and networking.

Pods have a lifecycle; they are defined, then they are assigned to run on a node, then they run until their container(s) exit or they are removed for some other reason. Pods, depending on policy and exit code, might be removed after exiting, or can be retained to enable access to the logs of their containers.

Red Hat OpenShift Service on AWS treats pods as largely immutable; changes cannot be made to a pod definition while it is running. Red Hat OpenShift Service on AWS implements changes by terminating an existing pod and recreating it with modified configuration, base image(s), or both. Pods are also treated as expendable, and do not maintain state when recreated. Therefore pods should usually be managed by higher-level controllers, rather than directly by users.

WARNING

Bare pods that are not managed by a replication controller will be not rescheduled upon node disruption.

2.1.2. Example pod configurations

Red Hat OpenShift Service on AWS leverages the Kubernetes concept of a *pod*, which is one or more containers deployed together on one host, and the smallest compute unit that can be defined, deployed, and managed.

The following is an example definition of a pod. It demonstrates many features of pods, most of which are discussed in other topics and thus only briefly mentioned here:

Pod object definition (YAML)

```
kind: Pod
apiVersion: v1
metadata:
  name: example
  labels:
    environment: production
    app: abc 1
spec:
  restartPolicy: Always 2
  securityContext: 3
  runAsNonRoot: true
  seccompProfile:
    type: RuntimeDefault
containers: 4
  - name: abc
    args:
    - sleep
    - "1000000"
    volumeMounts: 5
     - name: cache-volume
       mountPath: /cache 6
    image: registry.access.redhat.com/ubi7/ubi-init:latest 7
    securityContext:
      allowPrivilegeEscalation: false
      runAsNonRoot: true
      capabilities:
        drop: ["ALL"]
    resources:
      limits:
        memory: "100Mi"
        cpu: "1"
      requests:
        memory: "100Mi"
        cpu: "1"
volumes: 8
- name: cache-volume
  emptyDir:
    sizeLimit: 500Mi
```

1 Pods can be "tagged" with one or more labels, which can then be used to select and manage groups of pods in a single operation. The labels are stored in key/value format in the **metadata** hash.

2 The pod restart policy with possible values **Always**, **OnFailure**, and **Never**. The default value is **Always**.

3 Red Hat OpenShift Service on AWS defines a security context for containers which specifies whether they are allowed to run as privileged containers, run as a user of their choice, and more. The default context is very restrictive but administrators can modify this as needed.

4 **containers** specifies an array of one or more container definitions.

5 The container specifies where external storage volumes are mounted within the container.

6 Specify the volumes to provide for the pod. Volumes mount at the specified path. Do not mount to the container root, /, or any path that is the same in the host and the container. This can corrupt your host system if the container is sufficiently privileged, such as the host **/dev/pts** files. It is safe to mount the host by using **/host**.

7 Each container in the pod is instantiated from its own container image.

8 The pod defines storage volumes that are available to its container(s) to use.

If you attach persistent volumes that have high file counts to pods, those pods can fail or can take a long time to start. For more information, see When using Persistent Volumes with high file counts in OpenShift, why do pods fail to start or take an excessive amount of time to achieve "Ready" state?.

NOTE

This pod definition does not include attributes that are filled by Red Hat OpenShift Service on AWS automatically after the pod is created and its lifecycle begins. The Kubernetes pod documentation has details about the functionality and purpose of pods.

2.1.3. Additional resources

- For more information on pods and storage see Understanding persistent storage and Understanding ephemeral storage.

2.2. VIEWING PODS

As an administrator, you can view the pods in your cluster and to determine the health of those pods and the cluster as a whole.

2.2.1. About pods

Red Hat OpenShift Service on AWS leverages the Kubernetes concept of a *pod*, which is one or more containers deployed together on one host, and the smallest compute unit that can be defined, deployed, and managed. Pods are the rough equivalent of a machine instance (physical or virtual) to a container.

You can view a list of pods associated with a specific project or view usage statistics about pods.

2.2.2. Viewing pods in a project

You can view a list of pods associated with the current project, including the number of replica, the current status, number or restarts and the age of the pod.

Procedure

To view the pods in a project:

1. Change to the project:

```
$ oc project <project-name>
```

2. Run the following command:

```
$ oc get pods
```

For example:

```
$ oc get pods
```

Example output

```
NAME                    READY   STATUS    RESTARTS   AGE
console-698d866b78-bnshf   1/1     Running   2          165m
console-698d866b78-m87pm   1/1     Running   2          165m
```

Add the **-o wide** flags to view the pod IP address and the node where the pod is located.

```
$ oc get pods -o wide
```

Example output

```
NAME                    READY   STATUS    RESTARTS   AGE    IP            NODE
NOMINATED NODE
console-698d866b78-bnshf   1/1     Running   2          166m   10.128.0.24   ip-10-0-152-
71.ec2.internal    <none>
console-698d866b78-m87pm   1/1     Running   2          166m   10.129.0.23   ip-10-0-173-
237.ec2.internal   <none>
```

2.2.3. Viewing pod usage statistics

You can display usage statistics about pods, which provide the runtime environments for containers. These usage statistics include CPU, memory, and storage consumption.

Prerequisites

- You must have **cluster-reader** permission to view the usage statistics.
- Metrics must be installed to view the usage statistics.

Procedure

To view the usage statistics:

1. Run the following command:

```
$ oc adm top pods
```

For example:

```
$ oc adm top pods -n openshift-console
```

Example output

```
NAME                         CPU(cores)   MEMORY(bytes)
console-7f58c69899-q8c8k     0m           22Mi
console-7f58c69899-xhbgg     0m           25Mi
downloads-594fcccf94-bcxk8   3m           18Mi
downloads-594fcccf94-kv4p6   2m           15Mi
```

2. Run the following command to view the usage statistics for pods with labels:

```
$ oc adm top pod --selector=''
```

You must choose the selector (label query) to filter on. Supports **=**, **==**, and **!=**.

For example:

```
$ oc adm top pod --selector='name=my-pod'
```

2.2.4. Viewing resource logs

You can view the log for various resources in the OpenShift CLI (**oc**) and web console. Logs read from the tail, or end, of the log.

Prerequisites

- Access to the OpenShift CLI (**oc**).

Procedure (UI)

1. In the Red Hat OpenShift Service on AWS console, navigate to **Workloads** → **Pods** or navigate to the pod through the resource you want to investigate.

   NOTE

   Some resources, such as builds, do not have pods to query directly. In such instances, you can locate the **Logs** link on the **Details** page for the resource.

2. Select a project from the drop-down menu.
3. Click the name of the pod you want to investigate.
4. Click **Logs**.

Procedure (CLI)

- View the log for a specific pod:

```
$ oc logs -f <pod_name> -c <container_name>
```

where:

-f
   Optional: Specifies that the output follows what is being written into the logs.

<pod_name>
   Specifies the name of the pod.

<container_name>
   Optional: Specifies the name of a container. When a pod has more than one container, you must specify the container name.

For example:

```
$ oc logs ruby-58cd97df55-mww7r
$ oc logs -f ruby-57f7f4855b-znl92 -c ruby
```

The contents of log files are printed out.

- View the log for a specific resource:

```
$ oc logs <object_type>/<resource_name> 1
```

1 Specifies the resource type and name.

For example:

```
$ oc logs deployment/ruby
```

The contents of log files are printed out.

2.3. CONFIGURING AN RED HAT OPENSHIFT SERVICE ON AWS CLUSTER FOR PODS

As an administrator, you can create and maintain an efficient cluster for pods.

By keeping your cluster efficient, you can provide a better environment for your developers using such tools as what a pod does when it exits, ensuring that the required number of pods is always running, when to restart pods designed to run only once, limit the bandwidth available to pods, and how to keep pods running during disruptions.

2.3.1. Configuring how pods behave after restart

A pod restart policy determines how Red Hat OpenShift Service on AWS responds when Containers in that pod exit. The policy applies to all Containers in that pod.

The possible values are:

- **Always** - Tries restarting a successfully exited Container on the pod continuously, with an exponential back-off delay (10s, 20s, 40s) capped at 5 minutes. The default is **Always**.
- **OnFailure** - Tries restarting a failed Container on the pod with an exponential back-off delay (10s, 20s, 40s) capped at 5 minutes.
- **Never** - Does not try to restart exited or failed Containers on the pod. Pods immediately fail and exit.

After the pod is bound to a node, the pod will never be bound to another node. This means that a controller is necessary in order for a pod to survive node failure:

Condition	Controller Type	Restart Policy
Pods that are expected to terminate (such as batch computations)	Job	**OnFailure** or **Never**

Condition	Controller Type	Restart Policy
Pods that are expected to not terminate (such as web servers)	Replication controller	**Always**.
Pods that must run one-per-machine	Daemon set	Any

If a Container on a pod fails and the restart policy is set to **OnFailure**, the pod stays on the node and the Container is restarted. If you do not want the Container to restart, use a restart policy of **Never**.

If an entire pod fails, Red Hat OpenShift Service on AWS starts a new pod. Developers must address the possibility that applications might be restarted in a new pod. In particular, applications must handle temporary files, locks, incomplete output, and so forth caused by previous runs.

NOTE

Kubernetes architecture expects reliable endpoints from cloud providers. When a cloud provider is down, the kubelet prevents Red Hat OpenShift Service on AWS from restarting.

If the underlying cloud provider endpoints are not reliable, do not install a cluster using cloud provider integration. Install the cluster as if it was in a no-cloud environment. It is not recommended to toggle cloud provider integration on or off in an installed cluster.

For details on how Red Hat OpenShift Service on AWS uses restart policy with failed Containers, see the Example States in the Kubernetes documentation.

2.3.2. Limiting the bandwidth available to pods

You can apply quality-of-service traffic shaping to a pod and effectively limit its available bandwidth. Egress traffic (from the pod) is handled by policing, which simply drops packets in excess of the configured rate. Ingress traffic (to the pod) is handled by shaping queued packets to effectively handle data. The limits you place on a pod do not affect the bandwidth of other pods.

Procedure

To limit the bandwidth on a pod:

1. Write an object definition JSON file, and specify the data traffic speed using **kubernetes.io/ingress-bandwidth** and **kubernetes.io/egress-bandwidth** annotations. For example, to limit both pod egress and ingress bandwidth to 10M/s:

   Limited Pod object definition

```
{
    "kind": "Pod",
    "spec": {
        "containers": [
            {
                "image": "openshift/hello-openshift",
                "name": "hello-openshift"
            }
        ]
    },
    "apiVersion": "v1",
    "metadata": {
        "name": "iperf-slow",
        "annotations": {
            "kubernetes.io/ingress-bandwidth": "10M",
            "kubernetes.io/egress-bandwidth": "10M"
        }
    }
}
```

2. Create the pod using the object definition:

```
$ oc create -f <file_or_dir_path>
```

2.3.3. Understanding how to use pod disruption budgets to specify the number of pods that must be up

A *pod disruption budget* allows the specification of safety constraints on pods during operations, such as draining a node for maintenance.

PodDisruptionBudget is an API object that specifies the minimum number or percentage of replicas that must be up at a time. Setting these in projects can be helpful during node maintenance (such as scaling a cluster down or a cluster upgrade) and is only honored on voluntary evictions (not on node failures).

A **PodDisruptionBudget** object's configuration consists of the following key parts:

- A label selector, which is a label query over a set of pods.
- An availability level, which specifies the minimum number of pods that must be available simultaneously, either:
  - **minAvailable** is the number of pods must always be available, even during a disruption.
  - **maxUnavailable** is the number of pods can be unavailable during a disruption.

NOTE

Available refers to the number of pods that has condition **Ready=True**. **Ready=True** refers to the pod that is able to serve requests and should be added to the load balancing pools of all matching services.

A **maxUnavailable** of **0%** or **0** or a **minAvailable** of **100%** or equal to the number of replicas is permitted but can block nodes from being drained.

WARNING

The default setting for **maxUnavailable** is **1** for all the machine config pools in Red Hat OpenShift Service on AWS. It is recommended to not change this value and update one control plane node at a time. Do not change this value to **3** for the control plane pool.

You can check for pod disruption budgets across all projects with the following:

```
$ oc get poddisruptionbudget --all-namespaces
```

Example output

```
NAMESPACE                              NAME                                    MIN AVAILABLE   MAX UNAVAILABLE
ALLOWED DISRUPTIONS   AGE
openshift-apiserver                    openshift-apiserver-pdb                 N/A             1               1
121m
openshift-cloud-controller-manager     aws-cloud-controller-manager            1               N/A             1
125m
openshift-cloud-credential-operator    pod-identity-webhook                    1               N/A             1
117m
openshift-cluster-csi-drivers          aws-ebs-csi-driver-controller-pdb       N/A             1               1
121m
openshift-cluster-storage-operator     csi-snapshot-controller-pdb             N/A             1               1
122m
openshift-cluster-storage-operator     csi-snapshot-webhook-pdb                N/A             1               1
122m
openshift-console                      console                                 N/A             1               1
116m
#...
```

The **PodDisruptionBudget** is considered healthy when there are at least **minAvailable** pods running in the system. Every pod above that limit can be evicted.

NOTE

Depending on your pod priority and preemption settings, lower-priority pods might be removed despite their pod disruption budget requirements.

2.3.3.1. Specifying the number of pods that must be up with pod disruption budgets

You can use a **PodDisruptionBudget** object to specify the minimum number or percentage of replicas that must be up at a time.

Procedure

To configure a pod disruption budget:

1. Create a YAML file with the an object definition similar to the following:

```
apiVersion: policy/v1 (1)
kind: PodDisruptionBudget
metadata:
  name: my-pdb
spec:
  minAvailable: 2 (2)
  selector: (3)
    matchLabels:
      name: my-pod
```

1. **PodDisruptionBudget** is part of the **policy/v1** API group.
2. The minimum number of pods that must be available simultaneously. This can be either an integer or a string specifying a percentage, for example, **20%**.
3. A label query over a set of resources. The result of **matchLabels** and **matchExpressions** are logically conjoined. Leave this parameter blank, for example **selector {}**, to select all pods in the project.

Or:

```
apiVersion: policy/v1 (1)
kind: PodDisruptionBudget
metadata:
  name: my-pdb
spec:
  maxUnavailable: 25% (2)
  selector: (3)
    matchLabels:
      name: my-pod
```

1. **PodDisruptionBudget** is part of the **policy/v1** API group.
2. The maximum number of pods that can be unavailable simultaneously. This can be either an integer or a string specifying a percentage, for example, **20%**.
3. A label query over a set of resources. The result of **matchLabels** and **matchExpressions** are logically conjoined. Leave this parameter blank, for example **selector {}**, to select all pods in the project.

2. Run the following command to add the object to project:

```
$ oc create -f </path/to/file> -n <project_name>
```

2.4. PROVIDING SENSITIVE DATA TO PODS BY USING SECRETS

Additional resources

Some applications need sensitive information, such as passwords and user names, that you do not want developers to have.

As an administrator, you can use **Secret** objects to provide this information without exposing that information in clear text.

2.4.1. Understanding secrets

The **Secret** object type provides a mechanism to hold sensitive information such as passwords, Red Hat OpenShift Service on AWS client configuration files, private source repository credentials, and so on. Secrets decouple sensitive content from the pods. You can mount secrets into containers using a volume plugin or the system can use secrets to perform actions on behalf of a pod.

Key properties include:

- Secret data can be referenced independently from its definition.
- Secret data volumes are backed by temporary file-storage facilities (tmpfs) and never come to rest on a node.
- Secret data can be shared within a namespace.

YAML Secret object definition

```
apiVersion: v1
kind: Secret
metadata:
  name: test-secret
  namespace: my-namespace
type: Opaque (1)
data: (2)
  username: <username> (3)
  password: <password>
stringData: (4)
  hostname: myapp.mydomain.com (5)
```

1. Indicates the structure of the secret's key names and values.
2. The allowable format for the keys in the **data** field must meet the guidelines in the **DNS_SUBDOMAIN** value in the Kubernetes identifiers glossary.
3. The value associated with keys in the **data** map must be base64 encoded.
4. Entries in the **stringData** map are converted to base64 and the entry will then be moved to the **data** map automatically. This field is write-only; the value will only be returned via the **data** field.
5. The value associated with keys in the **stringData** map is made up of plain text strings.

You must create a secret before creating the pods that depend on that secret.

When creating secrets:

- Create a secret object with secret data.
- Update the pod's service account to allow the reference to the secret.
- Create a pod, which consumes the secret as an environment variable or as a file (using a **secret** volume).

2.4.1.1. Types of secrets

The value in the **type** field indicates the structure of the secret's key names and values. The type can be used to enforce the presence of user names and keys in the secret object. If you do not want validation, use the **opaque** type, which is the default.

Specify one of the following types to trigger minimal server-side validation to ensure the presence of specific key names in the secret data:

- **kubernetes.io/service-account-token**. Uses a service account token.
- **kubernetes.io/basic-auth**. Use with Basic Authentication.
- **kubernetes.io/ssh-auth**. Use with SSH Key Authentication.
- **kubernetes.io/tls**. Use with TLS certificate authorities.

Specify **type: Opaque** if you do not want validation, which means the secret does not claim to conform to any convention for key names or values. An *opaque* secret, allows for unstructured **key:value** pairs that can contain arbitrary values.

NOTE

You can specify other arbitrary types, such as **example.com/my-secret-type**. These types are not enforced server-side, but indicate that the creator of the secret intended to conform to the key/value requirements of that type.

For examples of different secret types, see the code samples in *Using Secrets*.

2.4.1.2. Secret data keys

Secret keys must be in a DNS subdomain.

2.4.1.3. Automatically generated secrets

By default, Red Hat OpenShift Service on AWS creates the following secrets for each service account:

- A dockercfg image pull secret
- A service account token secret

NOTE

Prior to Red Hat OpenShift Service on AWS 4.11, a second service account token secret was generated when a service account was created. This service account token secret was used to access the Kubernetes API.

Starting with Red Hat OpenShift Service on AWS 4.11, this second service account token secret is no longer created. This is because the **LegacyServiceAccountTokenNoAutoGeneration** upstream Kubernetes feature gate was enabled, which stops the automatic generation of secret-based service account tokens to access the Kubernetes API.

After upgrading to 4, any existing service account token secrets are not deleted and continue to function.

This service account token secret and docker configuration image pull secret are necessary to integrate the OpenShift image registry into the cluster's user authentication and authorization system.

However, if you do not enable the **ImageRegistry** capability or if you disable the integrated OpenShift image registry in the Cluster Image Registry Operator's configuration, these secrets are not generated for each service account.

> **WARNING**
>
> Do not rely on these automatically generated secrets for your own use; they might be removed in a future Red Hat OpenShift Service on AWS release.

Workloads are automatically injected with a projected volume to obtain a bound service account token. If your workload needs an additional service account token, add an additional projected volume in your workload manifest. Bound service account tokens are more secure than service account token secrets for the following reasons:

- Bound service account tokens have a bounded lifetime.
- Bound service account tokens contain audiences.
- Bound service account tokens can be bound to pods or secrets and the bound tokens are invalidated when the bound object is removed.

For more information, see *Configuring bound service account tokens using volume projection* .

You can also manually create a service account token secret to obtain a token, if the security exposure of a non-expiring token in a readable API object is acceptable to you. For more information, see *Creating a service account token secret* .

Additional resources

- For information about creating a service account token secret, see Creating a service account token secret.

2.4.2. Understanding how to create secrets

As an administrator you must create a secret before developers can create the pods that depend on that secret.

When creating secrets:

1. Create a secret object that contains the data you want to keep secret. The specific data required for each secret type is descibed in the following sections.

   Example YAML object that creates an opaque secret

   ```
   apiVersion: v1
   kind: Secret
   metadata:
     name: test-secret
   ```

```
type: Opaque (1)
data: (2)
  username: <username>
  password: <password>
stringData: (3)
  hostname: myapp.mydomain.com
  secret.properties: |
    property1=valueA
    property2=valueB
```

1. Specifies the type of secret.
2. Specifies encoded string and data.
3. Specifies decoded string and data.

Use either the **data** or **stringdata** fields, not both.

2. Update the pod's service account to reference the secret:

YAML of a service account that uses a secret

```
apiVersion: v1
kind: ServiceAccount
 ...
secrets:
- name: test-secret
```

3. Create a pod, which consumes the secret as an environment variable or as a file (using a **secret** volume):

YAML of a pod populating files in a volume with secret data

```
apiVersion: v1
kind: Pod
metadata:
  name: secret-example-pod
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - name: secret-test-container
      image: busybox
      command: [ "/bin/sh", "-c", "cat /etc/secret-volume/*" ]
      volumeMounts: (1)
          - name: secret-volume
            mountPath: /etc/secret-volume (2)
            readOnly: true (3)
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
  volumes:
    - name: secret-volume
      secret:
        secretName: test-secret 4
  restartPolicy: Never
```

1. Add a **volumeMounts** field to each container that needs the secret.
2. Specifies an unused directory name where you would like the secret to appear. Each key in the secret data map becomes the filename under **mountPath**.
3. Set to **true**. If true, this instructs the driver to provide a read-only volume.
4. Specifies the name of the secret.

YAML of a pod populating environment variables with secret data

```
apiVersion: v1
kind: Pod
metadata:
  name: secret-example-pod
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - name: secret-test-container
      image: busybox
      command: [ "/bin/sh", "-c", "export" ]
      env:
        - name: TEST_SECRET_USERNAME_ENV_VAR
          valueFrom:
            secretKeyRef: 1
              name: test-secret
              key: username
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
  restartPolicy: Never
```

1. Specifies the environment variable that consumes the secret key.

YAML of a build config populating environment variables with secret data

```
apiVersion: build.openshift.io/v1
kind: BuildConfig
metadata:
  name: secret-example-bc
spec:
  strategy:
    sourceStrategy:
```

```
env:
- name: TEST_SECRET_USERNAME_ENV_VAR
  valueFrom:
    secretKeyRef: 1
      name: test-secret
      key: username
from:
  kind: ImageStreamTag
  namespace: openshift
  name: 'cli:latest'
```

1 Specifies the environment variable that consumes the secret key.

2.4.2.1. Secret creation restrictions

To use a secret, a pod needs to reference the secret. A secret can be used with a pod in three ways:

- To populate environment variables for containers.
- As files in a volume mounted on one or more of its containers.
- By kubelet when pulling images for the pod.

Volume type secrets write data into the container as a file using the volume mechanism. Image pull secrets use service accounts for the automatic injection of the secret into all pods in a namespace.

When a template contains a secret definition, the only way for the template to use the provided secret is to ensure that the secret volume sources are validated and that the specified object reference actually points to a **Secret** object. Therefore, a secret needs to be created before any pods that depend on it. The most effective way to ensure this is to have it get injected automatically through the use of a service account.

Secret API objects reside in a namespace. They can only be referenced by pods in that same namespace.

Individual secrets are limited to 1MB in size. This is to discourage the creation of large secrets that could exhaust apiserver and kubelet memory. However, creation of a number of smaller secrets could also exhaust memory.

2.4.2.2. Creating an opaque secret

As an administrator, you can create an opaque secret, which allows you to store unstructured **key:value** pairs that can contain arbitrary values.

Procedure

1. Create a **Secret** object in a YAML file on a control plane node.
   For example:

```
apiVersion: v1
kind: Secret
metadata:
  name: mysecret
type: Opaque 1
```

```
data:
  username: <username>
  password: <password>
```

1 Specifies an opaque secret.

2. Use the following command to create a **Secret** object:

```
$ oc create -f <filename>.yaml
```

3. To use the secret in a pod:

   a. Update the pod’s service account to reference the secret, as shown in the "Understanding how to create secrets" section.

   b. Create the pod, which consumes the secret as an environment variable or as a file (using a **secret** volume), as shown in the "Understanding how to create secrets" section.

Additional resources

- For more information on using secrets in pods, see Understanding how to create secrets .

2.4.2.3. Creating a service account token secret

As an administrator, you can create a service account token secret, which allows you to distribute a service account token to applications that must authenticate to the API.

NOTE

It is recommended to obtain bound service account tokens using the TokenRequest API instead of using service account token secrets. The tokens obtained from the TokenRequest API are more secure than the tokens stored in secrets, because they have a bounded lifetime and are not readable by other API clients.

You should create a service account token secret only if you cannot use the TokenRequest API and if the security exposure of a non-expiring token in a readable API object is acceptable to you.

See the Additional resources section that follows for information on creating bound service account tokens.

Procedure

1. Create a **Secret** object in a YAML file on a control plane node:

Example secret object:

```
apiVersion: v1
kind: Secret
metadata:
  name: secret-sa-sample
  annotations:
    kubernetes.io/service-account.name: "sa-name" 1
type: kubernetes.io/service-account-token 2
```

1. Specifies an existing service account name. If you are creating both the **ServiceAccount** and the **Secret** objects, create the **ServiceAccount** object first.

2. Specifies a service account token secret.

2. Use the following command to create the **Secret** object:

```
$ oc create -f <filename>.yaml
```

3. To use the secret in a pod:

   a. Update the pod's service account to reference the secret, as shown in the "Understanding how to create secrets" section.

   b. Create the pod, which consumes the secret as an environment variable or as a file (using a **secret** volume), as shown in the "Understanding how to create secrets" section.

Additional resources

- For more information on using secrets in pods, see Understanding how to create secrets .

2.4.2.4. Creating a basic authentication secret

As an administrator, you can create a basic authentication secret, which allows you to store the credentials needed for basic authentication. When using this secret type, the **data** parameter of the **Secret** object must contain the following keys encoded in the base64 format:

- **username**: the user name for authentication
- **password**: the password or token for authentication

NOTE

You can use the **stringData** parameter to use clear text content.

Procedure

1. Create a **Secret** object in a YAML file on a control plane node:

Example secret object

```
apiVersion: v1
kind: Secret
metadata:
  name: secret-basic-auth
type: kubernetes.io/basic-auth 1
data:
stringData: 2
  username: admin
  password: <password>
```

1. Specifies a basic authentication secret.

2 Specifies the basic authentication values to use.

2. Use the following command to create the **Secret** object:

```
$ oc create -f <filename>.yaml
```

3. To use the secret in a pod:

    a. Update the pod’s service account to reference the secret, as shown in the "Understanding how to create secrets" section.

    b. Create the pod, which consumes the secret as an environment variable or as a file (using a **secret** volume), as shown in the "Understanding how to create secrets" section.

Additional resources

- For more information on using secrets in pods, see Understanding how to create secrets .

2.4.2.5. Creating an SSH authentication secret

As an administrator, you can create an SSH authentication secret, which allows you to store data used for SSH authentication. When using this secret type, the **data** parameter of the **Secret** object must contain the SSH credential to use.

Procedure

1. Create a **Secret** object in a YAML file on a control plane node:

Example secret object:

```
apiVersion: v1
kind: Secret
metadata:
  name: secret-ssh-auth
type: kubernetes.io/ssh-auth 1
data:
  ssh-privatekey: | 2
        MIIEpQIBAAKCAQEAulqb/Y ...
```

1 Specifies an SSH authentication secret.

2 Specifies the SSH key/value pair as the SSH credentials to use.

2. Use the following command to create the **Secret** object:

```
$ oc create -f <filename>.yaml
```

3. To use the secret in a pod:

    a. Update the pod’s service account to reference the secret, as shown in the "Understanding how to create secrets" section.

b. Create the pod, which consumes the secret as an environment variable or as a file (using a **secret** volume), as shown in the "Understanding how to create secrets" section.

Additional resources

- Understanding how to create secrets .

2.4.2.6. Creating a Docker configuration secret

As an administrator, you can create a Docker configuration secret, which allows you to store the credentials for accessing a container image registry.

- **kubernetes.io/dockercfg**. Use this secret type to store your local Docker configuration file. The **data** parameter of the **secret** object must contain the contents of a **.dockercfg** file encoded in the base64 format.
- **kubernetes.io/dockerconfigjson**. Use this secret type to store your local Docker configuration JSON file. The **data** parameter of the **secret** object must contain the contents of a **.docker/config.json** file encoded in the base64 format.

Procedure

1. Create a **Secret** object in a YAML file on a control plane node.

Example Docker configuration secret object

```
apiVersion: v1
kind: Secret
metadata:
  name: secret-docker-cfg
  namespace: my-project
type: kubernetes.io/dockerconfig (1)
data:

.dockerconfig:bm5ubm5ubm5ubm5ubm5ubm5ubmdnZ2dnZ2dnZ2dnZ2dnZ2dnZ2cgYXV
0aCBrZXlzCg== (2)
```

(1) Specifies that the secret is using a Docker configuration file.

(2) The output of a base64-encoded Docker configuration file

Example Docker configuration JSON secret object

```
apiVersion: v1
kind: Secret
metadata:
  name: secret-docker-json
  namespace: my-project
type: kubernetes.io/dockerconfig (1)
data:

.dockerconfigjson:bm5ubm5ubm5ubm5ubm5ubm5ubmdnZ2dnZ2dnZ2dnZ2dnZ2dnZ2cg
YXV0aCBrZXlzCg== (2)
```

1 Specifies that the secret is using a Docker configuration JSONfile.

2 The output of a base64-encoded Docker configuration JSON file

2. Use the following command to create the **Secret** object

```
$ oc create -f <filename>.yaml
```

3. To use the secret in a pod:

   a. Update the pod’s service account to reference the secret, as shown in the "Understanding how to create secrets" section.

   b. Create the pod, which consumes the secret as an environment variable or as a file (using a **secret** volume), as shown in the "Understanding how to create secrets" section.

Additional resources

- For more information on using secrets in pods, see Understanding how to create secrets .

2.4.2.7. Creating a secret using the web console

You can create secrets using the web console.

Procedure

1. Navigate to **Workloads** → **Secrets**.

2. Click **Create** → **From YAML**.

   a. Edit the YAML manually to your specifications, or drag and drop a file into the YAML editor. For example:

```
apiVersion: v1
kind: Secret
metadata:
  name: example
  namespace: <namespace>
type: Opaque 1
data:
  username: <base64 encoded username>
  password: <base64 encoded password>
stringData: 2
  hostname: myapp.mydomain.com
```

1 This example specifies an opaque secret; however, you may see other secret types such as service account token secret, basic authentication secret, SSH authentication secret, or a secret that uses Docker configuration.

2 Entries in the **stringData** map are converted to base64 and the entry will then be moved to the **data** map automatically. This field is write-only; the value will only be returned via the **data** field.

3. Click **Create**.
4. Click **Add Secret to workload**
   a. From the drop-down menu, select the workload to add.
   b. Click **Save**.

2.4.3. Understanding how to update secrets

When you modify the value of a secret, the value (used by an already running pod) will not dynamically change. To change a secret, you must delete the original pod and create a new pod (perhaps with an identical PodSpec).

Updating a secret follows the same workflow as deploying a new Container image. You can use the **kubectl rolling-update** command.

The **resourceVersion** value in a secret is not specified when it is referenced. Therefore, if a secret is updated at the same time as pods are starting, the version of the secret that is used for the pod is not defined.

NOTE

Currently, it is not possible to check the resource version of a secret object that was used when a pod was created. It is planned that pods will report this information, so that a controller could restart ones using an old **resourceVersion**. In the interim, do not update the data of existing secrets, but create new ones with distinct names.

2.4.4. Creating and using secrets

As an administrator, you can create a service account token secret. This allows you to distribute a service account token to applications that must authenticate to the API.

Procedure

1. Create a service account in your namespace by running the following command:

```
$ oc create sa <service_account_name> -n <your_namespace>
```

2. Save the following YAML example to a file named **service-account-token-secret.yaml**. The example includes a **Secret** object configuration that you can use to generate a service account token:

```
apiVersion: v1
kind: Secret
metadata:
  name: <secret_name> 1
  annotations:
    kubernetes.io/service-account.name: "sa-name" 2
type: kubernetes.io/service-account-token 3
```

1 Replace **<secret_name>** with the name of your service token secret.

2 Specifies an existing service account name. If you are creating both the **ServiceAccount** and the **Secret** objects, create the **ServiceAccount** object first.

(3) Specifies a service account token secret type.

3. Generate the service account token by applying the file:

```
$ oc apply -f service-account-token-secret.yaml
```

4. Get the service account token from the secret by running the following command:

```
$ oc get secret <sa_token_secret> -o jsonpath='{.data.token}' | base64 --decode (1)
```

Example output

```
ayJhbGciOiJSUzI1NiIsImtpZCI6IklOb2dtck1qZ3hCSWpoNnh5YnZhSE9QMkk3YnRZMVZoclFf
QTZfRFp1YlUifQ.eyJpc3MiOiJrdWJlcm5ldGVzL3NlcnZpY2VhY2NvdW50Iiwia3ViZXJuZXRlcy5
pby9zZXJ2aWNlYWNjb3VudC9uYW1lc3BhY2UiOiJkZWZhdWx0Iiwia3ViZXJuZXRlcy5pby9zZX
J2aWNlYWNjb3VudC9zZWNyZXQubmFtZSI6ImJ1aWxkZXItdG9rZW4tdHZrbnIiLCJrdWJlcm5l
dGVzLmlvL3NlcnZpY2VhY2NvdW50L3NlcnZpY2UtYWNjb3VudC5uYW1lIjoiYnVpbGRlciIsImt1
YmVybmV0ZXMuaW8vc2VydmljZWFjY291bnQvc2VydmljZS1hY2NvdW50LnVpZCI6IjNmZGU
2MGZmLTA1NGYtNDkyZi04YzhjLTNlZjE0NDk3MmFmNyIsInN1YiI6InN5c3RlbTpzZXJ2aWNl
YWNjb3VudDpkZWZhdWx0OmJ1aWxkZXIifQ.OmqFTDuMHC_lYvvEUrjr1x453hlEEHYcxS9VK
SzmRkP1SiVZWPNPkTWlfNRp6bIUZD3U6aN3N7dMSN0eI5hu36xPgpKTdvuckKLTCnelMx6c
xOdAbrcw1mCmOClNscwjS1KO1kzMtYnnq8rXHiMJELsNlhnRyyIXRTtNBsy4t64T3283s3SLsa
ncyx0gy0ujx-Ch3uKAKdZi5iT-I8jnnQ-ds5THDs2h65RJhgglQEmSxpHrLGZFmyHAQI-
_SjvmHZPXEc482x3SkaQHNLqpmrpJorNqh1M8ZHKzlujhZgVooMvJmWPXTb2vnvi3DGn2XI-
hZxl1yD2yGH1RBpYUHA
```

(1) Replace <sa_token_secret> with the name of your service token secret.

5. Use your service account token to authenticate with the API of your cluster:

```
$ curl -X GET <openshift_cluster_api> --header "Authorization: Bearer <token>" (1) (2)
```

(1) Replace **<openshift_cluster_api>** with the OpenShift cluster API.

(2) Replace **<token>** with the service account token that is output in the preceding command.

2.4.5. About using signed certificates with secrets

To secure communication to your service, you can configure Red Hat OpenShift Service on AWS to generate a signed serving certificate/key pair that you can add into a secret in a project.

A *service serving certificate secret* is intended to support complex middleware applications that need out-of-the-box certificates. It has the same settings as the server certificates generated by the administrator tooling for nodes and masters.

Service Pod spec configured for a service serving certificates secret.

```
apiVersion: v1
kind: Service
metadata:
  name: registry
  annotations:
    service.beta.openshift.io/serving-cert-secret-name: registry-cert (1)
# ...
```

(1) Specify the name for the certificate

Other pods can trust cluster-created certificates (which are only signed for internal DNS names), by using the CA bundle in the ***/var/run/secrets/kubernetes.io/serviceaccount/service-ca.crt*** file that is automatically mounted in their pod.

The signature algorithm for this feature is **x509.SHA256WithRSA**. To manually rotate, delete the generated secret. A new certificate is created.

2.4.5.1. Generating signed certificates for use with secrets

To use a signed serving certificate/key pair with a pod, create or edit the service to add the **service.beta.openshift.io/serving-cert-secret-name** annotation, then add the secret to the pod.

Procedure

To create a *service serving certificate secret*:

1. Edit the **Pod** spec for your service.
2. Add the **service.beta.openshift.io/serving-cert-secret-name** annotation with the name you want to use for your secret.

   ```
   kind: Service
   apiVersion: v1
   metadata:
     name: my-service
     annotations:
         service.beta.openshift.io/serving-cert-secret-name: my-cert (1)
   spec:
     selector:
       app: MyApp
     ports:
     - protocol: TCP
       port: 80
       targetPort: 9376
   ```

   The certificate and key are in PEM format, stored in **tls.crt** and **tls.key** respectively.

3. Create the service:

   ```
   $ oc create -f <file-name>.yaml
   ```

4. View the secret to make sure it was created:

   a. View a list of all secrets:

   ```
   $ oc get secrets
   ```

Example output

```
NAME                TYPE                          DATA     AGE
my-cert            kubernetes.io/tls                2        9m
```

b. View details on your secret:

```
$ oc describe secret my-cert
```

Example output

```
Name:         my-cert
Namespace:    openshift-console
Labels:       <none>
Annotations:  service.beta.openshift.io/expiry: 2023-03-08T23:22:40Z
              service.beta.openshift.io/originating-service-name: my-service
              service.beta.openshift.io/originating-service-uid: 640f0ec3-afc2-4380-bf31-
a8c784846a11
              service.beta.openshift.io/expiry: 2023-03-08T23:22:40Z

Type:  kubernetes.io/tls

Data
====
tls.key:  1679 bytes
tls.crt:  2595 bytes
```

5. Edit your **Pod** spec with that secret.

```
apiVersion: v1
kind: Pod
metadata:
  name: my-service-pod
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: mypod
    image: redis
    volumeMounts:
    - name: my-container
      mountPath: "/etc/my-path"
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
  volumes:
  - name: my-volume
    secret:
      secretName: my-cert
      items:
```

```
    - key: username
      path: my-group/my-username
      mode: 511
```

When it is available, your pod will run. The certificate will be good for the internal service DNS name, **<service.name>.<service.namespace>.svc**.

The certificate/key pair is automatically replaced when it gets close to expiration. View the expiration date in the **service.beta.openshift.io/expiry** annotation on the secret, which is in RFC3339 format.

NOTE

In most cases, the service DNS name **<service.name>.<service.namespace>.svc** is not externally routable. The primary use of **<service.name>.<service.namespace>.svc** is for intracluster or intraservice communication, and with re-encrypt routes.

2.4.6. Troubleshooting secrets

If a service certificate generation fails with (service's **service.beta.openshift.io/serving-cert-generation-error** annotation contains):

```
secret/ssl-key references serviceUID 62ad25ca-d703-11e6-9d6f-0e9c0057b608, which does not
match 77b6dd80-d716-11e6-9d6f-0e9c0057b60
```

The service that generated the certificate no longer exists, or has a different **serviceUID**. You must force certificates regeneration by removing the old secret, and clearing the following annotations on the service **service.beta.openshift.io/serving-cert-generation-error**, **service.beta.openshift.io/serving-cert-generation-error-num**:

1. Delete the secret:

```
$ oc delete secret <secret_name>
```

2. Clear the annotations:

```
$ oc annotate service <service_name> service.beta.openshift.io/serving-cert-generation-
error-
```

```
$ oc annotate service <service_name> service.beta.openshift.io/serving-cert-generation-
error-num-
```

NOTE

The command removing annotation has a **-** after the annotation name to be removed.

2.5. CREATING AND USING CONFIG MAPS

The following sections define config maps and how to create and use them.

2.5.1. Understanding config maps

Many applications require configuration by using some combination of configuration files, command line arguments, and environment variables. In Red Hat OpenShift Service on AWS, these configuration artifacts are decoupled from image content to keep containerized applications portable.

The **ConfigMap** object provides mechanisms to inject containers with configuration data while keeping containers agnostic of Red Hat OpenShift Service on AWS. A config map can be used to store fine-grained information like individual properties or coarse-grained information like entire configuration files or JSON blobs.

The **ConfigMap** object holds key-value pairs of configuration data that can be consumed in pods or used to store configuration data for system components such as controllers. For example:

ConfigMap Object Definition

```
kind: ConfigMap
apiVersion: v1
metadata:
  creationTimestamp: 2016-02-18T19:14:38Z
  name: example-config
  namespace: my-namespace
data: 1
  example.property.1: hello
  example.property.2: world
  example.property.file: |-
    property.1=value-1
    property.2=value-2
    property.3=value-3
binaryData:
  bar: L3Jvb3QvMTAw 2
```

1 1 Contains the configuration data.

2 Points to a file that contains non-UTF8 data, for example, a binary Java keystore file. Enter the file data in Base 64.

NOTE

You can use the **binaryData** field when you create a config map from a binary file, such as an image.

Configuration data can be consumed in pods in a variety of ways. A config map can be used to:

- Populate environment variable values in containers
- Set command-line arguments in a container
- Populate configuration files in a volume

Users and system components can store configuration data in a config map.

A config map is similar to a secret, but designed to more conveniently support working with strings that do not contain sensitive information.

Config map restrictions

A config map must be created before its contents can be consumed in pods.

Controllers can be written to tolerate missing configuration data. Consult individual components configured by using config maps on a case-by-case basis.

ConfigMap objects reside in a project.

They can only be referenced by pods in the same project.

The Kubelet only supports the use of a config map for pods it gets from the API server.

This includes any pods created by using the CLI, or indirectly from a replication controller. It does not include pods created by using the Red Hat OpenShift Service on AWS node's **--manifest-url** flag, its **--config** flag, or its REST API because these are not common ways to create pods.

2.5.2. Creating a config map in the Red Hat OpenShift Service on AWS web console

You can create a config map in the Red Hat OpenShift Service on AWS web console.

Procedure

- To create a config map as a cluster administrator:
  1. In the Administrator perspective, select **Workloads** → **Config Maps**.
  2. At the top right side of the page, select **Create Config Map**.
  3. Enter the contents of your config map.
  4. Select **Create**.
- To create a config map as a developer:
  1. In the Developer perspective, select **Config Maps**.
  2. At the top right side of the page, select **Create Config Map**.
  3. Enter the contents of your config map.
  4. Select **Create**.

2.5.3. Creating a config map by using the CLI

You can use the following command to create a config map from directories, specific files, or literal values.

Procedure

- Create a config map:

```
$ oc create configmap <configmap_name> [options]
```

2.5.3.1. Creating a config map from a directory

You can create a config map from a directory by using the **--from-file** flag. This method allows you to use multiple files within a directory to create a config map.

Each file in the directory is used to populate a key in the config map, where the name of the key is the file name, and the value of the key is the content of the file.

For example, the following command creates a config map with the contents of the **example-files** directory:

```
$ oc create configmap game-config --from-file=example-files/
```

View the keys in the config map:

```
$ oc describe configmaps game-config
```

Example output

```
Name:           game-config
Namespace:      default
Labels:         <none>
Annotations:    <none>

Data

game.properties:        158 bytes
ui.properties:          83 bytes
```

You can see that the two keys in the map are created from the file names in the directory specified in the command. The content of those keys might be large, so the output of **oc describe** only shows the names of the keys and their sizes.

Prerequisite

- You must have a directory with files that contain the data you want to populate a config map with.
  The following procedure uses these example files: **game.properties** and **ui.properties**:

  ```
  $ cat example-files/game.properties
  ```

  #### Example output

  ```
  enemies=aliens
  lives=3
  enemies.cheat=true
  enemies.cheat.level=noGoodRotten
  secret.code.passphrase=UUDDLRLRBABAS
  secret.code.allowed=true
  secret.code.lives=30
  ```

  ```
  $ cat example-files/ui.properties
  ```

  #### Example output

```
color.good=purple
color.bad=yellow
allow.textmode=true
how.nice.to.look=fairlyNice
```

Procedure

- Create a config map holding the content of each file in this directory by entering the following command:

```
$ oc create configmap game-config \
    --from-file=example-files/
```

Verification

- Enter the **oc get** command for the object with the **-o** option to see the values of the keys:

```
$ oc get configmaps game-config -o yaml
```

Example output

```
apiVersion: v1
data:
  game.properties: |-
    enemies=aliens
    lives=3
    enemies.cheat=true
    enemies.cheat.level=noGoodRotten
    secret.code.passphrase=UUDDLRLRBABAS
    secret.code.allowed=true
    secret.code.lives=30
  ui.properties: |
    color.good=purple
    color.bad=yellow
    allow.textmode=true
    how.nice.to.look=fairlyNice
kind: ConfigMap
metadata:
  creationTimestamp: 2016-02-18T18:34:05Z
  name: game-config
  namespace: default
  resourceVersion: "407"
  selflink: /api/v1/namespaces/default/configmaps/game-config
  uid: 30944725-d66e-11e5-8cd0-68f728db1985
```

2.5.3.2. Creating a config map from a file

You can create a config map from a file by using the **--from-file** flag. You can pass the **--from-file** option multiple times to the CLI.

You can also specify the key to set in a config map for content imported from a file by passing a **key=value** expression to the **--from-file** option. For example:

```
$ oc create configmap game-config-3 --from-file=game-special-key=example-files/game.properties
```

NOTE

If you create a config map from a file, you can include files containing non-UTF8 data that are placed in this field without corrupting the non-UTF8 data. Red Hat OpenShift Service on AWS detects binary files and transparently encodes the file as **MIME**. On the server, the **MIME** payload is decoded and stored without corrupting the data.

Prerequisite

- You must have a directory with files that contain the data you want to populate a config map with.
  The following procedure uses these example files: **game.properties** and **ui.properties**:

  ```
  $ cat example-files/game.properties
  ```

  Example output

  ```
  enemies=aliens
  lives=3
  enemies.cheat=true
  enemies.cheat.level=noGoodRotten
  secret.code.passphrase=UUDDLRLRBABAS
  secret.code.allowed=true
  secret.code.lives=30
  ```

  ```
  $ cat example-files/ui.properties
  ```

  Example output

  ```
  color.good=purple
  color.bad=yellow
  allow.textmode=true
  how.nice.to.look=fairlyNice
  ```

Procedure

- Create a config map by specifying a specific file:

  ```
  $ oc create configmap game-config-2 \
      --from-file=example-files/game.properties \
      --from-file=example-files/ui.properties
  ```

- Create a config map by specifying a key-value pair:

  ```
  $ oc create configmap game-config-3 \
      --from-file=game-special-key=example-files/game.properties
  ```

Verification

- Enter the **oc get** command for the object with the **-o** option to see the values of the keys from the file:

  ```
  $ oc get configmaps game-config-2 -o yaml
  ```

  Example output

  ```
  apiVersion: v1
  data:
    game.properties: |-
      enemies=aliens
      lives=3
      enemies.cheat=true
      enemies.cheat.level=noGoodRotten
      secret.code.passphrase=UUDDLRLRBABAS
      secret.code.allowed=true
      secret.code.lives=30
    ui.properties: |
      color.good=purple
      color.bad=yellow
      allow.textmode=true
      how.nice.to.look=fairlyNice
  kind: ConfigMap
  metadata:
    creationTimestamp: 2016-02-18T18:52:05Z
    name: game-config-2
    namespace: default
    resourceVersion: "516"
    selflink: /api/v1/namespaces/default/configmaps/game-config-2
    uid: b4952dc3-d670-11e5-8cd0-68f728db1985
  ```

- Enter the **oc get** command for the object with the **-o** option to see the values of the keys from the key-value pair:

  ```
  $ oc get configmaps game-config-3 -o yaml
  ```

  Example output

  ```
  apiVersion: v1
  data:
    game-special-key: |- 1
      enemies=aliens
      lives=3
      enemies.cheat=true
      enemies.cheat.level=noGoodRotten
      secret.code.passphrase=UUDDLRLRBABAS
      secret.code.allowed=true
      secret.code.lives=30
  kind: ConfigMap
  metadata:
    creationTimestamp: 2016-02-18T18:54:22Z
    name: game-config-3
    namespace: default
  ```

```
  resourceVersion: "530"
  selflink: /api/v1/namespaces/default/configmaps/game-config-3
  uid: 05f8da22-d671-11e5-8cd0-68f728db1985
```

1 This is the key that you set in the preceding step.

2.5.3.3. Creating a config map from literal values

You can supply literal values for a config map.

The **--from-literal** option takes a **key=value** syntax, which allows literal values to be supplied directly on the command line.

Procedure

- Create a config map by specifying a literal value:

```
$ oc create configmap special-config \
    --from-literal=special.how=very \
    --from-literal=special.type=charm
```

Verification

- Enter the **oc get** command for the object with the **-o** option to see the values of the keys:

```
$ oc get configmaps special-config -o yaml
```

Example output

```
apiVersion: v1
data:
  special.how: very
  special.type: charm
kind: ConfigMap
metadata:
  creationTimestamp: 2016-02-18T19:14:38Z
  name: special-config
  namespace: default
  resourceVersion: "651"
  selflink: /api/v1/namespaces/default/configmaps/special-config
  uid: dadce046-d673-11e5-8cd0-68f728db1985
```

2.5.4. Use cases: Consuming config maps in pods

The following sections describe some uses cases when consuming **ConfigMap** objects in pods.

2.5.4.1. Populating environment variables in containers by using config maps

You can use config maps to populate individual environment variables in containers or to populate environment variables in containers from all keys that form valid environment variable names.

As an example, consider the following config map:

ConfigMap with two environment variables

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: special-config 1
  namespace: default 2
data:
  special.how: very 3
  special.type: charm 4
```

1 Name of the config map.

2 The project in which the config map resides. Config maps can only be referenced by pods in the same project.

3 4 Environment variables to inject.

ConfigMap with one environment variable

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: env-config 1
  namespace: default
data:
  log_level: INFO 2
```

1 Name of the config map.

2 Environment variable to inject.

Procedure

- You can consume the keys of this **ConfigMap** in a pod using **configMapKeyRef** sections.

  Sample Pod specification configured to inject specific environment variables

  ```
  apiVersion: v1
  kind: Pod
  metadata:
    name: dapi-test-pod
  spec:
    securityContext:
      runAsNonRoot: true
      seccompProfile:
        type: RuntimeDefault
    containers:
      - name: test-container
        image: gcr.io/google_containers/busybox
        command: [ "/bin/sh", "-c", "env" ]
        env: 1
  ```

```
      - name: SPECIAL_LEVEL_KEY (2)
        valueFrom:
          configMapKeyRef:
            name: special-config (3)
            key: special.how (4)
      - name: SPECIAL_TYPE_KEY
        valueFrom:
          configMapKeyRef:
            name: special-config (5)
            key: special.type (6)
            optional: true (7)
    envFrom: (8)
      - configMapRef:
          name: env-config (9)
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
  restartPolicy: Never
```

1. Stanza to pull the specified environment variables from a **ConfigMap**.
2. Name of a pod environment variable that you are injecting a key's value into.
3. 5 Name of the **ConfigMap** to pull specific environment variables from.
4. 6 Environment variable to pull from the **ConfigMap**.
7. Makes the environment variable optional. As optional, the pod will be started even if the specified **ConfigMap** and keys do not exist.
8. Stanza to pull all environment variables from a **ConfigMap**.
9. Name of the **ConfigMap** to pull all environment variables from.

When this pod is run, the pod logs will include the following output:

```
SPECIAL_LEVEL_KEY=very
log_level=INFO
```

NOTE

SPECIAL_TYPE_KEY=charm is not listed in the example output because **optional: true** is set.

2.5.4.2. Setting command-line arguments for container commands with config maps

You can use a config map to set the value of the commands or arguments in a container by using the Kubernetes substitution syntax **$(VAR_NAME)**.

As an example, consider the following config map:

```
apiVersion: v1
```

```
kind: ConfigMap
metadata:
  name: special-config
  namespace: default
data:
  special.how: very
  special.type: charm
```

Procedure

- To inject values into a command in a container, you must consume the keys you want to use as environment variables. Then you can refer to them in a container’s command using the **$(VAR_NAME)** syntax.

  Sample pod specification configured to inject specific environment variables

```
apiVersion: v1
kind: Pod
metadata:
  name: dapi-test-pod
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - name: test-container
      image: gcr.io/google_containers/busybox
      command: [ "/bin/sh", "-c", "echo $(SPECIAL_LEVEL_KEY) $(SPECIAL_TYPE_KEY)" ]
1
      env:
        - name: SPECIAL_LEVEL_KEY
          valueFrom:
            configMapKeyRef:
              name: special-config
              key: special.how
        - name: SPECIAL_TYPE_KEY
          valueFrom:
            configMapKeyRef:
              name: special-config
              key: special.type
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
  restartPolicy: Never
```

1. Inject the values into a command in a container using the keys you want to use as environment variables.

When this pod is run, the output from the echo command run in the test-container container is as follows:

```
very charm
```

2.5.4.3. Injecting content into a volume by using config maps

You can inject content into a volume by using config maps.

Example **ConfigMap** custom resource (CR)

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: special-config
  namespace: default
data:
  special.how: very
  special.type: charm
```

Procedure

You have a couple different options for injecting content into a volume by using config maps.

- The most basic way to inject content into a volume by using a config map is to populate the volume with files where the key is the file name and the content of the file is the value of the key:

```
apiVersion: v1
kind: Pod
metadata:
  name: dapi-test-pod
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - name: test-container
      image: gcr.io/google_containers/busybox
      command: [ "/bin/sh", "-c", "cat", "/etc/config/special.how" ]
      volumeMounts:
      - name: config-volume
        mountPath: /etc/config
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
  volumes:
    - name: config-volume
      configMap:
        name: special-config 1
  restartPolicy: Never
```

1 File containing key.

When this pod is run, the output of the cat command will be:

```
very
```

- You can also control the paths within the volume where config map keys are projected:

```
apiVersion: v1
kind: Pod
metadata:
  name: dapi-test-pod
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - name: test-container
      image: gcr.io/google_containers/busybox
      command: [ "/bin/sh", "-c", "cat", "/etc/config/path/to/special-key" ]
      volumeMounts:
      - name: config-volume
        mountPath: /etc/config
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
  volumes:
    - name: config-volume
      configMap:
        name: special-config
        items:
        - key: special.how
          path: path/to/special-key 1
  restartPolicy: Never
```

1 Path to config map key.

When this pod is run, the output of the cat command will be:

```
very
```

2.6. INCLUDING POD PRIORITY IN POD SCHEDULING DECISIONS

You can enable pod priority and preemption in your cluster. Pod priority indicates the importance of a pod relative to other pods and queues the pods based on that priority. pod preemption allows the cluster to evict, or preempt, lower-priority pods so that higher-priority pods can be scheduled if there is no available space on a suitable node pod priority also affects the scheduling order of pods and out-of-resource eviction ordering on the node.

To use priority and preemption, reference a priority class in the pod specification to apply that weight for scheduling.

2.6.1. Understanding pod priority

When you use the Pod Priority and Preemption feature, the scheduler orders pending pods by their priority, and a pending pod is placed ahead of other pending pods with lower priority in the scheduling queue. As a result, the higher priority pod might be scheduled sooner than pods with lower priority if its scheduling requirements are met. If a pod cannot be scheduled, scheduler continues to schedule other lower priority pods.

2.6.1.1. Pod priority classes

You can assign pods a priority class, which is a non-namespaced object that defines a mapping from a name to the integer value of the priority. The higher the value, the higher the priority.

A priority class object can take any 32-bit integer value smaller than or equal to 1000000000 (one billion). Reserve numbers larger than or equal to one billion for critical pods that must not be preempted or evicted. By default, Red Hat OpenShift Service on AWS has two reserved priority classes for critical system pods to have guaranteed scheduling.

```
$ oc get priorityclasses
```

Example output

```
NAME                      VALUE        GLOBAL-DEFAULT   AGE
system-node-critical      2000001000   false            72m
system-cluster-critical   2000000000   false            72m
openshift-user-critical   1000000000   false            3d13h
cluster-logging           1000000      false            29s
```

- **system-node-critical** - This priority class has a value of 2000001000 and is used for all pods that should never be evicted from a node. Examples of pods that have this priority class are **sdn-ovs**, **sdn**, and so forth. A number of critical components include the **system-node-critical** priority class by default, for example:
  - master-api
  - master-controller
  - master-etcd
  - sdn
  - sdn-ovs
  - sync
- **system-cluster-critical** - This priority class has a value of 2000000000 (two billion) and is used with pods that are important for the cluster. Pods with this priority class can be evicted from a node in certain circumstances. For example, pods configured with the **system-node-critical** priority class can take priority. However, this priority class does ensure guaranteed scheduling. Examples of pods that can have this priority class are fluentd, add-on components like descheduler, and so forth. A number of critical components include the **system-cluster-critical** priority class by default, for example:
  - fluentd
  - metrics-server
  - descheduler
- **openshift-user-critical** - You can use the **priorityClassName** field with important pods that cannot bind their resource consumption and do not have predictable resource consumption

behavior. Prometheus pods under the **openshift-monitoring** and **openshift-user-workload-monitoring** namespaces use the **openshift-user-critical priorityClassName**. Monitoring workloads use **system-critical** as their first **priorityClass**, but this causes problems when monitoring uses excessive memory and the nodes cannot evict them. As a result, monitoring drops priority to give the scheduler flexibility, moving heavy workloads around to keep critical nodes operating.

- **cluster-logging** - This priority is used by Fluentd to make sure Fluentd pods are scheduled to nodes over other apps.

2.6.1.2. Pod priority names

After you have one or more priority classes, you can create pods that specify a priority class name in a **Pod** spec. The priority admission controller uses the priority class name field to populate the integer value of the priority. If the named priority class is not found, the pod is rejected.

2.6.2. Understanding pod preemption

When a developer creates a pod, the pod goes into a queue. If the developer configured the pod for pod priority or preemption, the scheduler picks a pod from the queue and tries to schedule the pod on a node. If the scheduler cannot find space on an appropriate node that satisfies all the specified requirements of the pod, preemption logic is triggered for the pending pod.

When the scheduler preempts one or more pods on a node, the **nominatedNodeName** field of higher-priority **Pod** spec is set to the name of the node, along with the **nodename** field. The scheduler uses the **nominatedNodeName** field to keep track of the resources reserved for pods and also provides information to the user about preemptions in the clusters.

After the scheduler preempts a lower-priority pod, the scheduler honors the graceful termination period of the pod. If another node becomes available while scheduler is waiting for the lower-priority pod to terminate, the scheduler can schedule the higher-priority pod on that node. As a result, the **nominatedNodeName** field and **nodeName** field of the **Pod** spec might be different.

Also, if the scheduler preempts pods on a node and is waiting for termination, and a pod with a higher-priority pod than the pending pod needs to be scheduled, the scheduler can schedule the higher-priority pod instead. In such a case, the scheduler clears the **nominatedNodeName** of the pending pod, making the pod eligible for another node.

Preemption does not necessarily remove all lower-priority pods from a node. The scheduler can schedule a pending pod by removing a portion of the lower-priority pods.

The scheduler considers a node for pod preemption only if the pending pod can be scheduled on the node.

2.6.2.1. Non-preempting priority classes

Pods with the preemption policy set to **Never** are placed in the scheduling queue ahead of lower-priority pods, but they cannot preempt other pods. A non-preempting pod waiting to be scheduled stays in the scheduling queue until sufficient resources are free and it can be scheduled. Non-preempting pods, like other pods, are subject to scheduler back-off. This means that if the scheduler tries unsuccessfully to schedule these pods, they are retried with lower frequency, allowing other pods with lower priority to be scheduled before them.

Non-preempting pods can still be preempted by other, high-priority pods.

2.6.2.2. Pod preemption and other scheduler settings

If you enable pod priority and preemption, consider your other scheduler settings:

Pod priority and pod disruption budget

A pod disruption budget specifies the minimum number or percentage of replicas that must be up at a time. If you specify pod disruption budgets, Red Hat OpenShift Service on AWS respects them when preempting pods at a best effort level. The scheduler attempts to preempt pods without violating the pod disruption budget. If no such pods are found, lower-priority pods might be preempted despite their pod disruption budget requirements.

Pod priority and pod affinity

Pod affinity requires a new pod to be scheduled on the same node as other pods with the same label.

If a pending pod has inter-pod affinity with one or more of the lower-priority pods on a node, the scheduler cannot preempt the lower-priority pods without violating the affinity requirements. In this case, the scheduler looks for another node to schedule the pending pod. However, there is no guarantee that the scheduler can find an appropriate node and pending pod might not be scheduled.

To prevent this situation, carefully configure pod affinity with equal-priority pods.

2.6.2.3. Graceful termination of preempted pods

When preempting a pod, the scheduler waits for the pod graceful termination period to expire, allowing the pod to finish working and exit. If the pod does not exit after the period, the scheduler kills the pod. This graceful termination period creates a time gap between the point that the scheduler preempts the pod and the time when the pending pod can be scheduled on the node.

To minimize this gap, configure a small graceful termination period for lower-priority pods.

2.6.3. Configuring priority and preemption

You apply pod priority and preemption by creating a priority class object and associating pods to the priority by using the **priorityClassName** in your pod specs.

NOTE

You cannot add a priority class directly to an existing scheduled pod.

Procedure

To configure your cluster to use priority and preemption:

1. Define a pod spec to include the name of a priority class by creating a YAML file similar to the following:

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
  labels:
    env: test
spec:
  containers:
  - name: nginx
```

```
    image: nginx
    imagePullPolicy: IfNotPresent
  priorityClassName: system-cluster-critical (1)
```

(1) Specify the priority class to use with this pod.

2. Create the pod:

```
$ oc create -f <file-name>.yaml
```

You can add the priority name directly to the pod configuration or to a pod template.

2.7. PLACING PODS ON SPECIFIC NODES USING NODE SELECTORS

A *node selector* specifies a map of key-value pairs. The rules are defined using custom labels on nodes and selectors specified in pods.

For the pod to be eligible to run on a node, the pod must have the indicated key-value pairs as the label on the node.

If you are using node affinity and node selectors in the same pod configuration, see the important considerations below.

2.7.1. Using node selectors to control pod placement

You can use node selectors on pods and labels on nodes to control where the pod is scheduled. With node selectors, Red Hat OpenShift Service on AWS schedules the pods on nodes that contain matching labels.

You add labels to a node, a compute machine set, or a machine config. Adding the label to the compute machine set ensures that if the node or machine goes down, new nodes have the label. Labels added to a node or machine config do not persist if the node or machine goes down.

To add node selectors to an existing pod, add a node selector to the controlling object for that pod, such as a **ReplicaSet** object, **DaemonSet** object, **StatefulSet** object, **Deployment** object, or **DeploymentConfig** object. Any existing pods under that controlling object are recreated on a node with a matching label. If you are creating a new pod, you can add the node selector directly to the pod spec. If the pod does not have a controlling object, you must delete the pod, edit the pod spec, and recreate the pod.

NOTE

You cannot add a node selector directly to an existing scheduled pod.

Prerequisites

To add a node selector to existing pods, determine the controlling object for that pod. For example, the **router-default-66d5cf9464-m2g75** pod is controlled by the **router-default-66d5cf9464** replica set:

```
$ oc describe pod router-default-66d5cf9464-7pwkc
```

Example output

```
kind: Pod
apiVersion: v1
metadata:
# ...
Name:              router-default-66d5cf9464-7pwkc
Namespace:         openshift-ingress
# ...
Controlled By:     ReplicaSet/router-default-66d5cf9464
# ...
```

The web console lists the controlling object under **ownerReferences** in the pod YAML:

```
apiVersion: v1
kind: Pod
metadata:
  name: router-default-66d5cf9464-7pwkc
# ...
  ownerReferences:
    - apiVersion: apps/v1
      kind: ReplicaSet
      name: router-default-66d5cf9464
      uid: d81dd094-da26-11e9-a48a-128e7edf0312
      controller: true
      blockOwnerDeletion: true
# ...
```

Procedure

- Add the matching node selector to a pod:
  - To add a node selector to existing and future pods, add a node selector to the controlling object for the pods:

    Example ReplicaSet object with labels

    ```
    kind: ReplicaSet
    apiVersion: apps/v1
    metadata:
      name: hello-node-6fbccf8d9
    # ...
    spec:
    # ...
      template:
        metadata:
          creationTimestamp: null
          labels:
            ingresscontroller.operator.openshift.io/deployment-ingresscontroller: default
            pod-template-hash: 66d5cf9464
        spec:
          nodeSelector:
            kubernetes.io/os: linux
            node-role.kubernetes.io/worker: ''
            type: user-node 1
    # ...
    ```

1 Add the node selector.

- To add a node selector to a specific, new pod, add the selector to the **Pod** object directly:

  Example Pod object with a node selector

  ```
  apiVersion: v1
  kind: Pod
  metadata:
    name: hello-node-6fbccf8d9
  # ...
  spec:
    nodeSelector:
      region: east
      type: user-node
  # ...
  ```

  NOTE

  You cannot add a node selector directly to an existing scheduled pod.

CHAPTER 3. AUTOMATICALLY SCALING PODS WITH THE CUSTOM METRICS AUTOSCALER OPERATOR

3.1. RELEASE NOTES

3.1.1. Custom Metrics Autoscaler Operator release notes

The release notes for the Custom Metrics Autoscaler Operator for Red Hat OpenShift describe new features and enhancements, deprecated features, and known issues.

The Custom Metrics Autoscaler Operator uses the Kubernetes-based Event Driven Autoscaler (KEDA) and is built on top of the Red Hat OpenShift Service on AWS horizontal pod autoscaler (HPA).

NOTE

The Custom Metrics Autoscaler Operator for Red Hat OpenShift is provided as an installable component, with a distinct release cycle from the core Red Hat OpenShift Service on AWS. The Red Hat OpenShift Container Platform Life Cycle Policy outlines release compatibility.

3.1.1.1. Supported versions

The following table defines the Custom Metrics Autoscaler Operator versions for each Red Hat OpenShift Service on AWS version.

Version	Red Hat OpenShift Service on AWS version	General availability
2.12.1	4.15	General availability
2.12.1	4.14	General availability
2.12.1	4.13	General availability
2.12.1	4.12	General availability

3.1.1.2. Custom Metrics Autoscaler Operator 2.12.1-384 release notes

This release of the Custom Metrics Autoscaler Operator 2.12.1-384 provides a bug fix for running the Operator in an Red Hat OpenShift Service on AWS cluster. The following advisory is available for the RHBA-2024:2043.

IMPORTANT

Before installing this version of the Custom Metrics Autoscaler Operator, remove any previously installed Technology Preview versions or the community-supported version of KEDA.

3.1.1.2.1. Bug fixes

- Previously, the **custom-metrics-autoscaler** and **custom-metrics-autoscaler-adapter** images were missing time zone information. As a consequence, scaled objects with **cron** triggers failed to work because the controllers were unable to find time zone information. With this fix, the image builds are updated to include time zone information. As a result, scaled objects containing **cron** triggers now function properly. (**OCPBUGS-32395**)

3.1.2. Release notes for past releases of the Custom Metrics Autoscaler Operator

The following release notes are for previous versions of the Custom Metrics Autoscaler Operator.

For the current version, see Custom Metrics Autoscaler Operator release notes .

3.1.2.1. Custom Metrics Autoscaler Operator 2.12.1-376 release notes

This release of the Custom Metrics Autoscaler Operator 2.12.1-376 provides security updates and bug fixes for running the Operator in an Red Hat OpenShift Service on AWS cluster. The following advisory is available for the RHSA-2024:1812.

IMPORTANT

Before installing this version of the Custom Metrics Autoscaler Operator, remove any previously installed Technology Preview versions or the community-supported version of KEDA.

3.1.2.1.1. Bug fixes

- Previously, if invalid values such as nonexistent namespaces were specified in scaled object metadata, the underlying scaler clients would not free, or close, their client descriptors, resulting in a slow memory leak. This fix properly closes the underlying client descriptors when there are errors, preventing memory from leaking. (**OCPBUGS-30145**)

- Previously the **ServiceMonitor** custom resource (CR) for the **keda-metrics-apiserver** pod was not functioning, because the CR referenced an incorrect metrics port name of **http**. This fix corrects the **ServiceMonitor** CR to reference the proper port name of **metrics**. As a result, the Service Monitor functions properly. (**OCPBUGS-25806**)

3.1.2.2. Custom Metrics Autoscaler Operator 2.11.2-322 release notes

This release of the Custom Metrics Autoscaler Operator 2.11.2-322 provides security updates and bug fixes for running the Operator in an Red Hat OpenShift Service on AWS cluster. The following advisory is available for the RHSA-2023:6144.

IMPORTANT

Before installing this version of the Custom Metrics Autoscaler Operator, remove any previously installed Technology Preview versions or the community-supported version of KEDA.

3.1.2.2.1. Bug fixes

- Because the Custom Metrics Autoscaler Operator version 3.11.2-311 was released without a required volume mount in the Operator deployment, the Custom Metrics Autoscaler Operator pod would restart every 15 minutes. This fix adds the required volume mount to the Operator deployment. As a result, the Operator no longer restarts every 15 minutes. (**OCPBUGS-22361**)

3.1.2.3. Custom Metrics Autoscaler Operator 2.11.2-311 release notes

This release of the Custom Metrics Autoscaler Operator 2.11.2-311 provides new features and bug fixes for running the Operator in an Red Hat OpenShift Service on AWS cluster. The components of the Custom Metrics Autoscaler Operator 2.11.2-311 were released in RHBA-2023:5981.

IMPORTANT

Before installing this version of the Custom Metrics Autoscaler Operator, remove any previously installed Technology Preview versions or the community-supported version of KEDA.

3.1.2.3.1. New features and enhancements

3.1.2.3.1.1. Red Hat OpenShift Service on AWS (ROSA) and OpenShift Dedicated are now supported

The Custom Metrics Autoscaler Operator 2.11.2-311 can be installed on OpenShift ROSA and OpenShift Dedicated managed clusters. Previous versions of the Custom Metrics Autoscaler Operator could be installed only in the **openshift-keda** namespace. This prevented the Operator from being installed on OpenShift ROSA and OpenShift Dedicated clusters. This version of Custom Metrics Autoscaler allows installation to other namespaces such as **openshift-operators** or **keda**, enabling installation into ROSA and Dedicated clusters.

3.1.2.3.2. Bug fixes

- Previously, if the Custom Metrics Autoscaler Operator was installed and configured, but not in use, the OpenShift CLI reported the **couldn't get resource list for external.metrics.k8s.io/v1beta1: Got empty response for: external.metrics.k8s.io/v1beta1** error after any **oc** command was entered. The message, although harmless, could have caused confusion. With this fix, the **Got empty response for: external.metrics…** error no longer appears inappropriately. (**OCPBUGS-15779**)

- Previously, any annotation or label change to objects managed by the Custom Metrics Autoscaler were reverted by Custom Metrics Autoscaler Operator any time the Keda Controller was modified, for example after a configuration change. This caused continuous changing of labels in your objects. The Custom Metrics Autoscaler now uses its own annotation to manage labels and annotations, and annotation or label are no longer inappropriately reverted. (**OCPBUGS-15590**)

3.1.2.4. Custom Metrics Autoscaler Operator 2.10.1-267 release notes

This release of the Custom Metrics Autoscaler Operator 2.10.1-267 provides new features and bug fixes for running the Operator in an Red Hat OpenShift Service on AWS cluster. The components of the Custom Metrics Autoscaler Operator 2.10.1-267 were released in RHBA-2023:4089.

IMPORTANT

Before installing this version of the Custom Metrics Autoscaler Operator, remove any previously installed Technology Preview versions or the community-supported version of KEDA.

3.1.2.4.1. Bug fixes

- Previously, the **custom-metrics-autoscaler** and **custom-metrics-autoscaler-adapter** images did not contain time zone information. Because of this, scaled objects with cron triggers failed to work because the controllers were unable to find time zone information. With this fix, the image builds now include time zone information. As a result, scaled objects containing cron triggers now function properly. (OCPBUGS-15264)

- Previously, the Custom Metrics Autoscaler Operator would attempt to take ownership of all managed objects, including objects in other namespaces and cluster-scoped objects. Because of this, the Custom Metrics Autoscaler Operator was unable to create the role binding for reading the credentials necessary to be an API server. This caused errors in the **kube-system** namespace. With this fix, the Custom Metrics Autoscaler Operator skips adding the **ownerReference** field to any object in another namespace or any cluster-scoped object. As a result, the role binding is now created without any errors. (OCPBUGS-15038)

- Previously, the Custom Metrics Autoscaler Operator added an **ownerReferences** field to the **openshift-keda** namespace. While this did not cause functionality problems, the presence of this field could have caused confusion for cluster administrators. With this fix, the Custom Metrics Autoscaler Operator does not add the **ownerReference** field to the **openshift-keda** namespace. As a result, the **openshift-keda** namespace no longer has a superfluous **ownerReference** field. (OCPBUGS-15293)

- Previously, if you used a Prometheus trigger configured with authentication method other than pod identity, and the **podIdentity** parameter was set to **none**, the trigger would fail to scale. With this fix, the Custom Metrics Autoscaler for OpenShift now properly handles the **none** pod identity provider type. As a result, a Prometheus trigger configured with authentication method other than pod identity, and the **podIdentity** parameter sset to **none** now properly scales. (OCPBUGS-15274)

3.1.2.5. Custom Metrics Autoscaler Operator 2.10.1 release notes

This release of the Custom Metrics Autoscaler Operator 2.10.1 provides new features and bug fixes for running the Operator in an Red Hat OpenShift Service on AWS cluster. The components of the Custom Metrics Autoscaler Operator 2.10.1 were released in RHEA-2023:3199.

IMPORTANT

Before installing this version of the Custom Metrics Autoscaler Operator, remove any previously installed Technology Preview versions or the community-supported version of KEDA.

3.1.2.5.1. New features and enhancements

3.1.2.5.1.1. Custom Metrics Autoscaler Operator general availability

The Custom Metrics Autoscaler Operator is now generally available as of Custom Metrics Autoscaler Operator version 2.10.1.

IMPORTANT

Scaling by using a scaled job is a Technology Preview feature only. 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 about the support scope of Red Hat Technology Preview features, see Technology Preview Features Support Scope .

3.1.2.5.1.2. Performance metrics

You can now use the Prometheus Query Language (PromQL) to query metrics on the Custom Metrics Autoscaler Operator.

3.1.2.5.1.3. Pausing the custom metrics autoscaling for scaled objects

You can now pause the autoscaling of a scaled object, as needed, and resume autoscaling when ready.

3.1.2.5.1.4. Replica fall back for scaled objects

You can now specify the number of replicas to fall back to if a scaled object fails to get metrics from the source.

3.1.2.5.1.5. Customizable HPA naming for scaled objects

You can now specify a custom name for the horizontal pod autoscaler in scaled objects.

3.1.2.5.1.6. Activation and scaling thresholds

Because the horizontal pod autoscaler (HPA) cannot scale to or from 0 replicas, the Custom Metrics Autoscaler Operator does that scaling, after which the HPA performs the scaling. You can now specify when the HPA takes over autoscaling, based on the number of replicas. This allows for more flexibility with your scaling policies.

3.1.2.6. Custom Metrics Autoscaler Operator 2.8.2-174 release notes

This release of the Custom Metrics Autoscaler Operator 2.8.2-174 provides new features and bug fixes for running the Operator in an Red Hat OpenShift Service on AWS cluster. The components of the Custom Metrics Autoscaler Operator 2.8.2-174 were released in RHEA-2023:1683.

IMPORTANT

The Custom Metrics Autoscaler Operator version 2.8.2-174 is a Technology Preview feature.

3.1.2.6.1. New features and enhancements

3.1.2.6.1.1. Operator upgrade support

You can now upgrade from a prior version of the Custom Metrics Autoscaler Operator. See "Changing the update channel for an Operator" in the "Additional resources" for information on upgrading an Operator.

3.1.2.6.1.2. must-gather support

You can now collect data about the Custom Metrics Autoscaler Operator and its components by using the Red Hat OpenShift Service on AWS **must-gather** tool. Currently, the process for using the **must-gather** tool with the Custom Metrics Autoscaler is different than for other operators. See "Gathering debugging data in the "Additional resources" for more information.

3.1.2.7. Custom Metrics Autoscaler Operator 2.8.2 release notes

This release of the Custom Metrics Autoscaler Operator 2.8.2 provides new features and bug fixes for running the Operator in an Red Hat OpenShift Service on AWS cluster. The components of the Custom Metrics Autoscaler Operator 2.8.2 were released in RHSA-2023:1042.

IMPORTANT

The Custom Metrics Autoscaler Operator version 2.8.2 is a Technology Preview feature.

3.1.2.7.1. New features and enhancements

3.1.2.7.1.1. Audit Logging

You can now gather and view audit logs for the Custom Metrics Autoscaler Operator and its associated components. Audit logs are security-relevant chronological sets of records that document the sequence of activities that have affected the system by individual users, administrators, or other components of the system.

3.1.2.7.1.2. Scale applications based on Apache Kafka metrics

You can now use the KEDA Apache kafka trigger/scaler to scale deployments based on an Apache Kafka topic.

3.1.2.7.1.3. Scale applications based on CPU metrics

You can now use the KEDA CPU trigger/scaler to scale deployments based on CPU metrics.

3.1.2.7.1.4. Scale applications based on memory metrics

You can now use the KEDA memory trigger/scaler to scale deployments based on memory metrics.

3.2. CUSTOM METRICS AUTOSCALER OPERATOR OVERVIEW

As a developer, you can use Custom Metrics Autoscaler Operator for Red Hat OpenShift to specify how Red Hat OpenShift Service on AWS should automatically increase or decrease the number of pods for a deployment, stateful set, custom resource, or job based on custom metrics that are not based only on CPU or memory.

The Custom Metrics Autoscaler Operator is an optional operator, based on the Kubernetes Event Driven Autoscaler (KEDA), that allows workloads to be scaled using additional metrics sources other than pod metrics.

The custom metrics autoscaler currently supports only the Prometheus, CPU, memory, and Apache Kafka metrics.

The Custom Metrics Autoscaler Operator scales your pods up and down based on custom, external metrics from specific applications. Your other applications continue to use other scaling methods. You configure *triggers*, also known as scalers, which are the source of events and metrics that the custom metrics autoscaler uses to determine how to scale. The custom metrics autoscaler uses a metrics API to convert the external metrics to a form that Red Hat OpenShift Service on AWS can use. The custom metrics autoscaler creates a horizontal pod autoscaler (HPA) that performs the actual scaling.

To use the custom metrics autoscaler, you create a **ScaledObject** or **ScaledJob** object for a workload, which is a custom resource (CR) that defines the scaling metadata. You specify the deployment or job to scale, the source of the metrics to scale on (trigger), and other parameters such as the minimum and maximum replica counts allowed.

NOTE

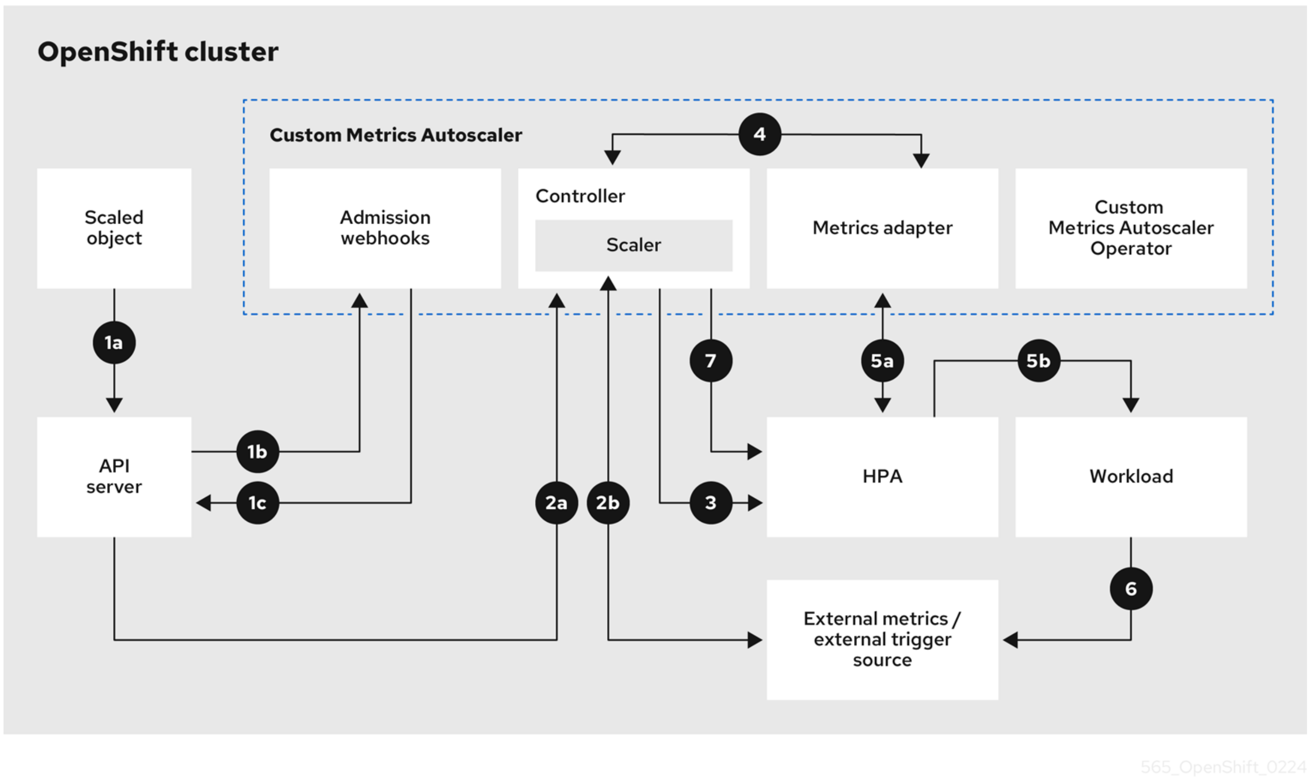
You can create only one scaled object or scaled job for each workload that you want to scale. Also, you cannot use a scaled object or scaled job and the horizontal pod autoscaler (HPA) on the same workload.

The custom metrics autoscaler, unlike the HPA, can scale to zero. If you set the **minReplicaCount** value in the custom metrics autoscaler CR to **0**, the custom metrics autoscaler scales the workload down from 1 to 0 replicas to or up from 0 replicas to 1. This is known as the *activation phase*. After scaling up to 1 replica, the HPA takes control of the scaling. This is known as the *scaling phase*.

Some triggers allow you to change the number of replicas that are scaled by the cluster metrics autoscaler. In all cases, the parameter to configure the activation phase always uses the same phrase, prefixed with *activation*. For example, if the **threshold** parameter configures scaling, **activationThreshold** would configure activation. Configuring the activation and scaling phases allows you more flexibility with your scaling policies. For example, you can configure a higher activation phase to prevent scaling up or down if the metric is particularly low.

The activation value has more priority than the scaling value in case of different decisions for each. For example, if the **threshold** is set to **10**, and the **activationThreshold** is **50**, if the metric reports **40**, the scaler is not active and the pods are scaled to zero even if the HPA requires 4 instances.

Figure 3.1. Custom metrics autoscaler workflow



1. You create or modify a scaled object custom resource for a workload on a cluster. The object contains the scaling configuration for that workload. Prior to accepting the new object, the OpenShift API server sends it to the custom metrics autoscaler admission webhooks process to ensure that the object is valid. If validation succeeds, the API server persists the object.

2. The custom metrics autoscaler controller watches for new or modified scaled objects. When the OpenShift API server notifies the controller of a change, the controller monitors any external trigger sources, also known as data sources, that are specified in the object for changes to the metrics data. One or more scalers request scaling data from the external trigger source. For example, for a Kafka trigger type, the controller uses the Kafka scaler to communicate with a Kafka instance to obtain the data requested by the trigger.

3. The controller creates a horizontal pod autoscaler object for the scaled object. As a result, the Horizontal Pod Autoscaler (HPA) Operator starts monitoring the scaling data associated with the trigger. The HPA requests scaling data from the cluster OpenShift API server endpoint.

4. The OpenShift API server endpoint is served by the custom metrics autoscaler metrics adapter. When the metrics adapter receives a request for custom metrics, it uses a GRPC connection to the controller to request it for the most recent trigger data received from the scaler.

5. The HPA makes scaling decisions based upon the data received from the metrics adapter and scales the workload up or down by increasing or decreasing the replicas.

6. As a it operates, a workload can affect the scaling metrics. For example, if a workload is scaled up to handle work in a Kafka queue, the queue size decreases after the workload processes all the work. As a result, the workload is scaled down.

7. If the metrics are in a range specified by the **minReplicaCount** value, the custom metrics autoscaler controller disables all scaling, and leaves the replica count at a fixed level. If the metrics exceed that range, the custom metrics autoscaler controller enables scaling and allows the HPA to scale the workload. While scaling is disabled, the HPA does not take any action.

3.3. INSTALLING THE CUSTOM METRICS AUTOSCALER

You can use the Red Hat OpenShift Service on AWS web console to install the Custom Metrics Autoscaler Operator.

The installation creates the following five CRDs:

- **ClusterTriggerAuthentication**
- **KedaController**
- **ScaledJob**
- **ScaledObject**
- **TriggerAuthentication**

3.3.1. Installing the custom metrics autoscaler

You can use the following procedure to install the Custom Metrics Autoscaler Operator.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- Remove any previously-installed Technology Preview versions of the Cluster Metrics Autoscaler Operator.
- Remove any versions of the community-based KEDA.
  Also, remove the KEDA 1.x custom resource definitions by running the following commands:

  ```
  $ oc delete crd scaledobjects.keda.k8s.io
  ```

  ```
  $ oc delete crd triggerauthentications.keda.k8s.io
  ```

- Ensure that the **keda** namespace exists. If not, you must manaully create the **keda** namespace.

Procedure

1. In the Red Hat OpenShift Service on AWS web console, click **Operators → OperatorHub**.
2. Choose **Custom Metrics Autoscaler** from the list of available Operators, and click **Install**.
3. On the **Install Operator** page, ensure that the **A specific namespace on the cluster**option is selected for **Installation Mode**.
4. For **Installed Namespace**, click **Select a namespace**.
5. Click **Select Project**:
   - If the **keda** namespace exists, select **keda** from the list.
   - If the **keda** namespace does not exist:
     a. Select **Create Project** to open the **Create Project** window.

b. In the **Name** field, enter **keda**.

c. In the **Display Name** field, enter a descriptive name, such as **keda**.

d. Optional: In the **Display Name** field, add a description for the namespace.

e. Click **Create**.

6. Click **Install**.

7. Verify the installation by listing the Custom Metrics Autoscaler Operator components:

   a. Navigate to **Workloads → Pods**.

   b. Select the **keda** project from the drop-down menu and verify that the **custom-metrics-autoscaler-operator-*** pod is running.

   c. Navigate to **Workloads → Deployments** to verify that the **custom-metrics-autoscaler-operator** deployment is running.

8. Optional: Verify the installation in the OpenShift CLI using the following command:

```
$ oc get all -n keda
```

The output appears similar to the following:

Example output

```
NAME                                                      READY   STATUS    RESTARTS   AGE
pod/custom-metrics-autoscaler-operator-5fd8d9ffd8-xt4xp   1/1     Running   0          18m

NAME                                                 READY   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/custom-metrics-autoscaler-operator   1/1     1            1           18m

NAME                                                            DESIRED   CURRENT   READY   AGE
replicaset.apps/custom-metrics-autoscaler-operator-5fd8d9ffd8   1         1         1       18m
```

9. Install the **KedaController** custom resource, which creates the required CRDs:

   a. In the Red Hat OpenShift Service on AWS web console, click **Operators → Installed Operators**.

   b. Click **Custom Metrics Autoscaler**.

   c. On the **Operator Details** page, click the **KedaController** tab.

   d. On the **KedaController** tab, click **Create KedaController** and edit the file.

```
kind: KedaController
apiVersion: keda.sh/v1alpha1
metadata:
  name: keda
  namespace: keda
spec:
  watchNamespace: '' (1)
  operator:
    logLevel: info (2)
    logEncoder: console (3)
  metricsServer:
    logLevel: '0' (4)
    auditConfig: (5)
      logFormat: "json"
      logOutputVolumeClaim: "persistentVolumeClaimName"
      policy:
        rules:
        - level: Metadata
        omitStages: ["RequestReceived"]
        omitManagedFields: false
      lifetime:
        maxAge: "2"
        maxBackup: "1"
        maxSize: "50"
  serviceAccount: {}
```

1. Specifies a single namespace in which the Custom Metrics Autoscaler Operator should scale applications. Leave it blank or leave it empty to scale applications in all namespaces. This field should have a namespace or be empty. The default value is empty.
2. Specifies the level of verbosity for the Custom Metrics Autoscaler Operator log messages. The allowed values are **debug**, **info**, **error**. The default is **info**.
3. Specifies the logging format for the Custom Metrics Autoscaler Operator log messages. The allowed values are **console** or **json**. The default is **console**.
4. Specifies the logging level for the Custom Metrics Autoscaler Metrics Server. The allowed values are **0** for **info** and **4** or **debug**. The default is **0**.
5. Activates audit logging for the Custom Metrics Autoscaler Operator and specifies the audit policy to use, as described in the "Configuring audit logging" section.

e. Click **Create** to create the KEDA controller.

3.4. UNDERSTANDING CUSTOM METRICS AUTOSCALER TRIGGERS

Triggers, also known as scalers, provide the metrics that the Custom Metrics Autoscaler Operator uses to scale your pods.

The custom metrics autoscaler currently supports only the Prometheus, CPU, memory, and Apache Kafka triggers.

You use a **ScaledObject** or **ScaledJob** custom resource to configure triggers for specific objects, as described in the sections that follow.

3.4.1. Understanding the Prometheus trigger

You can scale pods based on Prometheus metrics, which can use the installed Red Hat OpenShift Service on AWS monitoring or an external Prometheus server as the metrics source. See "Additional resources" for information on the configurations required to use the Red Hat OpenShift Service on AWS monitoring as a source for metrics.

NOTE

If Prometheus is collecting metrics from the application that the custom metrics autoscaler is scaling, do not set the minimum replicas to **0** in the custom resource. If there are no application pods, the custom metrics autoscaler does not have any metrics to scale on.

Example scaled object with a Prometheus target

```
apiVersion: keda.sh/v1alpha1
kind: ScaledObject
metadata:
  name: prom-scaledobject
  namespace: my-namespace
spec:
# ...
  triggers:
  - type: prometheus (1)
    metadata:
      serverAddress: https://thanos-querier.openshift-monitoring.svc.cluster.local:9092 (2)
      namespace: kedatest (3)
      metricName: http_requests_total (4)
      threshold: '5' (5)
      query: sum(rate(http_requests_total{job="test-app"}[1m])) (6)
      authModes: basic (7)
      cortexOrgID: my-org (8)
      ignoreNullValues: "false" (9)
      unsafeSsl: "false" (10)
```

1. Specifies Prometheus as the trigger type.
2. Specifies the address of the Prometheus server. This example uses Red Hat OpenShift Service on AWS monitoring.
3. Optional: Specifies the namespace of the object you want to scale. This parameter is mandatory if using Red Hat OpenShift Service on AWS monitoring as a source for the metrics.
4. Specifies the name to identify the metric in the **external.metrics.k8s.io** API. If you are using more than one trigger, all metric names must be unique.
5. Specifies the value that triggers scaling. Must be specified as a quoted string value.
6. Specifies the Prometheus query to use.
7. Specifies the authentication method to use. Prometheus scalers support bearer authentication (**bearer**), basic authentication (**basic**), or TLS authentication (**tls**). You configure the specific authentication parameters in a trigger authentication, as discussed in a following section. As needed, you can also use a secret.
8. Optional: Passes the **X-Scope-OrgID** header to multi-tenant Cortex or Mimir storage for Prometheus. This parameter is required only with multi-tenant Prometheus storage, to indicate which data Prometheus should return.
9. Optional: Specifies how the trigger should proceed if the Prometheus target is lost.

- If **true**, the trigger continues to operate if the Prometheus target is lost. This is the default behavior.
- If **false**, the trigger returns an error if the Prometheus target is lost.

10 Optional: Specifies whether the certificate check should be skipped. For example, you might skip the check if you use self-signed certificates at the Prometheus endpoint.

- If **true**, the certificate check is performed.
- If **false**, the certificate check is not performed. This is the default behavior.

3.4.1.1. Configuring the custom metrics autoscaler to use Red Hat OpenShift Service on AWS monitoring

You can use the installed Red Hat OpenShift Service on AWS Prometheus monitoring as a source for the metrics used by the custom metrics autoscaler. However, there are some additional configurations you must perform.

NOTE

These steps are not required for an external Prometheus source.

You must perform the following tasks, as described in this section:

- Create a service account to get a token.
- Create a role.
- Add that role to the service account.
- Reference the token in the trigger authentication object used by Prometheus.

Prerequisites

- Red Hat OpenShift Service on AWS monitoring must be installed.
- Monitoring of user-defined workloads must be enabled in Red Hat OpenShift Service on AWS monitoring, as described in the **Creating a user-defined workload monitoring config map** section.
- The Custom Metrics Autoscaler Operator must be installed.

Procedure

1. Change to the project with the object you want to scale:

```
$ oc project my-project
```

2. Use the following command to create a service account, if your cluster does not have one:

```
$ oc create serviceaccount <service_account>
```

where:

<service_account>
Specifies the name of the service account.

3. Use the following command to locate the token assigned to the service account:

```
$ oc describe serviceaccount <service_account>
```

where:

<service_account>
Specifies the name of the service account.

Example output

```
Name:              thanos
Namespace:           my-project
Labels:            <none>
Annotations:         <none>
Image pull secrets:  thanos-dockercfg-nnwgj
Mountable secrets:   thanos-dockercfg-nnwgj
Tokens:            thanos-token-9g4n5 1
Events:            <none>
```

1 Use this token in the trigger authentication.

4. Create a trigger authentication with the service account token:

a. Create a YAML file similar to the following:

```
apiVersion: keda.sh/v1alpha1
kind: TriggerAuthentication
metadata:
  name: keda-trigger-auth-prometheus
spec:
  secretTargetRef: 1
  - parameter: bearerToken 2
    name: thanos-token-9g4n5 3
    key: token 4
  - parameter: ca
    name: thanos-token-9g4n5
    key: ca.crt
```

1 Specifies that this object uses a secret for authorization.

2 Specifies the authentication parameter to supply by using the token.

3 Specifies the name of the token to use.

4 Specifies the key in the token to use with the specified parameter.

b. Create the CR object:

```
$ oc create -f <file-name>.yaml
```

5. Create a role for reading Thanos metrics:

   a. Create a YAML file with the following parameters:

```
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: thanos-metrics-reader
rules:
- apiGroups:
  - ""
  resources:
  - pods
  verbs:
  - get
- apiGroups:
  - metrics.k8s.io
  resources:
  - pods
  - nodes
  verbs:
  - get
  - list
  - watch
```

   b. Create the CR object:

```
$ oc create -f <file-name>.yaml
```

6. Create a role binding for reading Thanos metrics:

   a. Create a YAML file similar to the following:

```
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: thanos-metrics-reader 1
  namespace: my-project 2
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
  name: thanos-metrics-reader
subjects:
- kind: ServiceAccount
  name: thanos 3
  namespace: my-project 4
```

1 Specifies the name of the role you created.

2 Specifies the namespace of the object you want to scale.

3 Specifies the name of the service account to bind to the role.

4 Specifies the namespace of the object you want to scale.

b. Create the CR object:

```
$ oc create -f <file-name>.yaml
```

You can now deploy a scaled object or scaled job to enable autoscaling for your application, as described in "Understanding how to add custom metrics autoscalers". To use Red Hat OpenShift Service on AWS monitoring as the source, in the trigger, or scaler, you must include the following parameters:

- **triggers.type** must be **prometheus**
- **triggers.metadata.serverAddress** must be **https://thanos-querier.openshift-monitoring.svc.cluster.local:9092**
- **triggers.metadata.authModes** must be **bearer**
- **triggers.metadata.namespace** must be set to the namespace of the object to scale
- **triggers.authenticationRef** must point to the trigger authentication resource specified in the previous step

3.4.2. Understanding the CPU trigger

You can scale pods based on CPU metrics. This trigger uses cluster metrics as the source for metrics.

The custom metrics autoscaler scales the pods associated with an object to maintain the CPU usage that you specify. The autoscaler increases or decreases the number of replicas between the minimum and maximum numbers to maintain the specified CPU utilization across all pods. The memory trigger considers the memory utilization of the entire pod. If the pod has multiple containers, the memory trigger considers the total memory utilization of all containers in the pod.

NOTE

- This trigger cannot be used with the **ScaledJob** custom resource.
- When using a memory trigger to scale an object, the object does not scale to **0**, even if you are using multiple triggers.

Example scaled object with a CPU target

```
apiVersion: keda.sh/v1alpha1
kind: ScaledObject
metadata:
  name: cpu-scaledobject
  namespace: my-namespace
spec:
# ...
  triggers:
  - type: cpu 1
    metricType: Utilization 2
    metadata:
      value: '60' (3)
  minReplicaCount: 1 (4)
```

1. Specifies CPU as the trigger type.
2. Specifies the type of metric to use, either **Utilization** or **AverageValue**.
3. Specifies the value that triggers scaling. Must be specified as a quoted string value.
   - When using **Utilization**, the target value is the average of the resource metrics across all relevant pods, represented as a percentage of the requested value of the resource for the pods.
   - When using **AverageValue**, the target value is the average of the metrics across all relevant pods.
4. Specifies the minimum number of replicas when scaling down. For a CPU trigger, enter a value of **1** or greater, because the HPA cannot scale to zero if you are using only CPU metrics.

3.4.3. Understanding the memory trigger

You can scale pods based on memory metrics. This trigger uses cluster metrics as the source for metrics.

The custom metrics autoscaler scales the pods associated with an object to maintain the average memory usage that you specify. The autoscaler increases and decreases the number of replicas between the minimum and maximum numbers to maintain the specified memory utilization across all pods. The memory trigger considers the memory utilization of entire pod. If the pod has multiple containers, the memory utilization is the sum of all of the containers.

NOTE

- This trigger cannot be used with the **ScaledJob** custom resource.
- When using a memory trigger to scale an object, the object does not scale to **0**, even if you are using multiple triggers.

Example scaled object with a memory target

```
apiVersion: keda.sh/v1alpha1
kind: ScaledObject
metadata:
  name: memory-scaledobject
  namespace: my-namespace
spec:
# ...
  triggers:
  - type: memory (1)
    metricType: Utilization (2)
    metadata:
      value: '60' (3)
      containerName: api (4)
```

1. Specifies memory as the trigger type.
2. Specifies the type of metric to use, either **Utilization** or **AverageValue**.
3. Specifies the value that triggers scaling. Must be specified as a quoted string value.
    - When using **Utilization**, the target value is the average of the resource metrics across all relevant pods, represented as a percentage of the requested value of the resource for the pods.
    - When using **AverageValue**, the target value is the average of the metrics across all relevant pods.
4. Optional: Specifies an individual container to scale, based on the memory utilization of only that container, rather than the entire pod. In this example, only the container named **api** is to be scaled.

3.4.4. Understanding the Kafka trigger

You can scale pods based on an Apache Kafka topic or other services that support the Kafka protocol. The custom metrics autoscaler does not scale higher than the number of Kafka partitions, unless you set the **allowIdleConsumers** parameter to **true** in the scaled object or scaled job.

NOTE

If the number of consumer groups exceeds the number of partitions in a topic, the extra consumer groups remain idle. To avoid this, by default the number of replicas does not exceed:

- The number of partitions on a topic, if a topic is specified
- The number of partitions of all topics in the consumer group, if no topic is specified
- The **maxReplicaCount** specified in scaled object or scaled job CR

You can use the **allowIdleConsumers** parameter to disable these default behaviors.

Example scaled object with a Kafka target

```
apiVersion: keda.sh/v1alpha1
kind: ScaledObject
metadata:
  name: kafka-scaledobject
  namespace: my-namespace
spec:
# ...
  triggers:
  - type: kafka 1
    metadata:
      topic: my-topic 2
      bootstrapServers: my-cluster-kafka-bootstrap.openshift-operators.svc:9092 3
      consumerGroup: my-group 4
      lagThreshold: '10' 5
      activationLagThreshold: '5' 6
      offsetResetPolicy: latest (7)
      allowIdleConsumers: true (8)
      scaleToZeroOnInvalidOffset: false (9)
      excludePersistentLag: false (10)
      version: '1.0.0' (11)
      partitionLimitation: '1,2,10-20,31' (12)
```

1. Specifies Kafka as the trigger type.

2. Specifies the name of the Kafka topic on which Kafka is processing the offset lag.

3. Specifies a comma-separated list of Kafka brokers to connect to.

4. Specifies the name of the Kafka consumer group used for checking the offset on the topic and processing the related lag.

5. Optional: Specifies the average target value that triggers scaling. Must be specified as a quoted string value. The default is **5**.

6. Optional: Specifies the target value for the activation phase. Must be specified as a quoted string value.

7. Optional: Specifies the Kafka offset reset policy for the Kafka consumer. The available values are: **latest** and **earliest**. The default is **latest**.

8. Optional: Specifies whether the number of Kafka replicas can exceed the number of partitions on a topic.

    - If **true**, the number of Kafka replicas can exceed the number of partitions on a topic. This allows for idle Kafka consumers.

    - If **false**, the number of Kafka replicas cannot exceed the number of partitions on a topic. This is the default.

9. Specifies how the trigger behaves when a Kafka partition does not have a valid offset.

    - If **true**, the consumers are scaled to zero for that partition.

    - If **false**, the scaler keeps a single consumer for that partition. This is the default.

10. Optional: Specifies whether the trigger includes or excludes partition lag for partitions whose current offset is the same as the current offset of the previous polling cycle.

    - If **true**, the scaler excludes partition lag in these partitions.

    - If **false**, the trigger includes all consumer lag in all partitions. This is the default.

11. Optional: Specifies the version of your Kafka brokers. Must be specified as a quoted string value. The default is **1.0.0**.

12. Optional: Specifies a comma-separated list of partition IDs to scope the scaling on. If set, only the listed IDs are considered when calculating lag. Must be specified as a quoted string value. The default is to consider all partitions.

3.5. UNDERSTANDING CUSTOM METRICS AUTOSCALER TRIGGER AUTHENTICATIONS

A trigger authentication allows you to include authentication information in a scaled object or a scaled job that can be used by the associated containers. You can use trigger authentications to pass Red Hat OpenShift Service on AWS secrets, platform-native pod authentication mechanisms, environment variables, and so on.

You define a **TriggerAuthentication** object in the same namespace as the object that you want to scale. That trigger authentication can be used only by objects in that namespace.

Alternatively, to share credentials between objects in multiple namespaces, you can create a **ClusterTriggerAuthentication** object that can be used across all namespaces.

Trigger authentications and cluster trigger authentication use the same configuration. However, a cluster trigger authentication requires an additional **kind** parameter in the authentication reference of the scaled object.

Example trigger authentication with a secret

```
kind: TriggerAuthentication
apiVersion: keda.sh/v1alpha1
metadata:
  name: secret-triggerauthentication
  namespace: my-namespace 1
spec:
  secretTargetRef: 2
  - parameter: user-name 3
    name: my-secret 4
    key: USER_NAME 5
  - parameter: password
    name: my-secret
    key: USER_PASSWORD
```

1 Specifies the namespace of the object you want to scale.

2 Specifies that this trigger authentication uses a secret for authorization.

3 Specifies the authentication parameter to supply by using the secret.

4 Specifies the name of the secret to use.

5 Specifies the key in the secret to use with the specified parameter.

Example cluster trigger authentication with a secret

```
kind: ClusterTriggerAuthentication
apiVersion: keda.sh/v1alpha1
metadata: 1
  name: secret-cluster-triggerauthentication
spec:
  secretTargetRef: 2
  - parameter: user-name 3
```

```
    name: secret-name (4)
    key: USER_NAME (5)
  - parameter: user-password
    name: secret-name
    key: USER_PASSWORD
```

1. Note that no namespace is used with a cluster trigger authentication.
2. Specifies that this trigger authentication uses a secret for authorization.
3. Specifies the authentication parameter to supply by using the secret.
4. Specifies the name of the secret to use.
5. Specifies the key in the secret to use with the specified parameter.

Example trigger authentication with a token

```
kind: TriggerAuthentication
apiVersion: keda.sh/v1alpha1
metadata:
  name: token-triggerauthentication
  namespace: my-namespace (1)
spec:
  secretTargetRef: (2)
  - parameter: bearerToken (3)
    name: my-token-2vzfq (4)
    key: token (5)
  - parameter: ca
    name: my-token-2vzfq
    key: ca.crt
```

1. Specifies the namespace of the object you want to scale.
2. Specifies that this trigger authentication uses a secret for authorization.
3. Specifies the authentication parameter to supply by using the token.
4. Specifies the name of the token to use.
5. Specifies the key in the token to use with the specified parameter.

Example trigger authentication with an environment variable

```
kind: TriggerAuthentication
apiVersion: keda.sh/v1alpha1
metadata:
  name: env-var-triggerauthentication
  namespace: my-namespace (1)
spec:
  env: (2)
  - parameter: access_key (3)
    name: ACCESS_KEY (4)
    containerName: my-container (5)
```

(1) Specifies the namespace of the object you want to scale.

(2) Specifies that this trigger authentication uses environment variables for authorization.

(3) Specify the parameter to set with this variable.

(4) Specify the name of the environment variable.

(5) Optional: Specify a container that requires authentication. The container must be in the same resource as referenced by **scaleTargetRef** in the scaled object.

Example trigger authentication with pod authentication providers

```
kind: TriggerAuthentication
apiVersion: keda.sh/v1alpha1
metadata:
  name: pod-id-triggerauthentication
  namespace: my-namespace (1)
spec:
  podIdentity: (2)
    provider: aws-eks (3)
```

(1) Specifies the namespace of the object you want to scale.

(2) Specifies that this trigger authentication uses a platform-native pod authentication method for authorization.

(3) Specifies a pod identity. Supported values are **none**, **azure**, **aws-eks**, or **aws-kiam**. The default is **none**.

3.5.1. Using trigger authentications

You use trigger authentications and cluster trigger authentications by using a custom resource to create the authentication, then add a reference to a scaled object or scaled job.

Prerequisites

- The Custom Metrics Autoscaler Operator must be installed.
- If you are using a secret, the **Secret** object must exist, for example:

  Example secret

  ```
  apiVersion: v1
  kind: Secret
  metadata:
    name: my-secret
  ```

```
data:
  user-name: <base64_USER_NAME>
  password: <base64_USER_PASSWORD>
```

Procedure

1. Create the **TriggerAuthentication** or **ClusterTriggerAuthentication** object.

   a. Create a YAML file that defines the object:

   #### Example trigger authentication with a secret

   ```
   kind: TriggerAuthentication
   apiVersion: keda.sh/v1alpha1
   metadata:
     name: prom-triggerauthentication
     namespace: my-namespace
   spec:
     secretTargetRef:
     - parameter: user-name
       name: my-secret
       key: USER_NAME
     - parameter: password
       name: my-secret
       key: USER_PASSWORD
   ```

   b. Create the **TriggerAuthentication** object:

   ```
   $ oc create -f <filename>.yaml
   ```

2. Create or edit a **ScaledObject** YAML file that uses the trigger authentication:

   a. Create a YAML file that defines the object by running the following command:

   #### Example scaled object with a trigger authentication

   ```
   apiVersion: keda.sh/v1alpha1
   kind: ScaledObject
   metadata:
     name: scaledobject
     namespace: my-namespace
   spec:
     scaleTargetRef:
       name: example-deployment
     maxReplicaCount: 100
     minReplicaCount: 0
     pollingInterval: 30
     triggers:
     - type: prometheus
       metadata:
         serverAddress: https://thanos-querier.openshift-monitoring.svc.cluster.local:9092
         namespace: kedatest # replace <NAMESPACE>
         metricName: http_requests_total
         threshold: '5'
         query: sum(rate(http_requests_total{job="test-app"}[1m]))
   ```

```
    authModes: "basic"
  authenticationRef:
    name: prom-triggerauthentication 1
    kind: TriggerAuthentication 2
```

1. Specify the name of your trigger authentication object.
2. Specify **TriggerAuthentication**. **TriggerAuthentication** is the default.

Example scaled object with a cluster trigger authentication

```
apiVersion: keda.sh/v1alpha1
kind: ScaledObject
metadata:
  name: scaledobject
  namespace: my-namespace
spec:
  scaleTargetRef:
    name: example-deployment
  maxReplicaCount: 100
  minReplicaCount: 0
  pollingInterval: 30
  triggers:
  - type: prometheus
    metadata:
      serverAddress: https://thanos-querier.openshift-monitoring.svc.cluster.local:9092
      namespace: kedatest # replace <NAMESPACE>
      metricName: http_requests_total
      threshold: '5'
      query: sum(rate(http_requests_total{job="test-app"}[1m]))
      authModes: "basic"
    authenticationRef:
      name: prom-cluster-triggerauthentication 1
      kind: ClusterTriggerAuthentication 2
```

1. Specify the name of your trigger authentication object.
2. Specify **ClusterTriggerAuthentication**.

b. Create the scaled object by running the following command:

```
$ oc apply -f <filename>
```

3.6. PAUSING THE CUSTOM METRICS AUTOSCALER FOR A SCALED OBJECT

You can pause and restart the autoscaling of a workload, as needed.

For example, you might want to pause autoscaling before performing cluster maintenance or to avoid resource starvation by removing non-mission-critical workloads.

3.6.1. Pausing a custom metrics autoscaler

You can pause the autoscaling of a scaled object by adding the **autoscaling.keda.sh/paused-replicas** annotation to the custom metrics autoscaler for that scaled object. The custom metrics autoscaler scales the replicas for that workload to the specified value and pauses autoscaling until the annotation is removed.

```
apiVersion: keda.sh/v1alpha1
kind: ScaledObject
metadata:
  annotations:
    autoscaling.keda.sh/paused-replicas: "4"
# ...
```

Procedure

1. Use the following command to edit the **ScaledObject** CR for your workload:

   ```
   $ oc edit ScaledObject scaledobject
   ```

2. Add the **autoscaling.keda.sh/paused-replicas** annotation with any value:

   ```
   apiVersion: keda.sh/v1alpha1
   kind: ScaledObject
   metadata:
     annotations:
       autoscaling.keda.sh/paused-replicas: "4" 1
     creationTimestamp: "2023-02-08T14:41:01Z"
     generation: 1
     name: scaledobject
     namespace: my-project
     resourceVersion: '65729'
     uid: f5aec682-acdf-4232-a783-58b5b82f5dd0
   ```

   1 Specifies that the Custom Metrics Autoscaler Operator is to scale the replicas to the specified value and stop autoscaling.

3.6.2. Restarting the custom metrics autoscaler for a scaled object

You can restart a paused custom metrics autoscaler by removing the **autoscaling.keda.sh/paused-replicas** annotation for that **ScaledObject**.

```
apiVersion: keda.sh/v1alpha1
kind: ScaledObject
metadata:
  annotations:
    autoscaling.keda.sh/paused-replicas: "4"
# ...
```

Procedure

1. Use the following command to edit the **ScaledObject** CR for your workload:

```
$ oc edit ScaledObject scaledobject
```

2. Remove the **autoscaling.keda.sh/paused-replicas** annotation.

```
apiVersion: keda.sh/v1alpha1
kind: ScaledObject
metadata:
  annotations:
    autoscaling.keda.sh/paused-replicas: "4" (1)
  creationTimestamp: "2023-02-08T14:41:01Z"
  generation: 1
  name: scaledobject
  namespace: my-project
  resourceVersion: '65729'
  uid: f5aec682-acdf-4232-a783-58b5b82f5dd0
```

(1) Remove this annotation to restart a paused custom metrics autoscaler.

3.7. GATHERING AUDIT LOGS

You can gather audit logs, which are a security-relevant chronological set of records documenting the sequence of activities that have affected the system by individual users, administrators, or other components of the system.

For example, audit logs can help you understand where an autoscaling request is coming from. This is key information when backends are getting overloaded by autoscaling requests made by user applications and you need to determine which is the troublesome application.

3.7.1. Configuring audit logging

You can configure auditing for the Custom Metrics Autoscaler Operator by editing the **KedaController** custom resource. The logs are sent to an audit log file on a volume that is secured by using a persistent volume claim in the **KedaController** CR.

Prerequisites

- The Custom Metrics Autoscaler Operator must be installed.

Procedure

1. Edit the **KedaController** custom resource to add the **auditConfig** stanza:

```
kind: KedaController
apiVersion: keda.sh/v1alpha1
metadata:
  name: keda
  namespace: keda
spec:
# ...
  metricsServer:
# ...
    auditConfig:
      logFormat: "json" (1)
    logOutputVolumeClaim: "pvc-audit-log" (2)
    policy:
      rules: (3)
      - level: Metadata
      omitStages: "RequestReceived" (4)
      omitManagedFields: false (5)
    lifetime: (6)
      maxAge: "2"
      maxBackup: "1"
      maxSize: "50"
```

1. Specifies the output format of the audit log, either **legacy** or **json**.
2. Specifies an existing persistent volume claim for storing the log data. All requests coming to the API server are logged to this persistent volume claim. If you leave this field empty, the log data is sent to stdout.
3. Specifies which events should be recorded and what data they should include:
    - **None**: Do not log events.
    - **Metadata**: Log only the metadata for the request, such as user, timestamp, and so forth. Do not log the request text and the response text. This is the default.
    - **Request**: Log only the metadata and the request text but not the response text. This option does not apply for non-resource requests.
    - **RequestResponse**: Log event metadata, request text, and response text. This option does not apply for non-resource requests.
4. Specifies stages for which no event is created.
5. Specifies whether to omit the managed fields of the request and response bodies from being written to the API audit log, either **true** to omit the fields or **false** to include the fields.
6. Specifies the size and lifespan of the audit logs.
    - **maxAge**: The maximum number of days to retain audit log files, based on the timestamp encoded in their filename.
    - **maxBackup**: The maximum number of audit log files to retain. Set to **0** to retain all audit log files.
    - **maxSize**: The maximum size in megabytes of an audit log file before it gets rotated.

Verification

1. View the audit log file directly:
    a. Obtain the name of the **keda-metrics-apiserver-*** pod:

    ```
    oc get pod -n keda
    ```

    ### Example output

```
NAME                                       READY   STATUS    RESTARTS   AGE
custom-metrics-autoscaler-operator-5cb44cd75d-9v4lv   1/1     Running   0          8m20s
keda-metrics-apiserver-65c7cc44fd-rrl4r              1/1     Running   0          2m55s
keda-operator-776cbb6768-zpj5b                       1/1     Running   0          2m55s
```

b. View the log data by using a command similar to the following:

```
$ oc logs keda-metrics-apiserver-<hash>|grep -i metadata (1)
```

(1) Optional: You can use the **grep** command to specify the log level to display: **Metadata**, **Request**, **RequestResponse**.

For example:

```
$ oc logs keda-metrics-apiserver-65c7cc44fd-rrl4r|grep -i metadata
```

Example output

```
 ...
{"kind":"Event","apiVersion":"audit.k8s.io/v1","level":"Metadata","auditID":"4c81d41b-3dab-4675-90ce-20b87ce24013","stage":"ResponseComplete","requestURI":"/healthz","verb":"get","user":{"username":"system:anonymous","groups":["system:unauthenticated"]},"sourceIPs":["10.131.0.1"],"userAgent":"kube-probe/1.28","responseStatus":{"metadata":{},"code":200},"requestReceivedTimestamp":"2023-02-16T13:00:03.554567Z","stageTimestamp":"2023-02-16T13:00:03.555032Z","annotations":{"authorization.k8s.io/decision":"allow","authorization.k8s.io/reason":""}}
 ...
```

2. Alternatively, you can view a specific log:

a. Use a command similar to the following to log into the **keda-metrics-apiserver-*** pod:

```
$ oc rsh pod/keda-metrics-apiserver-<hash> -n keda
```

For example:

```
$ oc rsh pod/keda-metrics-apiserver-65c7cc44fd-rrl4r -n keda
```

b. Change to the **/var/audit-policy/** directory:

```
sh-4.4$ cd /var/audit-policy/
```

c. List the available logs:

```
sh-4.4$ ls
```

Example output

```
log-2023.02.17-14:50  policy.yaml
```

d. View the log, as needed:

```
sh-4.4$ cat <log_name>/<pvc_name>|grep -i <log_level> (1)
```

(1) Optional: You can use the **grep** command to specify the log level to display: **Metadata**, **Request**, **RequestResponse**.

For example:

```
sh-4.4$ cat log-2023.02.17-14:50/pvc-audit-log|grep -i Request
```

Example output

```
...
{"kind":"Event","apiVersion":"audit.k8s.io/v1","level":"Request","auditID":"63e7f68c-04ec-
4f4d-8749-
bf1656572a41","stage":"ResponseComplete","requestURI":"/openapi/v2","verb":"get","user
":{"username":"system:aggregator","groups":["system:authenticated"]},"sourceIPs":
["10.128.0.1"],"responseStatus":{"metadata":
{},"code":304},"requestReceivedTimestamp":"2023-02-
17T13:12:55.035478Z","stageTimestamp":"2023-02-
17T13:12:55.038346Z","annotations":
{"authorization.k8s.io/decision":"allow","authorization.k8s.io/reason":"RBAC: allowed by
ClusterRoleBinding \"system:discovery\" of ClusterRole \"system:discovery\" to Group
\"system:authenticated\""}}
...
```

3.8. GATHERING DEBUGGING DATA

When opening a support case, it is helpful to provide debugging information about your cluster to Red Hat Support.

To help troubleshoot your issue, provide the following information:

- Data gathered using the **must-gather** tool.
- The unique cluster ID.

You can use the **must-gather** tool to collect data about the Custom Metrics Autoscaler Operator and its components, including the following items:

- The **keda** namespace and its child objects.
- The Custom Metric Autoscaler Operator installation objects.
- The Custom Metric Autoscaler Operator CRD objects.

3.8.1. Gathering debugging data

The following command runs the **must-gather** tool for the Custom Metrics Autoscaler Operator:

```
$ oc adm must-gather --image="$(oc get packagemanifests openshift-custom-metrics-autoscaler-
operator \
-n openshift-marketplace \
-o jsonpath='{.status.channels[?
(@.name=="stable")].currentCSVDesc.annotations.containerImage}')"
```

NOTE

The standard Red Hat OpenShift Service on AWS **must-gather** command, **oc adm must-gather**, does not collect Custom Metrics Autoscaler Operator data.

Prerequisites

- You are logged in to Red Hat OpenShift Service on AWS as a user with the **dedicated-admin** role.
- The Red Hat OpenShift Service on AWS CLI (**oc**) installed.

Procedure

1. Navigate to the directory where you want to store the **must-gather** data.
2. Perform one of the following:
   - To get only the Custom Metrics Autoscaler Operator **must-gather** data, use the following command:

     ```
     $ oc adm must-gather --image="$(oc get packagemanifests openshift-custom-metrics-
     autoscaler-operator \
     -n openshift-marketplace \
     -o jsonpath='{.status.channels[?
     (@.name=="stable")].currentCSVDesc.annotations.containerImage}')"
     ```

     The custom image for the **must-gather** command is pulled directly from the Operator package manifests, so that it works on any cluster where the Custom Metric Autoscaler Operator is available.

   - To gather the default **must-gather** data in addition to the Custom Metric Autoscaler Operator information:

     a. Use the following command to obtain the Custom Metrics Autoscaler Operator image and set it as an environment variable:

     ```
     $ IMAGE="$(oc get packagemanifests openshift-custom-metrics-autoscaler-operator
     \
       -n openshift-marketplace \
       -o jsonpath='{.status.channels[?
     (@.name=="stable")].currentCSVDesc.annotations.containerImage}')"
     ```

     b. Use the **oc adm must-gather** with the Custom Metrics Autoscaler Operator image:

     ```
     $ oc adm must-gather --image-stream=openshift/must-gather --image=${IMAGE}
     ```

Example 3.1. Example must-gather output for the Custom Metric Autoscaler:

```
└── keda
```

```
├── apps
│   ├── daemonsets.yaml
│   ├── deployments.yaml
│   ├── replicasets.yaml
│   └── statefulsets.yaml
├── apps.openshift.io
│   └── deploymentconfigs.yaml
├── autoscaling
│   └── horizontalpodautoscalers.yaml
├── batch
│   ├── cronjobs.yaml
│   └── jobs.yaml
├── build.openshift.io
│   ├── buildconfigs.yaml
│   └── builds.yaml
├── core
│   ├── configmaps.yaml
│   ├── endpoints.yaml
│   ├── events.yaml
│   ├── persistentvolumeclaims.yaml
│   ├── pods.yaml
│   ├── replicationcontrollers.yaml
│   ├── secrets.yaml
│   └── services.yaml
├── discovery.k8s.io
│   └── endpointslices.yaml
├── image.openshift.io
│   └── imagestreams.yaml
├── k8s.ovn.org
│   ├── egressfirewalls.yaml
│   └── egressqoses.yaml
├── keda.sh
│   ├── kedacontrollers
│   │   └── keda.yaml
│   ├── scaledobjects
│   │   └── example-scaledobject.yaml
│   └── triggerauthentications
│      └── example-triggerauthentication.yaml
├── monitoring.coreos.com
│   └── servicemonitors.yaml
├── networking.k8s.io
│   └── networkpolicies.yaml
├── keda.yaml
├── pods
│   ├── custom-metrics-autoscaler-operator-58bd9f458-ptgwx
│   │   ├── custom-metrics-autoscaler-operator
│   │   │   └── custom-metrics-autoscaler-operator
│   │   │      └── logs
│   │   │          ├── current.log
│   │   │          ├── previous.insecure.log
│   │   │          └── previous.log
│   │   └── custom-metrics-autoscaler-operator-58bd9f458-ptgwx.yaml
│   ├── custom-metrics-autoscaler-operator-58bd9f458-thbsh
│   │   └── custom-metrics-autoscaler-operator
│   │      └── custom-metrics-autoscaler-operator
│   │         └── logs
│   ├── keda-metrics-apiserver-65c7cc44fd-6wq4g
│   │   ├── keda-metrics-apiserver
│   │   │   └── keda-metrics-apiserver
│   │   │       └── logs
│   │   │           ├── current.log
│   │   │           ├── previous.insecure.log
│   │   │           └── previous.log
│   │   └── keda-metrics-apiserver-65c7cc44fd-6wq4g.yaml
│   └── keda-operator-776cbb6768-fb6m5
│       ├── keda-operator
│       │   └── keda-operator
│       │       └── logs
│       │           ├── current.log
│       │           ├── previous.insecure.log
│       │           └── previous.log
│       └── keda-operator-776cbb6768-fb6m5.yaml
├── policy
│   └── poddisruptionbudgets.yaml
└── route.openshift.io
    └── routes.yaml
```

3. Create a compressed file from the **must-gather** directory that was created in your working directory. For example, on a computer that uses a Linux operating system, run the following command:

```
$ tar cvaf must-gather.tar.gz must-gather.local.5421342344627712289/ 1
```

1 Replace **must-gather-local.5421342344627712289/** with the actual directory name.

4. Attach the compressed file to your support case on the Red Hat Customer Portal.

3.9. VIEWING OPERATOR METRICS

The Custom Metrics Autoscaler Operator exposes ready-to-use metrics that it pulls from the on-cluster monitoring component. You can query the metrics by using the Prometheus Query Language (PromQL) to analyze and diagnose issues. All metrics are reset when the controller pod restarts.

3.9.1. Accessing performance metrics

You can access the metrics and run queries by using the Red Hat OpenShift Service on AWS web console.

Procedure

1. Select the **Administrator** perspective in the Red Hat OpenShift Service on AWS web console.
2. Select **Observe** → **Metrics**.
3. To create a custom query, add your PromQL query to the **Expression** field.
4. To add multiple queries, select **Add Query**.

3.9.1.1. Provided Operator metrics

The Custom Metrics Autoscaler Operator exposes the following metrics, which you can view by using the Red Hat OpenShift Service on AWS web console.

Table 3.1. Custom Metric Autoscaler Operator metrics

Metric name	Description
keda_scaler_activity	Whether the particular scaler is active or inactive. A value of **1** indicates the scaler is active; a value of **0** indicates the scaler is inactive.
keda_scaler_metrics_value	The current value for each scaler’s metric, which is used by the Horizontal Pod Autoscaler (HPA) in computing the target average.
keda_scaler_metrics_latency	The latency of retrieving the current metric from each scaler.
keda_scaler_errors	The number of errors that have occurred for each scaler.
keda_scaler_errors_total	The total number of errors encountered for all scalers.
keda_scaled_object_errors	The number of errors that have occurred for each scaled obejct.
keda_resource_totals	The total number of Custom Metrics Autoscaler custom resources in each namespace for each custom resource type.
keda_trigger_totals	The total number of triggers by trigger type.

Custom Metrics Autoscaler Admission webhook metrics

The Custom Metrics Autoscaler Admission webhook also exposes the following Prometheus metrics.

Metric name	Description
keda_scaled_object_validation_total	The number of scaled object validations.
keda_scaled_object_validation_errors	The number of validation errors.

3.10. UNDERSTANDING HOW TO ADD CUSTOM METRICS AUTOSCALERS

To add a custom metrics autoscaler, create a **ScaledObject** custom resource for a deployment, stateful set, or custom resource. Create a **ScaledJob** custom resource for a job.

You can create only one scaled object for each workload that you want to scale. Also, you cannot use a scaled object and the horizontal pod autoscaler (HPA) on the same workload.

3.10.1. Adding a custom metrics autoscaler to a workload

You can create a custom metrics autoscaler for a workload that is created by a **Deployment**, **StatefulSet**, or **custom resource** object.

Prerequisites

- The Custom Metrics Autoscaler Operator must be installed.
- If you use a custom metrics autoscaler for scaling based on CPU or memory:
  - Your cluster administrator must have properly configured cluster metrics. You can use the **oc describe PodMetrics <pod-name>** command to determine if metrics are configured. If metrics are configured, the output appears similar to the following, with CPU and Memory displayed under Usage.

    ```
    $ oc describe PodMetrics openshift-kube-scheduler-ip-10-0-135-131.ec2.internal
    ```

    Example output

    ```
    Name:         openshift-kube-scheduler-ip-10-0-135-131.ec2.internal
    Namespace:    openshift-kube-scheduler
    Labels:       <none>
    Annotations:  <none>
    API Version:  metrics.k8s.io/v1beta1
    Containers:
      Name:  wait-for-host-port
      Usage:
        Memory:  0
      Name:      scheduler
      Usage:
        Cpu:     8m
        Memory:  45440Ki
    Kind:        PodMetrics
    Metadata:
      Creation Timestamp:  2019-05-23T18:47:56Z
      Self Link:           /apis/metrics.k8s.io/v1beta1/namespaces/openshift-kube-
    scheduler/pods/openshift-kube-scheduler-ip-10-0-135-131.ec2.internal
    Timestamp:             2019-05-23T18:47:56Z
    Window:                1m0s
    Events:                <none>
    ```

  - The pods associated with the object you want to scale must include specified memory and CPU limits. For example:

    Example pod spec

    ```
    apiVersion: v1
    kind: Pod
    # ...
    spec:
      containers:
      - name: app
        image: images.my-company.example/app:v4
        resources:
    ```

```
        limits:
          memory: "128Mi"
          cpu: "500m"
    # ...
```

Procedure

1. Create a YAML file similar to the following. Only the name **<2>**, object name **<4>**, and object kind **<5>** are required:

Example scaled object

```
apiVersion: keda.sh/v1alpha1
kind: ScaledObject
metadata:
  annotations:
    autoscaling.keda.sh/paused-replicas: "0" 1
  name: scaledobject 2
  namespace: my-namespace
spec:
  scaleTargetRef:
    apiVersion: apps/v1 3
    name: example-deployment 4
    kind: Deployment 5
    envSourceContainerName: .spec.template.spec.containers[0] 6
  cooldownPeriod:  200 7
  maxReplicaCount: 100 8
  minReplicaCount: 0 9
  metricsServer: 10
    auditConfig:
      logFormat: "json"
      logOutputVolumeClaim: "persistentVolumeClaimName"
      policy:
        rules:
        - level: Metadata
        omitStages: "RequestReceived"
        omitManagedFields: false
      lifetime:
        maxAge: "2"
        maxBackup: "1"
        maxSize: "50"
  fallback: 11
    failureThreshold: 3
    replicas: 6
  pollingInterval: 30 12
  advanced:
    restoreToOriginalReplicaCount: false 13
    horizontalPodAutoscalerConfig:
      name: keda-hpa-scale-down 14
      behavior: 15
        scaleDown:
          stabilizationWindowSeconds: 300
          policies:
```

```
        - type: Percent
          value: 100
          periodSeconds: 15
triggers:
- type: prometheus (16)
  metadata:
    serverAddress: https://thanos-querier.openshift-monitoring.svc.cluster.local:9092
    namespace: kedatest
    metricName: http_requests_total
    threshold: '5'
    query: sum(rate(http_requests_total{job="test-app"}[1m]))
    authModes: basic
  authenticationRef: (17)
    name: prom-triggerauthentication
    kind: TriggerAuthentication
```

1. Optional: Specifies that the Custom Metrics Autoscaler Operator is to scale the replicas to the specified value and stop autoscaling, as described in the "Pausing the custom metrics autoscaler for a workload" section.
2. Specifies a name for this custom metrics autoscaler.
3. Optional: Specifies the API version of the target resource. The default is **apps/v1**.
4. Specifies the name of the object that you want to scale.
5. Specifies the **kind** as **Deployment**, **StatefulSet** or **CustomResource**.
6. Optional: Specifies the name of the container in the target resource, from which the custom metrics autoscaler gets environment variables holding secrets and so forth. The default is **.spec.template.spec.containers[0]**.
7. Optional. Specifies the period in seconds to wait after the last trigger is reported before scaling the deployment back to **0** if the **minReplicaCount** is set to **0**. The default is **300**.
8. Optional: Specifies the maximum number of replicas when scaling up. The default is **100**.
9. Optional: Specifies the minimum number of replicas when scaling down.
10. Optional: Specifies the parameters for audit logs. as described in the "Configuring audit logging" section.
11. Optional: Specifies the number of replicas to fall back to if a scaler fails to get metrics from the source for the number of times defined by the **failureThreshold** parameter. For more information on fallback behavior, see the KEDA documentation.
12. Optional: Specifies the interval in seconds to check each trigger on. The default is **30**.
13. Optional: Specifies whether to scale back the target resource to the original replica count after the scaled object is deleted. The default is **false**, which keeps the replica count as it is when the scaled object is deleted.
14. Optional: Specifies a name for the horizontal pod autoscaler. The default is **keda-hpa-{scaled-object-name}**.
15. Optional: Specifies a scaling policy to use to control the rate to scale pods up or down, as described in the "Scaling policies" section.

16 Specifies the trigger to use as the basis for scaling, as described in the "Understanding the custom metrics autoscaler triggers" section. This example uses Red Hat OpenShift Service

17 Optional: Specifies a trigger authentication or a cluster trigger authentication. For more information, see *Understanding the custom metrics autoscaler trigger authentication* in the *Additional resources* section.

- Enter **TriggerAuthentication** to use a trigger authentication. This is the default.
- Enter **ClusterTriggerAuthentication** to use a cluster trigger authentication.

2. Create the custom metrics autoscaler by running the following command:

```
$ oc create -f <filename>.yaml
```

Verification

- View the command output to verify that the custom metrics autoscaler was created:

```
$ oc get scaledobject <scaled_object_name>
```

Example output

```
NAME          SCALETARGETKIND      SCALETARGETNAME        MIN   MAX   TRIGGERS
AUTHENTICATION           READY   ACTIVE   FALLBACK   AGE
scaledobject   apps/v1.Deployment   example-deployment    0     50    prometheus   prom-
triggerauthentication   True    True     True       17s
```

Note the following fields in the output:

- **TRIGGERS**: Indicates the trigger, or scaler, that is being used.
- **AUTHENTICATION**: Indicates the name of any trigger authentication being used.
- **READY**: Indicates whether the scaled object is ready to start scaling:
  - If **True**, the scaled object is ready.
  - If **False**, the scaled object is not ready because of a problem in one or more of the objects you created.
- **ACTIVE**: Indicates whether scaling is taking place:
  - If **True**, scaling is taking place.
  - If **False**, scaling is not taking place because there are no metrics or there is a problem in one or more of the objects you created.
- **FALLBACK**: Indicates whether the custom metrics autoscaler is able to get metrics from the source
  - If **False**, the custom metrics autoscaler is getting metrics.
  - If **True**, the custom metrics autoscaler is getting metrics because there are no metrics or there is a problem in one or more of the objects you created.

3.10.2. Additional resources

- Understanding custom metrics autoscaler trigger authentications

3.11. REMOVING THE CUSTOM METRICS AUTOSCALER OPERATOR

You can remove the custom metrics autoscaler from your Red Hat OpenShift Service on AWS cluster. After removing the Custom Metrics Autoscaler Operator, remove other components associated with the Operator to avoid potential issues.

NOTE

Delete the **KedaController** custom resource (CR) first. If you do not delete the **KedaController** CR, Red Hat OpenShift Service on AWS can hang when you delete the **keda** project. If you delete the Custom Metrics Autoscaler Operator before deleting the CR, you are not able to delete the CR.

3.11.1. Uninstalling the Custom Metrics Autoscaler Operator

Use the following procedure to remove the custom metrics autoscaler from your Red Hat OpenShift Service on AWS cluster.

Prerequisites

- The Custom Metrics Autoscaler Operator must be installed.

Procedure

1. In the Red Hat OpenShift Service on AWS web console, click **Operators → Installed Operators**.
2. Switch to the **keda** project.
3. Remove the **KedaController** custom resource.
   a. Find the **CustomMetricsAutoscaler** Operator and click the **KedaController** tab.
   b. Find the custom resource, and then click **Delete KedaController**.
   c. Click **Uninstall**.
4. Remove the Custom Metrics Autoscaler Operator:
   a. Click **Operators → Installed Operators**.
   b. Find the **CustomMetricsAutoscaler** Operator and click the **Options** menu ⋮ and select **Uninstall Operator**.
   c. Click **Uninstall**.
5. Optional: Use the OpenShift CLI to remove the custom metrics autoscaler components:
   a. Delete the custom metrics autoscaler CRDs:
      - **clustertriggerauthentications.keda.sh**

- **kedacontrollers.keda.sh**
- **scaledjobs.keda.sh**
- **scaledobjects.keda.sh**
- **triggerauthentications.keda.sh**

```
$ oc delete crd clustertriggerauthentications.keda.sh kedacontrollers.keda.sh
scaledjobs.keda.sh scaledobjects.keda.sh triggerauthentications.keda.sh
```

Deleting the CRDs removes the associated roles, cluster roles, and role bindings. However, there might be a few cluster roles that must be manually deleted.

b. List any custom metrics autoscaler cluster roles:

```
$ oc get clusterrole | grep keda.sh
```

c. Delete the listed custom metrics autoscaler cluster roles. For example:

```
$ oc delete clusterrole.keda.sh-v1alpha1-admin
```

d. List any custom metrics autoscaler cluster role bindings:

```
$ oc get clusterrolebinding | grep keda.sh
```

e. Delete the listed custom metrics autoscaler cluster role bindings. For example:

```
$ oc delete clusterrolebinding.keda.sh-v1alpha1-admin
```

6. Delete the custom metrics autoscaler project:

```
$ oc delete project keda
```

7. Delete the Cluster Metric Autoscaler Operator:

```
$ oc delete operator/openshift-custom-metrics-autoscaler-operator.keda
```

CHAPTER 4. CONTROLLING POD PLACEMENT ONTO NODES (SCHEDULING)

4.1. CONTROLLING POD PLACEMENT USING THE SCHEDULER

Pod scheduling is an internal process that determines placement of new pods onto nodes within the cluster.

The scheduler code has a clean separation that watches new pods as they get created and identifies the most suitable node to host them. It then creates bindings (pod to node bindings) for the pods using the master API.

Default pod scheduling

Red Hat OpenShift Service on AWS comes with a default scheduler that serves the needs of most users. The default scheduler uses both inherent and customization tools to determine the best fit for a pod.

Advanced pod scheduling

In situations where you might want more control over where new pods are placed, the Red Hat OpenShift Service on AWS advanced scheduling features allow you to configure a pod so that the pod is required or has a preference to run on a particular node or alongside a specific pod.
You can control pod placement by using the following scheduling features:

- Pod affinity and anti-affinity rules
- Node affinity
- Node selectors
- Taints and tolerations
- Node overcommitment

4.1.1. About the default scheduler

The default Red Hat OpenShift Service on AWS pod scheduler is responsible for determining the placement of new pods onto nodes within the cluster. It reads data from the pod and finds a node that is a good fit based on configured profiles. It is completely independent and exists as a standalone solution. It does not modify the pod; it creates a binding for the pod that ties the pod to the particular node.

4.1.1.1. Understanding default scheduling

The existing generic scheduler is the default platform-provided scheduler *engine* that selects a node to host the pod in a three-step operation:

Filters the nodes

The available nodes are filtered based on the constraints or requirements specified. This is done by running each node through the list of filter functions called *predicates*, or *filters*.

Prioritizes the filtered list of nodes

This is achieved by passing each node through a series of *priority*, or *scoring*, functions that assign it a score between 0 - 10, with 0 indicating a bad fit and 10 indicating a good fit to host the pod. The scheduler configuration can also take in a simple *weight* (positive numeric value) for each scoring function. The node score provided by each scoring function is multiplied by the weight (default weight for most scores is 1) and then combined by adding the scores for each node provided by all the scores. This weight attribute can be used by administrators to give higher importance to some scores.

Selects the best fit node

The nodes are sorted based on their scores and the node with the highest score is selected to host the pod. If multiple nodes have the same high score, then one of them is selected at random.

4.1.2. Scheduler use cases

One of the important use cases for scheduling within Red Hat OpenShift Service on AWS is to support flexible affinity and anti-affinity policies.

4.1.2.1. Affinity

Administrators should be able to configure the scheduler to specify affinity at any topological level, or even at multiple levels. Affinity at a particular level indicates that all pods that belong to the same service are scheduled onto nodes that belong to the same level. This handles any latency requirements of applications by allowing administrators to ensure that peer pods do not end up being too geographically separated. If no node is available within the same affinity group to host the pod, then the pod is not scheduled.

If you need greater control over where the pods are scheduled, see Controlling pod placement on nodes using node affinity rules and Placing pods relative to other pods using affinity and anti-affinity rules .

These advanced scheduling features allow administrators to specify which node a pod can be scheduled on and to force or reject scheduling relative to other pods.

4.1.2.2. Anti-affinity

Administrators should be able to configure the scheduler to specify anti-affinity at any topological level, or even at multiple levels. Anti-affinity (or 'spread') at a particular level indicates that all pods that belong to the same service are spread across nodes that belong to that level. This ensures that the application is well spread for high availability purposes. The scheduler tries to balance the service pods across all applicable nodes as evenly as possible.

If you need greater control over where the pods are scheduled, see Controlling pod placement on nodes using node affinity rules and Placing pods relative to other pods using affinity and anti-affinity rules .

These advanced scheduling features allow administrators to specify which node a pod can be scheduled on and to force or reject scheduling relative to other pods.

4.2. PLACING PODS RELATIVE TO OTHER PODS USING AFFINITY AND ANTI-AFFINITY RULES

Affinity is a property of pods that controls the nodes on which they prefer to be scheduled. Anti-affinity is a property of pods that prevents a pod from being scheduled on a node.

In Red Hat OpenShift Service on AWS, *pod affinity* and *pod anti-affinity* allow you to constrain which nodes your pod is eligible to be scheduled on based on the key-value labels on other pods.

4.2.1. Understanding pod affinity

Pod affinity and *pod anti-affinity* allow you to constrain which nodes your pod is eligible to be scheduled on based on the key/value labels on other pods.

- Pod affinity can tell the scheduler to locate a new pod on the same node as other pods if the label selector on the new pod matches the label on the current pod.
- Pod anti-affinity can prevent the scheduler from locating a new pod on the same node as pods with the same labels if the label selector on the new pod matches the label on the current pod.

For example, using affinity rules, you could spread or pack pods within a service or relative to pods in other services. Anti-affinity rules allow you to prevent pods of a particular service from scheduling on the same nodes as pods of another service that are known to interfere with the performance of the pods of the first service. Or, you could spread the pods of a service across nodes, availability zones, or availability sets to reduce correlated failures.

NOTE

A label selector might match pods with multiple pod deployments. Use unique combinations of labels when configuring anti-affinity rules to avoid matching pods.

There are two types of pod affinity rules: *required* and *preferred*.

Required rules **must** be met before a pod can be scheduled on a node. Preferred rules specify that, if the rule is met, the scheduler tries to enforce the rules, but does not guarantee enforcement.

NOTE

Depending on your pod priority and preemption settings, the scheduler might not be able to find an appropriate node for a pod without violating affinity requirements. If so, a pod might not be scheduled.

To prevent this situation, carefully configure pod affinity with equal-priority pods.

You configure pod affinity/anti-affinity through the **Pod** spec files. You can specify a required rule, a preferred rule, or both. If you specify both, the node must first meet the required rule, then attempts to meet the preferred rule.

The following example shows a **Pod** spec configured for pod affinity and anti-affinity.

In this example, the pod affinity rule indicates that the pod can schedule onto a node only if that node has at least one already-running pod with a label that has the key **security** and value **S1**. The pod anti-affinity rule says that the pod prefers to not schedule onto a node if that node is already running a pod with label having key **security** and value **S2**.

Sample Pod config file with pod affinity

```
apiVersion: v1
kind: Pod
metadata:
  name: with-pod-affinity
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
```

```
affinity:
  podAffinity: (1)
    requiredDuringSchedulingIgnoredDuringExecution: (2)
    - labelSelector:
        matchExpressions:
        - key: security (3)
          operator: In (4)
          values:
          - S1 (5)
      topologyKey: topology.kubernetes.io/zone
containers:
- name: with-pod-affinity
  image: docker.io/ocpqe/hello-pod
  securityContext:
    allowPrivilegeEscalation: false
    capabilities:
      drop: [ALL]
```

1. Stanza to configure pod affinity.
2. Defines a required rule.

3 5 The key and value (label) that must be matched to apply the rule.

4. The operator represents the relationship between the label on the existing pod and the set of values in the **matchExpression** parameters in the specification for the new pod. Can be **In**, **NotIn**, **Exists**, or **DoesNotExist**.

Sample Pod config file with pod anti-affinity

```
apiVersion: v1
kind: Pod
metadata:
  name: with-pod-antiaffinity
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  affinity:
    podAntiAffinity: (1)
      preferredDuringSchedulingIgnoredDuringExecution: (2)
      - weight: 100 (3)
        podAffinityTerm:
          labelSelector:
            matchExpressions:
            - key: security (4)
              operator: In (5)
              values:
              - S2
          topologyKey: kubernetes.io/hostname
  containers:
  - name: with-pod-affinity
  image: docker.io/ocpqe/hello-pod
  securityContext:
    allowPrivilegeEscalation: false
    capabilities:
      drop: [ALL]
```

1. Stanza to configure pod anti-affinity.
2. Defines a preferred rule.
3. Specifies a weight for a preferred rule. The node with the highest weight is preferred.
4. Description of the pod label that determines when the anti-affinity rule applies. Specify a key and value for the label.
5. The operator represents the relationship between the label on the existing pod and the set of values in the **matchExpression** parameters in the specification for the new pod. Can be **In**, **NotIn**, **Exists**, or **DoesNotExist**.

NOTE

If labels on a node change at runtime such that the affinity rules on a pod are no longer met, the pod continues to run on the node.

4.2.2. Configuring a pod affinity rule

The following steps demonstrate a simple two-pod configuration that creates pod with a label and a pod that uses affinity to allow scheduling with that pod.

NOTE

You cannot add an affinity directly to a scheduled pod.

Procedure

1. Create a pod with a specific label in the pod spec:

   a. Create a YAML file with the following content:

```
apiVersion: v1
kind: Pod
metadata:
  name: security-s1
  labels:
    security: S1
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: security-s1
    image: docker.io/ocpqe/hello-pod
    securityContext:
      runAsNonRoot: true
      seccompProfile:
        type: RuntimeDefault
```

b. Create the pod.

```
$ oc create -f <pod-spec>.yaml
```

2. When creating other pods, configure the following parameters to add the affinity:

a. Create a YAML file with the following content:

```
apiVersion: v1
kind: Pod
metadata:
  name: security-s1-east
# ...
spec:
  affinity: (1)
    podAffinity:
      requiredDuringSchedulingIgnoredDuringExecution: (2)
      - labelSelector:
          matchExpressions:
          - key: security (3)
            values:
            - S1
            operator: In (4)
        topologyKey: topology.kubernetes.io/zone (5)
# ...
```

(1) Adds a pod affinity.

(2) Configures the **requiredDuringSchedulingIgnoredDuringExecution** parameter or the **preferredDuringSchedulingIgnoredDuringExecution** parameter.

(3) Specifies the **key** and **values** that must be met. If you want the new pod to be scheduled with the other pod, use the same **key** and **values** parameters as the label on the first pod.

(4) Specifies an **operator**. The operator can be **In**, **NotIn**, **Exists**, or **DoesNotExist**. For example, use the operator **In** to require the label to be in the node.

(5) Specify a **topologyKey**, which is a prepopulated Kubernetes label that the system uses to denote such a topology domain.

b. Create the pod.

```
$ oc create -f <pod-spec>.yaml
```

4.2.3. Configuring a pod anti-affinity rule

The following steps demonstrate a simple two-pod configuration that creates pod with a label and a pod that uses an anti-affinity preferred rule to attempt to prevent scheduling with that pod.

NOTE

You cannot add an affinity directly to a scheduled pod.

Procedure

1. Create a pod with a specific label in the pod spec:

   a. Create a YAML file with the following content:

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: security-s1
     labels:
       security: S1
   spec:
     securityContext:
       runAsNonRoot: true
       seccompProfile:
         type: RuntimeDefault
     containers:
     - name: security-s1
       image: docker.io/ocpqe/hello-pod
       securityContext:
         allowPrivilegeEscalation: false
         capabilities:
           drop: [ALL]
   ```

   b. Create the pod.

   ```
   $ oc create -f <pod-spec>.yaml
   ```

2. When creating other pods, configure the following parameters:

   a. Create a YAML file with the following content:

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: security-s2-east
   # ...
   spec:
   # ...
     affinity: 1
       podAntiAffinity:
         preferredDuringSchedulingIgnoredDuringExecution: 2
         - weight: 100 3
           podAffinityTerm:
             labelSelector:
               matchExpressions:
               - key: security 4
                 values:
                 - S1
   ```

```
            operator: In 5
          topologyKey: kubernetes.io/hostname 6
# ...
```

1. Adds a pod anti-affinity.

2. Configures the **requiredDuringSchedulingIgnoredDuringExecution** parameter or the **preferredDuringSchedulingIgnoredDuringExecution** parameter.

3. For a preferred rule, specifies a weight for the node, 1-100. The node that with highest weight is preferred.

4. Specifies the **key** and **values** that must be met. If you want the new pod to not be scheduled with the other pod, use the same **key** and **values** parameters as the label on the first pod.

5. Specifies an **operator**. The operator can be **In**, **NotIn**, **Exists**, or **DoesNotExist**. For example, use the operator **In** to require the label to be in the node.

6. Specifies a **topologyKey**, which is a prepopulated Kubernetes label that the system uses to denote such a topology domain.

b. Create the pod.

```
$ oc create -f <pod-spec>.yaml
```

4.2.4. Sample pod affinity and anti-affinity rules

The following examples demonstrate pod affinity and pod anti-affinity.

4.2.4.1. Pod Affinity

The following example demonstrates pod affinity for pods with matching labels and label selectors.

- The pod **team4** has the label **team:4**.

```
apiVersion: v1
kind: Pod
metadata:
  name: team4
  labels:
     team: "4"
# ...
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: ocp
    image: docker.io/ocpqe/hello-pod
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
# ...
```

- The pod **team4a** has the label selector **team:4** under **podAffinity**.

```
apiVersion: v1
kind: Pod
metadata:
  name: team4a
# ...
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  affinity:
    podAffinity:
      requiredDuringSchedulingIgnoredDuringExecution:
      - labelSelector:
          matchExpressions:
          - key: team
            operator: In
            values:
            - "4"
        topologyKey: kubernetes.io/hostname
  containers:
  - name: pod-affinity
    image: docker.io/ocpqe/hello-pod
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
# ...
```

- The **team4a** pod is scheduled on the same node as the **team4** pod.

4.2.4.2. Pod Anti-affinity

The following example demonstrates pod anti-affinity for pods with matching labels and label selectors.

- The pod **pod-s1** has the label **security:s1**.

```
apiVersion: v1
kind: Pod
metadata:
  name: pod-s1
  labels:
    security: s1
# ...
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: ocp
    image: docker.io/ocpqe/hello-pod
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
# ...
```

- The pod **pod-s2** has the label selector **security:s1** under **podAntiAffinity**.

```
apiVersion: v1
kind: Pod
metadata:
  name: pod-s2
# ...
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  affinity:
    podAntiAffinity:
      requiredDuringSchedulingIgnoredDuringExecution:
      - labelSelector:
          matchExpressions:
          - key: security
            operator: In
            values:
            - s1
        topologyKey: kubernetes.io/hostname
  containers:
  - name: pod-antiaffinity
    image: docker.io/ocpqe/hello-pod
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
# ...
```

- The pod **pod-s2** cannot be scheduled on the same node as **pod-s1**.

4.2.4.3. Pod Affinity with no Matching Labels

The following example demonstrates pod affinity for pods without matching labels and label selectors.

- The pod **pod-s1** has the label **security:s1**.

```
apiVersion: v1
kind: Pod
metadata:
  name: pod-s1
  labels:
    security: s1
# ...
```

```
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: ocp
    image: docker.io/ocpqe/hello-pod
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
# ...
```

- The pod **pod-s2** has the label selector **security:s2**.

```
apiVersion: v1
kind: Pod
metadata:
  name: pod-s2
# ...
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  affinity:
    podAffinity:
      requiredDuringSchedulingIgnoredDuringExecution:
      - labelSelector:
          matchExpressions:
          - key: security
            operator: In
            values:
            - s2
        topologyKey: kubernetes.io/hostname
  containers:
  - name: pod-affinity
    image: docker.io/ocpqe/hello-pod
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
# ...
```

- The pod **pod-s2** is not scheduled unless there is a node with a pod that has the **security:s2** label. If there is no other pod with that label, the new pod remains in a pending state:

Example output

```
NAME     READY    STATUS    RESTARTS   AGE     IP       NODE
pod-s2   0/1      Pending   0          32s     <none>
```

4.3. CONTROLLING POD PLACEMENT ON NODES USING NODE AFFINITY RULES

Affinity is a property of pods that controls the nodes on which they prefer to be scheduled.

In Red Hat OpenShift Service on AWS node affinity is a set of rules used by the scheduler to determine where a pod can be placed. The rules are defined using custom labels on the nodes and label selectors specified in pods.

4.3.1. Understanding node affinity

Node affinity allows a pod to specify an affinity towards a group of nodes it can be placed on. The node does not have control over the placement.

For example, you could configure a pod to only run on a node with a specific CPU or in a specific availability zone.

There are two types of node affinity rules: *required* and *preferred*.

Required rules **must** be met before a pod can be scheduled on a node. Preferred rules specify that, if the rule is met, the scheduler tries to enforce the rules, but does not guarantee enforcement.

NOTE

If labels on a node change at runtime that results in an node affinity rule on a pod no longer being met, the pod continues to run on the node.

You configure node affinity through the **Pod** spec file. You can specify a required rule, a preferred rule, or both. If you specify both, the node must first meet the required rule, then attempts to meet the preferred rule.

The following example is a **Pod** spec with a rule that requires the pod be placed on a node with a label whose key is **e2e-az-NorthSouth** and whose value is either **e2e-az-North** or **e2e-az-South**:

Example pod configuration file with a node affinity required rule

```
apiVersion: v1
kind: Pod
metadata:
  name: with-node-affinity
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  affinity:
    nodeAffinity: 1
      requiredDuringSchedulingIgnoredDuringExecution: 2
        nodeSelectorTerms:
        - matchExpressions:
          - key: e2e-az-NorthSouth 3
            operator: In 4
            values:
            - e2e-az-North 5
          - e2e-az-South (6)
  containers:
  - name: with-node-affinity
    image: docker.io/ocpqe/hello-pod
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
# ...
```

(1) The stanza to configure node affinity.

(2) Defines a required rule.

(3) (5) (6) The key/value pair (label) that must be matched to apply the rule.

(4) The operator represents the relationship between the label on the node and the set of values in the **matchExpression** parameters in the **Pod** spec. This value can be **In**, **NotIn**, **Exists**, or **DoesNotExist**, **Lt**, or **Gt**.

The following example is a node specification with a preferred rule that a node with a label whose key is **e2e-az-EastWest** and whose value is either **e2e-az-East** or **e2e-az-West** is preferred for the pod:

Example pod configuration file with a node affinity preferred rule

```
apiVersion: v1
kind: Pod
metadata:
  name: with-node-affinity
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  affinity:
    nodeAffinity: (1)
      preferredDuringSchedulingIgnoredDuringExecution: (2)
      - weight: 1 (3)
        preference:
          matchExpressions:
          - key: e2e-az-EastWest (4)
            operator: In (5)
            values:
            - e2e-az-East (6)
            - e2e-az-West (7)
  containers:
  - name: with-node-affinity
    image: docker.io/ocpqe/hello-pod
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
# ...
```

1 The stanza to configure node affinity.

2 Defines a preferred rule.

3 Specifies a weight for a preferred rule. The node with highest weight is preferred.

4 6 7 The key/value pair (label) that must be matched to apply the rule.

5 The operator represents the relationship between the label on the node and the set of values in the **matchExpression** parameters in the **Pod** spec. This value can be **In**, **NotIn**, **Exists**, or **DoesNotExist**, **Lt**, or **Gt**.

There is no explicit *node anti-affinity* concept, but using the **NotIn** or **DoesNotExist** operator replicates that behavior.

NOTE

If you are using node affinity and node selectors in the same pod configuration, note the following:

- If you configure both **nodeSelector** and **nodeAffinity**, both conditions must be satisfied for the pod to be scheduled onto a candidate node.
- If you specify multiple **nodeSelectorTerms** associated with **nodeAffinity** types, then the pod can be scheduled onto a node if one of the **nodeSelectorTerms** is satisfied.
- If you specify multiple **matchExpressions** associated with **nodeSelectorTerms**, then the pod can be scheduled onto a node only if all **matchExpressions** are satisfied.

4.3.2. Configuring a required node affinity rule

Required rules **must** be met before a pod can be scheduled on a node.

Procedure

The following steps demonstrate a simple configuration that creates a node and a pod that the scheduler is required to place on the node.

1. Create a pod with a specific label in the pod spec:
   a. Create a YAML file with the following content:

NOTE

You cannot add an affinity directly to a scheduled pod.

Example output

```
apiVersion: v1
kind: Pod
metadata:
  name: s1
spec:
  affinity: (1)
    nodeAffinity:
      requiredDuringSchedulingIgnoredDuringExecution: (2)
        nodeSelectorTerms:
        - matchExpressions:
          - key: e2e-az-name (3)
            values:
            - e2e-az1
            - e2e-az2
            operator: In (4)
#...
```

(1) Adds a pod affinity.

(2) Configures the **requiredDuringSchedulingIgnoredDuringExecution** parameter.

(3) Specifies the **key** and **values** that must be met. If you want the new pod to be scheduled on the node you edited, use the same **key** and **values** parameters as the label in the node.

(4) Specifies an **operator**. The operator can be **In**, **NotIn**, **Exists**, or **DoesNotExist**. For example, use the operator **In** to require the label to be in the node.

b. Create the pod:

```
$ oc create -f <file-name>.yaml
```

4.3.3. Configuring a preferred node affinity rule

Preferred rules specify that, if the rule is met, the scheduler tries to enforce the rules, but does not guarantee enforcement.

Procedure

The following steps demonstrate a simple configuration that creates a node and a pod that the scheduler tries to place on the node.

1. Create a pod with a specific label:

   a. Create a YAML file with the following content:

NOTE

You cannot add an affinity directly to a scheduled pod.

```
apiVersion: v1
kind: Pod
metadata:
  name: s1
spec:
  affinity: (1)
    nodeAffinity:
      preferredDuringSchedulingIgnoredDuringExecution: (2)
      - weight: 3
        preference:
          matchExpressions:
          - key: e2e-az-name 4
            values:
            - e2e-az3
            operator: In 5
#...
```

1 Adds a pod affinity.

2 Configures the **preferredDuringSchedulingIgnoredDuringExecution** parameter.

3 Specifies a weight for the node, as a number 1-100. The node with highest weight is preferred.

4 Specifies the **key** and **values** that must be met. If you want the new pod to be scheduled on the node you edited, use the same **key** and **values** parameters as the label in the node.

5 Specifies an **operator**. The operator can be **In**, **NotIn**, **Exists**, or **DoesNotExist**. For example, use the operator **In** to require the label to be in the node.

b. Create the pod.

```
$ oc create -f <file-name>.yaml
```

4.3.4. Sample node affinity rules

The following examples demonstrate node affinity.

4.3.4.1. Node affinity with matching labels

The following example demonstrates node affinity for a node and pod with matching labels:

- The Node1 node has the label **zone:us**:

```
$ oc label node node1 zone=us
```

TIP

You can alternatively apply the following YAML to add the label:

```
kind: Node
apiVersion: v1
metadata:
  name: <node_name>
  labels:
    zone: us
#...
```

- The pod-s1 pod has the **zone** and **us** key/value pair under a required node affinity rule:

```
$ cat pod-s1.yaml
```

Example output

```
apiVersion: v1
kind: Pod
metadata:
  name: pod-s1
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - image: "docker.io/ocpqe/hello-pod"
      name: hello-pod
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
  affinity:
    nodeAffinity:
      requiredDuringSchedulingIgnoredDuringExecution:
        nodeSelectorTerms:
          - matchExpressions:
            - key: "zone"
              operator: In
              values:
              - us
#...
```

- The pod-s1 pod can be scheduled on Node1:

```
$ oc get pod -o wide
```

Example output

```
NAME     READY    STATUS       RESTARTS   AGE      IP      NODE
pod-s1   1/1      Running      0          4m       IP1     node1
```

4.3.4.2. Node affinity with no matching labels

The following example demonstrates node affinity for a node and pod without matching labels:

- The Node1 node has the label **zone:emea**:

```
$ oc label node node1 zone=emea
```

TIP

You can alternatively apply the following YAML to add the label:

```
kind: Node
apiVersion: v1
metadata:
  name: <node_name>
  labels:
    zone: emea
#...
```

- The pod-s1 pod has the **zone** and **us** key/value pair under a required node affinity rule:

```
$ cat pod-s1.yaml
```

Example output

```
apiVersion: v1
kind: Pod
metadata:
  name: pod-s1
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - image: "docker.io/ocpqe/hello-pod"
      name: hello-pod
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
  affinity:
    nodeAffinity:
      requiredDuringSchedulingIgnoredDuringExecution:
        nodeSelectorTerms:
          - matchExpressions:
            - key: "zone"
              operator: In
              values:
              - us
#...
```

- The pod-s1 pod cannot be scheduled on Node1:

```
$ oc describe pod pod-s1
```

Example output

```
...
```

```
Events:
 FirstSeen LastSeen Count From            SubObjectPath  Type              Reason
 --------- -------- ----- ----            -------------  --------          ------
 1m        33s      8     default-scheduler Warning       FailedScheduling    No nodes are
available that match all of the following predicates:: MatchNodeSelector (1).
```

4.4. PLACING PODS ONTO OVERCOMMITED NODES

In an *overcommited* state, the sum of the container compute resource requests and limits exceeds the resources available on the system. Overcommitment might be desirable in development environments where a trade-off of guaranteed performance for capacity is acceptable.

Requests and limits enable administrators to allow and manage the overcommitment of resources on a node. The scheduler uses requests for scheduling your container and providing a minimum service guarantee. Limits constrain the amount of compute resource that may be consumed on your node.

4.4.1. Understanding overcommitment

Requests and limits enable administrators to allow and manage the overcommitment of resources on a node. The scheduler uses requests for scheduling your container and providing a minimum service guarantee. Limits constrain the amount of compute resource that may be consumed on your node.

Red Hat OpenShift Service on AWS administrators can control the level of overcommit and manage container density on nodes by configuring masters to override the ratio between request and limit set on developer containers. In conjunction with a per-project **LimitRange** object specifying limits and defaults, this adjusts the container limit and request to achieve the desired level of overcommit.

NOTE

That these overrides have no effect if no limits have been set on containers. Create a **LimitRange** object with default limits, per individual project, or in the project template, to ensure that the overrides apply.

After these overrides, the container limits and requests must still be validated by any **LimitRange** object in the project. It is possible, for example, for developers to specify a limit close to the minimum limit, and have the request then be overridden below the minimum limit, causing the pod to be forbidden. This unfortunate user experience should be addressed with future work, but for now, configure this capability and **LimitRange** objects with caution.

4.4.2. Understanding nodes overcommitment

In an overcommitted environment, it is important to properly configure your node to provide best system behavior.

When the node starts, it ensures that the kernel tunable flags for memory management are set properly. The kernel should never fail memory allocations unless it runs out of physical memory.

To ensure this behavior, Red Hat OpenShift Service on AWS configures the kernel to always overcommit memory by setting the **vm.overcommit_memory** parameter to **1**, overriding the default operating system setting.

Red Hat OpenShift Service on AWS also configures the kernel not to panic when it runs out of memory by setting the **vm.panic_on_oom** parameter to **0**. A setting of 0 instructs the kernel to call oom_killer in an Out of Memory (OOM) condition, which kills processes based on priority

You can view the current setting by running the following commands on your nodes:

```
$ sysctl -a |grep commit
```

Example output

```
#...
vm.overcommit_memory = 0
#...
```

```
$ sysctl -a |grep panic
```

Example output

```
#...
vm.panic_on_oom = 0
#...
```

NOTE

The above flags should already be set on nodes, and no further action is required.

You can also perform the following configurations for each node:

- Disable or enforce CPU limits using CPU CFS quotas
- Reserve resources for system processes
- Reserve memory across quality of service tiers

4.5. CONTROLLING POD PLACEMENT USING NODE TAINTS

Taints and tolerations allow the node to control which pods should (or should not) be scheduled on them.

4.5.1. Understanding taints and tolerations

A *taint* allows a node to refuse a pod to be scheduled unless that pod has a matching *toleration*.

You apply taints to a node through the **Node** specification (**NodeSpec**) and apply tolerations to a pod through the **Pod** specification (**PodSpec**). When you apply a taint a node, the scheduler cannot place a pod on that node unless the pod can tolerate the taint.

Example taint in a node specification

```
apiVersion: v1
kind: Node
metadata:
  name: my-node
#...
spec:
  taints:
```

```
  - effect: NoExecute
    key: key1
    value: value1
#...
```

Example toleration in a **Pod** spec

```
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
#...
spec:
  tolerations:
  - key: "key1"
    operator: "Equal"
    value: "value1"
    effect: "NoExecute"
    tolerationSeconds: 3600
#...
```

Taints and tolerations consist of a key, value, and effect.

Table 4.1. Taint and toleration components

Parameter	Description
key	The **key** is any string, up to 253 characters. The key must begin with a letter or number, and may contain letters, numbers, hyphens, dots, and underscores.
value	The **value** is any string, up to 63 characters. The value must begin with a letter or number, and may contain letters, numbers, hyphens, dots, and underscores.

Parameter	Description
effect	The effect is one of the following: **NoSchedule** [1]: • New pods that do not match the taint are not scheduled onto that node. • Existing pods on the node remain. **PreferNoSchedule**: • New pods that do not match the taint might be scheduled onto that node, but the scheduler tries not to. • Existing pods on the node remain. **NoExecute**: • New pods that do not match the taint cannot be scheduled onto that node. • Existing pods on the node that do not have a matching toleration are removed.
operator	**Equal**: The **key**/**value**/**effect** parameters must match. This is the default. **Exists**: The **key**/**effect** parameters must match. You must leave a blank **value** parameter, which matches any.

1. If you add a **NoSchedule** taint to a control plane node, the node must have the **node-role.kubernetes.io/master=:NoSchedule** taint, which is added by default.
   For example:

```
apiVersion: v1
kind: Node
metadata:
  annotations:
    machine.openshift.io/machine: openshift-machine-api/ci-ln-62s7gtb-f76d1-v8jxv-master-0
    machineconfiguration.openshift.io/currentConfig: rendered-master-
cdc1ab7da414629332cc4c3926e6e59c
  name: my-node
#...
spec:
  taints:
  - effect: NoSchedule
    key: node-role.kubernetes.io/master
#...
```

A toleration matches a taint:

- If the **operator** parameter is set to **Equal**:
  - the **key** parameters are the same;
  - the **value** parameters are the same;
  - the **effect** parameters are the same.
- If the **operator** parameter is set to **Exists**:
  - the **key** parameters are the same;
  - the **effect** parameters are the same.

The following taints are built into Red Hat OpenShift Service on AWS:

- **node.kubernetes.io/not-ready**: The node is not ready. This corresponds to the node condition **Ready=False**.
- **node.kubernetes.io/unreachable**: The node is unreachable from the node controller. This corresponds to the node condition **Ready=Unknown**.
- **node.kubernetes.io/memory-pressure**: The node has memory pressure issues. This corresponds to the node condition **MemoryPressure=True**.
- **node.kubernetes.io/disk-pressure**: The node has disk pressure issues. This corresponds to the node condition **DiskPressure=True**.
- **node.kubernetes.io/network-unavailable**: The node network is unavailable.
- **node.kubernetes.io/unschedulable**: The node is unschedulable.
- **node.cloudprovider.kubernetes.io/uninitialized**: When the node controller is started with an external cloud provider, this taint is set on a node to mark it as unusable. After a controller from the cloud-controller-manager initializes this node, the kubelet removes this taint.
- **node.kubernetes.io/pid-pressure**: The node has pid pressure. This corresponds to the node condition **PIDPressure=True**.

IMPORTANT

Red Hat OpenShift Service on AWS does not set a default pid.available **evictionHard**.

4.5.1.1. Understanding how to use toleration seconds to delay pod evictions

You can specify how long a pod can remain bound to a node before being evicted by specifying the **tolerationSeconds** parameter in the **Pod** specification or **MachineSet** object. If a taint with the **NoExecute** effect is added to a node, a pod that does tolerate the taint, which has the **tolerationSeconds** parameter, the pod is not evicted until that time period expires.

Example output

```
apiVersion: v1
kind: Pod
```

```
metadata:
  name: my-pod
#...
spec:
  tolerations:
  - key: "key1"
    operator: "Equal"
    value: "value1"
    effect: "NoExecute"
    tolerationSeconds: 3600
#...
```

Here, if this pod is running but does not have a matching toleration, the pod stays bound to the node for 3,600 seconds and then be evicted. If the taint is removed before that time, the pod is not evicted.

4.5.1.2. Understanding how to use multiple taints

You can put multiple taints on the same node and multiple tolerations on the same pod. Red Hat OpenShift Service on AWS processes multiple taints and tolerations as follows:

1. Process the taints for which the pod has a matching toleration.
2. The remaining unmatched taints have the indicated effects on the pod:
    - If there is at least one unmatched taint with effect **NoSchedule**, Red Hat OpenShift Service on AWS cannot schedule a pod onto that node.
    - If there is no unmatched taint with effect **NoSchedule** but there is at least one unmatched taint with effect **PreferNoSchedule**, Red Hat OpenShift Service on AWS tries to not schedule the pod onto the node.
    - If there is at least one unmatched taint with effect **NoExecute**, Red Hat OpenShift Service on AWS evicts the pod from the node if it is already running on the node, or the pod is not scheduled onto the node if it is not yet running on the node.
        - Pods that do not tolerate the taint are evicted immediately.
        - Pods that tolerate the taint without specifying **tolerationSeconds** in their **Pod** specification remain bound forever.
        - Pods that tolerate the taint with a specified **tolerationSeconds** remain bound for the specified amount of time.

For example:

- Add the following taints to the node:

  ```
  $ oc adm taint nodes node1 key1=value1:NoSchedule
  ```

  ```
  $ oc adm taint nodes node1 key1=value1:NoExecute
  ```

  ```
  $ oc adm taint nodes node1 key2=value2:NoSchedule
  ```

- The pod has the following tolerations:

```
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
#...
spec:
  tolerations:
  - key: "key1"
    operator: "Equal"
    value: "value1"
    effect: "NoSchedule"
  - key: "key1"
    operator: "Equal"
    value: "value1"
    effect: "NoExecute"
#...
```

In this case, the pod cannot be scheduled onto the node, because there is no toleration matching the third taint. The pod continues running if it is already running on the node when the taint is added, because the third taint is the only one of the three that is not tolerated by the pod.

4.5.1.3. Understanding pod scheduling and node conditions (taint node by condition)

The Taint Nodes By Condition feature, which is enabled by default, automatically taints nodes that report conditions such as memory pressure and disk pressure. If a node reports a condition, a taint is added until the condition clears. The taints have the **NoSchedule** effect, which means no pod can be scheduled on the node unless the pod has a matching toleration.

The scheduler checks for these taints on nodes before scheduling pods. If the taint is present, the pod is scheduled on a different node. Because the scheduler checks for taints and not the actual node conditions, you configure the scheduler to ignore some of these node conditions by adding appropriate pod tolerations.

To ensure backward compatibility, the daemon set controller automatically adds the following tolerations to all daemons:

- node.kubernetes.io/memory-pressure
- node.kubernetes.io/disk-pressure
- node.kubernetes.io/unschedulable (1.10 or later)
- node.kubernetes.io/network-unavailable (host network only)

You can also add arbitrary tolerations to daemon sets.

NOTE

The control plane also adds the **node.kubernetes.io/memory-pressure** toleration on pods that have a QoS class. This is because Kubernetes manages pods in the **Guaranteed** or **Burstable** QoS classes. The new **BestEffort** pods do not get scheduled onto the affected node.

4.5.1.4. Understanding evicting pods by condition (taint-based evictions)

The Taint-Based Evictions feature, which is enabled by default, evicts pods from a node that experiences specific conditions, such as **not-ready** and **unreachable**. When a node experiences one of these conditions, Red Hat OpenShift Service on AWS automatically adds taints to the node, and starts evicting and rescheduling the pods on different nodes.

Taint Based Evictions have a **NoExecute** effect, where any pod that does not tolerate the taint is evicted immediately and any pod that does tolerate the taint will never be evicted, unless the pod uses the **tolerationSeconds** parameter.

The **tolerationSeconds** parameter allows you to specify how long a pod stays bound to a node that has a node condition. If the condition still exists after the **tolerationSeconds** period, the taint remains on the node and the pods with a matching toleration are evicted. If the condition clears before the **tolerationSeconds** period, pods with matching tolerations are not removed.

If you use the **tolerationSeconds** parameter with no value, pods are never evicted because of the not ready and unreachable node conditions.

NOTE

Red Hat OpenShift Service on AWS evicts pods in a rate-limited way to prevent massive pod evictions in scenarios such as the master becoming partitioned from the nodes.

By default, if more than 55% of nodes in a given zone are unhealthy, the node lifecycle controller changes that zone's state to **PartialDisruption** and the rate of pod evictions is reduced. For small clusters (by default, 50 nodes or less) in this state, nodes in this zone are not tainted and evictions are stopped.

For more information, see Rate limits on eviction in the Kubernetes documentation.

Red Hat OpenShift Service on AWS automatically adds a toleration for **node.kubernetes.io/not-ready** and **node.kubernetes.io/unreachable** with **tolerationSeconds=300**, unless the **Pod** configuration specifies either toleration.

```
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
#...
spec:
  tolerations:
  - key: node.kubernetes.io/not-ready
    operator: Exists
    effect: NoExecute
    tolerationSeconds: 300 (1)
  - key: node.kubernetes.io/unreachable
    operator: Exists
    effect: NoExecute
    tolerationSeconds: 300
#...
```

(1) These tolerations ensure that the default pod behavior is to remain bound for five minutes after one of these node conditions problems is detected.

You can configure these tolerations as needed. For example, if you have an application with a lot of local state, you might want to keep the pods bound to node for a longer time in the event of network partition, allowing for the partition to recover and avoiding pod eviction.

Pods spawned by a daemon set are created with **NoExecute** tolerations for the following taints with no **tolerationSeconds**:

- **node.kubernetes.io/unreachable**
- **node.kubernetes.io/not-ready**

As a result, daemon set pods are never evicted because of these node conditions.

4.5.1.5. Tolerating all taints

You can configure a pod to tolerate all taints by adding an **operator: "Exists"** toleration with no **key** and **values** parameters. Pods with this toleration are not removed from a node that has taints.

Pod spec for tolerating all taints

```
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
#...
spec:
  tolerations:
  - operator: "Exists"
#...
```

4.5.2. Adding taints and tolerations

You add tolerations to pods and taints to nodes to allow the node to control which pods should or should not be scheduled on them. For existing pods and nodes, you should add the toleration to the pod first, then add the taint to the node to avoid pods being removed from the node before you can add the toleration.

Procedure

1. Add a toleration to a pod by editing the **Pod** spec to include a **tolerations** stanza:

   Sample pod configuration file with an Equal operator

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: my-pod
   #...
   spec:
     tolerations:
     - key: "key1" (1)
       value: "value1"
       operator: "Equal"
   ```

```
    effect: "NoExecute"
    tolerationSeconds: 3600 (2)
#...
```

(1) The toleration parameters, as described in the **Taint and toleration components** table.

(2) The **tolerationSeconds** parameter specifies how long a pod can remain bound to a node before being evicted.

For example:

Sample pod configuration file with an Exists operator

```
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
#...
spec:
   tolerations:
   - key: "key1"
     operator: "Exists" (1)
     effect: "NoExecute"
     tolerationSeconds: 3600
#...
```

(1) The **Exists** operator does not take a **value**.

This example places a taint on **node1** that has key **key1**, value **value1**, and taint effect **NoExecute**.

2. Add a taint to a node by using the following command with the parameters described in the **Taint and toleration components** table:

```
$ oc adm taint nodes <node_name> <key>=<value>:<effect>
```

For example:

```
$ oc adm taint nodes node1 key1=value1:NoExecute
```

This command places a taint on **node1** that has key **key1**, value **value1**, and effect **NoExecute**.

NOTE

If you add a **NoSchedule** taint to a control plane node, the node must have the **node-role.kubernetes.io/master=:NoSchedule** taint, which is added by default.

For example:

```
apiVersion: v1
kind: Node
metadata:
  annotations:
    machine.openshift.io/machine: openshift-machine-api/ci-ln-62s7gtb-f76d1-v8jxv-master-0
    machineconfiguration.openshift.io/currentConfig: rendered-master-cdc1ab7da414629332cc4c3926e6e59c
  name: my-node
#...
spec:
  taints:
  - effect: NoSchedule
    key: node-role.kubernetes.io/master
#...
```

The tolerations on the pod match the taint on the node. A pod with either toleration can be scheduled onto **node1**.

4.5.2.1. Adding taints and tolerations using a compute machine set

You can add taints to nodes using a compute machine set. All nodes associated with the **MachineSet** object are updated with the taint. Tolerations respond to taints added by a compute machine set in the same manner as taints added directly to the nodes.

Procedure

1. Add a toleration to a pod by editing the **Pod** spec to include a **tolerations** stanza:

Sample pod configuration file with Equal operator

```
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
#...
spec:
  tolerations:
  - key: "key1" 1
    value: "value1"
    operator: "Equal"
    effect: "NoExecute"
    tolerationSeconds: 3600 2
#...
```

1 The toleration parameters, as described in the **Taint and toleration components** table.

2 The **tolerationSeconds** parameter specifies how long a pod is bound to a node before being evicted.

For example:

Sample pod configuration file with Exists operator

```
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
#...
spec:
  tolerations:
  - key: "key1"
    operator: "Exists"
    effect: "NoExecute"
    tolerationSeconds: 3600
#...
```

2. Add the taint to the **MachineSet** object:

   a. Edit the **MachineSet** YAML for the nodes you want to taint or you can create a new **MachineSet** object:

   ```
   $ oc edit machineset <machineset>
   ```

   b. Add the taint to the **spec.template.spec** section:

   Example taint in a compute machine set specification

   ```
   apiVersion: machine.openshift.io/v1beta1
   kind: MachineSet
   metadata:
     name: my-machineset
   #...
   spec:
   #...
     template:
   #...
       spec:
         taints:
         - effect: NoExecute
           key: key1
           value: value1
   #...
   ```

   This example places a taint that has the key **key1**, value **value1**, and taint effect **NoExecute** on the nodes.

   c. Scale down the compute machine set to 0:

   ```
   $ oc scale --replicas=0 machineset <machineset> -n openshift-machine-api
   ```

TIP

You can alternatively apply the following YAML to scale the compute machine set:

```
apiVersion: machine.openshift.io/v1beta1
kind: MachineSet
metadata:
  name: <machineset>
  namespace: openshift-machine-api
spec:
  replicas: 0
```

Wait for the machines to be removed.

d. Scale up the compute machine set as needed:

```
$ oc scale --replicas=2 machineset <machineset> -n openshift-machine-api
```

Or:

```
$ oc edit machineset <machineset> -n openshift-machine-api
```

Wait for the machines to start. The taint is added to the nodes associated with the **MachineSet** object.

4.5.2.2. Binding a user to a node using taints and tolerations

If you want to dedicate a set of nodes for exclusive use by a particular set of users, add a toleration to their pods. Then, add a corresponding taint to those nodes. The pods with the tolerations are allowed to use the tainted nodes or any other nodes in the cluster.

If you want ensure the pods are scheduled to only those tainted nodes, also add a label to the same set of nodes and add a node affinity to the pods so that the pods can only be scheduled onto nodes with that label.

Procedure

To configure a node so that users can use only that node:

1. Add a corresponding taint to those nodes:
   For example:

```
$ oc adm taint nodes node1 dedicated=groupName:NoSchedule
```

TIP

You can alternatively apply the following YAML to add the taint:

```
kind: Node
apiVersion: v1
metadata:
  name: my-node
#...
spec:
  taints:
    - key: dedicated
      value: groupName
      effect: NoSchedule
#...
```

2. Add a toleration to the pods by writing a custom admission controller.

4.5.2.3. Creating a project with a node selector and toleration

You can create a project that uses a node selector and toleration, which are set as annotations, to control the placement of pods onto specific nodes. Any subsequent resources created in the project are then scheduled on nodes that have a taint matching the toleration.

Prerequisites

- A label for node selection has been added to one or more nodes by using a compute machine set or editing the node directly.
- A taint has been added to one or more nodes by using a compute machine set or editing the node directly.

Procedure

1. Create a **Project** resource definition, specifying a node selector and toleration in the **metadata.annotations** section:

Example project.yaml file

```
kind: Project
apiVersion: project.openshift.io/v1
metadata:
  name: <project_name> (1)
  annotations:
    openshift.io/node-selector: '<label>' (2)
    scheduler.alpha.kubernetes.io/defaultTolerations: >-
      [{"operator": "Exists", "effect": "NoSchedule", "key":
      "<key_name>"} (3)
      ]
```

(1) The project name.

(2) The default node selector label.

3 The toleration parameters, as described in the **Taint and toleration components** table. This example uses the **NoSchedule** effect, which allows existing pods on the node to

2. Use the **oc apply** command to create the project:

```
$ oc apply -f project.yaml
```

Any subsequent resources created in the **<project_name>** namespace should now be scheduled on the specified nodes.

Additional resources

- Adding taints and tolerations manually to nodes or with compute machine sets

4.5.2.4. Controlling nodes with special hardware using taints and tolerations

In a cluster where a small subset of nodes have specialized hardware, you can use taints and tolerations to keep pods that do not need the specialized hardware off of those nodes, leaving the nodes for pods that do need the specialized hardware. You can also require pods that need specialized hardware to use specific nodes.

You can achieve this by adding a toleration to pods that need the special hardware and tainting the nodes that have the specialized hardware.

Procedure

To ensure nodes with specialized hardware are reserved for specific pods:

1. Add a toleration to pods that need the special hardware.
   For example:

```
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
#...
spec:
  tolerations:
    - key: "disktype"
      value: "ssd"
      operator: "Equal"
      effect: "NoSchedule"
      tolerationSeconds: 3600
#...
```

2. Taint the nodes that have the specialized hardware using one of the following commands:

```
$ oc adm taint nodes <node-name> disktype=ssd:NoSchedule
```

Or:

```
$ oc adm taint nodes <node-name> disktype=ssd:PreferNoSchedule
```

TIP

You can alternatively apply the following YAML to add the taint:

```
kind: Node
apiVersion: v1
metadata:
  name: my_node
#...
spec:
  taints:
    - key: disktype
      value: ssd
      effect: PreferNoSchedule
#...
```

4.5.3. Removing taints and tolerations

You can remove taints from nodes and tolerations from pods as needed. You should add the toleration to the pod first, then add the taint to the node to avoid pods being removed from the node before you can add the toleration.

Procedure

To remove taints and tolerations:

1. To remove a taint from a node:

   ```
   $ oc adm taint nodes <node-name> <key>-
   ```

   For example:

   ```
   $ oc adm taint nodes ip-10-0-132-248.ec2.internal key1-
   ```

   Example output

   ```
   node/ip-10-0-132-248.ec2.internal untainted
   ```

2. To remove a toleration from a pod, edit the **Pod** spec to remove the toleration:

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: my-pod
   #...
   spec:
     tolerations:
     - key: "key2"
       operator: "Exists"
       effect: "NoExecute"
       tolerationSeconds: 3600
   #...
   ```

4.6. PLACING PODS ON SPECIFIC NODES USING NODE SELECTORS

A *node selector* specifies a map of key/value pairs that are defined using custom labels on nodes and selectors specified in pods.

For the pod to be eligible to run on a node, the pod must have the same key/value node selector as the label on the node.

4.6.1. About node selectors

You can use node selectors on pods and labels on nodes to control where the pod is scheduled. With node selectors, Red Hat OpenShift Service on AWS schedules the pods on nodes that contain matching labels.

You can use a node selector to place specific pods on specific nodes, cluster-wide node selectors to place new pods on specific nodes anywhere in the cluster, and project node selectors to place new pods in a project on specific nodes.

For example, as a cluster administrator, you can create an infrastructure where application developers can deploy pods only onto the nodes closest to their geographical location by including a node selector in every pod they create. In this example, the cluster consists of five data centers spread across two regions. In the U.S., label the nodes as **us-east**, **us-central**, or **us-west**. In the Asia-Pacific region (APAC), label the nodes as **apac-east** or **apac-west**. The developers can add a node selector to the pods they create to ensure the pods get scheduled on those nodes.

A pod is not scheduled if the **Pod** object contains a node selector, but no node has a matching label.

IMPORTANT

If you are using node selectors and node affinity in the same pod configuration, the following rules control pod placement onto nodes:

- If you configure both **nodeSelector** and **nodeAffinity**, both conditions must be satisfied for the pod to be scheduled onto a candidate node.
- If you specify multiple **nodeSelectorTerms** associated with **nodeAffinity** types, then the pod can be scheduled onto a node if one of the **nodeSelectorTerms** is satisfied.
- If you specify multiple **matchExpressions** associated with **nodeSelectorTerms**, then the pod can be scheduled onto a node only if all **matchExpressions** are satisfied.

Node selectors on specific pods and nodes

You can control which node a specific pod is scheduled on by using node selectors and labels.
To use node selectors and labels, first label the node to avoid pods being descheduled, then add the node selector to the pod.

NOTE

You cannot add a node selector directly to an existing scheduled pod. You must label the object that controls the pod, such as deployment config.

For example, the following **Node** object has the **region: east** label:

Sample Node object with a label

```
kind: Node
apiVersion: v1
metadata:
  name: ip-10-0-131-14.ec2.internal
  selfLink: /api/v1/nodes/ip-10-0-131-14.ec2.internal
  uid: 7bc2580a-8b8e-11e9-8e01-021ab4174c74
  resourceVersion: '478704'
  creationTimestamp: '2019-06-10T14:46:08Z'
  labels:
    kubernetes.io/os: linux
    topology.kubernetes.io/zone: us-east-1a
    node.openshift.io/os_version: '4.5'
    node-role.kubernetes.io/worker: ''
    topology.kubernetes.io/region: us-east-1
    node.openshift.io/os_id: rhcos
    node.kubernetes.io/instance-type: m4.large
    kubernetes.io/hostname: ip-10-0-131-14
    kubernetes.io/arch: amd64
    region: east 1
    type: user-node
#...
```

1 Labels to match the pod node selector.

A pod has the **type: user-node,region: east** node selector:

Sample Pod object with node selectors

```
apiVersion: v1
kind: Pod
metadata:
  name: s1
#...
spec:
  nodeSelector: 1
    region: east
    type: user-node
#...
```

1 Node selectors to match the node label. The node must have a label for each node selector.

When you create the pod using the example pod spec, it can be scheduled on the example node.

Default cluster-wide node selectors

With default cluster-wide node selectors, when you create a pod in that cluster, Red Hat OpenShift Service on AWS adds the default node selectors to the pod and schedules the pod on nodes with matching labels.
For example, the following **Scheduler** object has the default cluster-wide **region=east** and **type=user-node** node selectors:

Example Scheduler Operator Custom Resource

```
apiVersion: config.openshift.io/v1
kind: Scheduler
metadata:
  name: cluster
#...
spec:
  defaultNodeSelector: type=user-node,region=east
#...
```

A node in that cluster has the **type=user-node,region=east** labels:

Example Node object

```
apiVersion: v1
kind: Node
metadata:
  name: ci-ln-qg1il3k-f76d1-hlmhl-worker-b-df2s4
#...
  labels:
    region: east
    type: user-node
#...
```

Example Pod object with a node selector

```
apiVersion: v1
kind: Pod
metadata:
  name: s1
#...
spec:
  nodeSelector:
    region: east
#...
```

When you create the pod using the example pod spec in the example cluster, the pod is created with the cluster-wide node selector and is scheduled on the labeled node:

Example pod list with the pod on the labeled node

```
NAME     READY   STATUS    RESTARTS   AGE   IP           NODE
NOMINATED NODE   READINESS GATES
pod-s1   1/1     Running   0          20s   10.131.2.6   ci-ln-qg1il3k-f76d1-hlmhl-worker-b-df2s4
<none>           <none>
```

NOTE

If the project where you create the pod has a project node selector, that selector takes preference over a cluster-wide node selector. Your pod is not created or scheduled if the pod does not have the project node selector.

Project node selectors

With project node selectors, when you create a pod in this project, Red Hat OpenShift Service on AWS adds the node selectors to the pod and schedules the pods on a node with matching labels. If there is a cluster-wide default node selector, a project node selector takes preference.
For example, the following project has the **region=east** node selector:

Example Namespace object

```
apiVersion: v1
kind: Namespace
metadata:
  name: east-region
  annotations:
    openshift.io/node-selector: "region=east"
#...
```

The following node has the **type=user-node,region=east** labels:

Example Node object

```
apiVersion: v1
kind: Node
metadata:
  name: ci-ln-qg1il3k-f76d1-hlmhl-worker-b-df2s4
#...
  labels:
    region: east
    type: user-node
#...
```

When you create the pod using the example pod spec in this example project, the pod is created with the project node selectors and is scheduled on the labeled node:

Example Pod object

```
apiVersion: v1
kind: Pod
metadata:
  namespace: east-region
#...
spec:
  nodeSelector:
    region: east
    type: user-node
#...
```

Example pod list with the pod on the labeled node

```
NAME     READY   STATUS    RESTARTS   AGE   IP           NODE
NOMINATED NODE   READINESS GATES
pod-s1   1/1     Running   0          20s   10.131.2.6   ci-ln-qg1il3k-f76d1-hlmhl-worker-b-df2s4
<none>           <none>
```

A pod in the project is not created or scheduled if the pod contains different node selectors. For example, if you deploy the following pod into the example project, it is not be created:

Example Pod object with an invalid node selector

```
apiVersion: v1
kind: Pod
metadata:
  name: west-region
#...
spec:
  nodeSelector:
    region: west
#...
```

4.6.2. Using node selectors to control pod placement

You can use node selectors on pods and labels on nodes to control where the pod is scheduled. With node selectors, Red Hat OpenShift Service on AWS schedules the pods on nodes that contain matching labels.

You add labels to a node, a compute machine set, or a machine config. Adding the label to the compute machine set ensures that if the node or machine goes down, new nodes have the label. Labels added to a node or machine config do not persist if the node or machine goes down.

To add node selectors to an existing pod, add a node selector to the controlling object for that pod, such as a **ReplicaSet** object, **DaemonSet** object, **StatefulSet** object, **Deployment** object, or **DeploymentConfig** object. Any existing pods under that controlling object are recreated on a node with a matching label. If you are creating a new pod, you can add the node selector directly to the pod spec. If the pod does not have a controlling object, you must delete the pod, edit the pod spec, and recreate the pod.

NOTE

You cannot add a node selector directly to an existing scheduled pod.

Prerequisites

To add a node selector to existing pods, determine the controlling object for that pod. For example, the **router-default-66d5cf9464-m2g75** pod is controlled by the **router-default-66d5cf9464** replica set:

```
$ oc describe pod router-default-66d5cf9464-7pwkc
```

Example output

```
kind: Pod
apiVersion: v1
metadata:
# ...
Name:               router-default-66d5cf9464-7pwkc
Namespace:          openshift-ingress
```

```
# ...
Controlled By:      ReplicaSet/router-default-66d5cf9464
# ...
```

The web console lists the controlling object under **ownerReferences** in the pod YAML:

```
apiVersion: v1
kind: Pod
metadata:
  name: router-default-66d5cf9464-7pwkc
# ...
  ownerReferences:
    - apiVersion: apps/v1
      kind: ReplicaSet
      name: router-default-66d5cf9464
      uid: d81dd094-da26-11e9-a48a-128e7edf0312
      controller: true
      blockOwnerDeletion: true
# ...
```

Procedure

- Add the matching node selector to a pod:
  - To add a node selector to existing and future pods, add a node selector to the controlling object for the pods:

    Example ReplicaSet object with labels

    ```
    kind: ReplicaSet
    apiVersion: apps/v1
    metadata:
      name: hello-node-6fbccf8d9
    # ...
    spec:
    # ...
      template:
        metadata:
          creationTimestamp: null
          labels:
            ingresscontroller.operator.openshift.io/deployment-ingresscontroller: default
            pod-template-hash: 66d5cf9464
        spec:
          nodeSelector:
            kubernetes.io/os: linux
            node-role.kubernetes.io/worker: ''
            type: user-node (1)
    # ...
    ```

    (1) Add the node selector.

  - To add a node selector to a specific, new pod, add the selector to the **Pod** object directly:

    Example Pod object with a node selector

```
apiVersion: v1
kind: Pod
metadata:
  name: hello-node-6fbccf8d9
# ...
spec:
  nodeSelector:
    region: east
    type: user-node
# ...
```

NOTE

You cannot add a node selector directly to an existing scheduled pod.

Additional resources

- Creating a project with a node selector and toleration

4.7. CONTROLLING POD PLACEMENT BY USING POD TOPOLOGY SPREAD CONSTRAINTS

You can use pod topology spread constraints to control the placement of your pods across nodes, zones, regions, or other user-defined topology domains.

4.7.1. About pod topology spread constraints

By using a *pod topology spread constraint* , you provide fine-grained control over the distribution of pods across failure domains to help achieve high availability and more efficient resource utilization.

Red Hat OpenShift Service on AWS administrators can label nodes to provide topology information, such as regions, zones, nodes, or other user-defined domains. After these labels are set on nodes, users can then define pod topology spread constraints to control the placement of pods across these topology domains.

You specify which pods to group together, which topology domains they are spread among, and the acceptable skew. Only pods within the same namespace are matched and grouped together when spreading due to a constraint.

4.7.2. Configuring pod topology spread constraints

The following steps demonstrate how to configure pod topology spread constraints to distribute pods that match the specified labels based on their zone.

You can specify multiple pod topology spread constraints, but you must ensure that they do not conflict with each other. All pod topology spread constraints must be satisfied for a pod to be placed.

Prerequisites

- A user with the **dedicated-admin** role has added the required labels to nodes.

Procedure

1. Create a **Pod** spec and specify a pod topology spread constraint:

   Example pod-spec.yaml file

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: my-pod
     labels:
       region: us-east
   spec:
     securityContext:
       runAsNonRoot: true
       seccompProfile:
         type: RuntimeDefault
     topologySpreadConstraints:
     - maxSkew: 1 (1)
       topologyKey: topology.kubernetes.io/zone (2)
       whenUnsatisfiable: DoNotSchedule (3)
       labelSelector: (4)
         matchLabels:
           region: us-east (5)
       matchLabelKeys:
         - my-pod-label (6)
     containers:
     - image: "docker.io/ocpqe/hello-pod"
       name: hello-pod
       securityContext:
         allowPrivilegeEscalation: false
         capabilities:
           drop: [ALL]
   ```

   1. The maximum difference in number of pods between any two topology domains. The default is **1**, and you cannot specify a value of **0**.

   2. The key of a node label. Nodes with this key and identical value are considered to be in the same topology.

   3. How to handle a pod if it does not satisfy the spread constraint. The default is **DoNotSchedule**, which tells the scheduler not to schedule the pod. Set to **ScheduleAnyway** to still schedule the pod, but the scheduler prioritizes honoring the skew to not make the cluster more imbalanced.

   4. Pods that match this label selector are counted and recognized as a group when spreading to satisfy the constraint. Be sure to specify a label selector, otherwise no pods can be matched.

   5. Be sure that this **Pod** spec also sets its labels to match this label selector if you want it to be counted properly in the future.

   6. A list of pod label keys to select which pods to calculate spreading over.

2. Create the pod:

```
$ oc create -f pod-spec.yaml
```

4.7.3. Example pod topology spread constraints

The following examples demonstrate pod topology spread constraint configurations.

4.7.3.1. Single pod topology spread constraint example

This example **Pod** spec defines one pod topology spread constraint. It matches on pods labeled **region: us-east**, distributes among zones, specifies a skew of **1**, and does not schedule the pod if it does not meet these requirements.

```
kind: Pod
apiVersion: v1
metadata:
  name: my-pod
  labels:
    region: us-east
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  topologySpreadConstraints:
  - maxSkew: 1
    topologyKey: topology.kubernetes.io/zone
    whenUnsatisfiable: DoNotSchedule
    labelSelector:
      matchLabels:
        region: us-east
  containers:
  - image: "docker.io/ocpqe/hello-pod"
    name: hello-pod
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
```

4.7.3.2. Multiple pod topology spread constraints example

This example **Pod** spec defines two pod topology spread constraints. Both match on pods labeled **region: us-east**, specify a skew of **1**, and do not schedule the pod if it does not meet these requirements.

The first constraint distributes pods based on a user-defined label **node**, and the second constraint distributes pods based on a user-defined label **rack**. Both constraints must be met for the pod to be scheduled.

```
kind: Pod
apiVersion: v1
metadata:
  name: my-pod-2
  labels:
    region: us-east
```

```
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  topologySpreadConstraints:
  - maxSkew: 1
    topologyKey: node
    whenUnsatisfiable: DoNotSchedule
    labelSelector:
      matchLabels:
        region: us-east
  - maxSkew: 1
    topologyKey: rack
    whenUnsatisfiable: DoNotSchedule
    labelSelector:
      matchLabels:
        region: us-east
  containers:
  - image: "docker.io/ocpqe/hello-pod"
    name: hello-pod
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
```

CHAPTER 5. USING JOBS AND DAEMONSETS

5.1. RUNNING BACKGROUND TASKS ON NODES AUTOMATICALLY WITH DAEMON SETS

As an administrator, you can create and use daemon sets to run replicas of a pod on specific or all nodes in an Red Hat OpenShift Service on AWS cluster.

A daemon set ensures that all (or some) nodes run a copy of a pod. As nodes are added to the cluster, pods are added to the cluster. As nodes are removed from the cluster, those pods are removed through garbage collection. Deleting a daemon set will clean up the pods it created.

You can use daemon sets to create shared storage, run a logging pod on every node in your cluster, or deploy a monitoring agent on every node.

For security reasons, the cluster administrators and the project administrators can create daemon sets.

For more information on daemon sets, see the Kubernetes documentation.

IMPORTANT

Daemon set scheduling is incompatible with project's default node selector. If you fail to disable it, the daemon set gets restricted by merging with the default node selector. This results in frequent pod recreates on the nodes that got unselected by the merged node selector, which in turn puts unwanted load on the cluster.

5.1.1. Scheduled by default scheduler

A daemon set ensures that all eligible nodes run a copy of a pod. Normally, the node that a pod runs on is selected by the Kubernetes scheduler. However, daemon set pods are created and scheduled by the daemon set controller. That introduces the following issues:

- Inconsistent pod behavior: Normal pods waiting to be scheduled are created and in Pending state, but daemon set pods are not created in **Pending** state. This is confusing to the user.
- Pod preemption is handled by default scheduler. When preemption is enabled, the daemon set controller will make scheduling decisions without considering pod priority and preemption.

The **ScheduleDaemonSetPods** feature, enabled by default in Red Hat OpenShift Service on AWS, lets you schedule daemon sets using the default scheduler instead of the daemon set controller, by adding the **NodeAffinity** term to the daemon set pods, instead of the **spec.nodeName** term. The default scheduler is then used to bind the pod to the target host. If node affinity of the daemon set pod already exists, it is replaced. The daemon set controller only performs these operations when creating or modifying daemon set pods, and no changes are made to the **spec.template** of the daemon set.

```
kind: Pod
apiVersion: v1
metadata:
  name: hello-node-6fbccf8d9-9tmzr
#...
spec:
  nodeAffinity:
    requiredDuringSchedulingIgnoredDuringExecution:
      nodeSelectorTerms:
        - matchFields:
          - key: metadata.name
            operator: In
            values:
            - target-host-name
#...
```

In addition, a **node.kubernetes.io/unschedulable:NoSchedule** toleration is added automatically to daemon set pods. The default scheduler ignores unschedulable Nodes when scheduling daemon set pods.

5.1.2. Creating daemonsets

When creating daemon sets, the **nodeSelector** field is used to indicate the nodes on which the daemon set should deploy replicas.

Prerequisites

- Before you start using daemon sets, disable the default project-wide node selector in your namespace, by setting the namespace annotation **openshift.io/node-selector** to an empty string:

  ```
  $ oc patch namespace myproject -p \
      '{"metadata": {"annotations": {"openshift.io/node-selector": ""}}}'
  ```

  #### TIP

  You can alternatively apply the following YAML to disable the default project-wide node selector for a namespace:

  ```
  apiVersion: v1
  kind: Namespace
  metadata:
    name: <namespace>
    annotations:
      openshift.io/node-selector: ''
  #...
  ```

Procedure

To create a daemon set:

1. Define the daemon set yaml file:

   ```
   apiVersion: apps/v1
   kind: DaemonSet
   metadata:
     name: hello-daemonset
   spec:
     selector:
         matchLabels:
           name: hello-daemonset 1
     template:
       metadata:
   ```

```
      labels:
        name: hello-daemonset (2)
    spec:
      nodeSelector: (3)
        role: worker
      containers:
      - image: openshift/hello-openshift
        imagePullPolicy: Always
        name: registry
        ports:
        - containerPort: 80
          protocol: TCP
        resources: {}
        terminationMessagePath: /dev/termination-log
      serviceAccount: default
      terminationGracePeriodSeconds: 10
#...
```

1. The label selector that determines which pods belong to the daemon set.
2. The pod template's label selector. Must match the label selector above.
3. The node selector that determines on which nodes pod replicas should be deployed. A matching label must be present on the node.

2. Create the daemon set object:

```
$ oc create -f daemonset.yaml
```

3. To verify that the pods were created, and that each node has a pod replica:

   a. Find the daemonset pods:

   ```
   $ oc get pods
   ```

   Example output

   ```
   hello-daemonset-cx6md   1/1       Running   0         2m
   hello-daemonset-e3md9   1/1       Running   0         2m
   ```

   b. View the pods to verify the pod has been placed onto the node:

   ```
   $ oc describe pod/hello-daemonset-cx6md|grep Node
   ```

   Example output

   ```
   Node:        openshift-node01.hostname.com/10.14.20.134
   ```

   ```
   $ oc describe pod/hello-daemonset-e3md9|grep Node
   ```

   Example output

```
Node:       openshift-node02.hostname.com/10.14.20.137
```

IMPORTANT

- If you update a daemon set pod template, the existing pod replicas are not affected.
- If you delete a daemon set and then create a new daemon set with a different template but the same label selector, it recognizes any existing pod replicas as having matching labels and thus does not update them or create new replicas despite a mismatch in the pod template.
- If you change node labels, the daemon set adds pods to nodes that match the new labels and deletes pods from nodes that do not match the new labels.

To update a daemon set, force new pod replicas to be created by deleting the old replicas or nodes.

5.2. RUNNING TASKS IN PODS USING JOBS

A *job* executes a task in your Red Hat OpenShift Service on AWS cluster.

A job tracks the overall progress of a task and updates its status with information about active, succeeded, and failed pods. Deleting a job will clean up any pod replicas it created. Jobs are part of the Kubernetes API, which can be managed with **oc** commands like other object types.

Sample Job specification

```
apiVersion: batch/v1
kind: Job
metadata:
  name: pi
spec:
  parallelism: 1    1
  completions: 1    2
  activeDeadlineSeconds: 1800 3
  backoffLimit: 6   4
  template:         5
    metadata:
      name: pi
    spec:
      containers:
      - name: pi
        image: perl
        command: ["perl",  "-Mbignum=bpi", "-wle", "print bpi(2000)"]
      restartPolicy: OnFailure    6
#...
```

1 The pod replicas a job should run in parallel.

2 Successful pod completions are needed to mark a job completed.

3 The maximum duration the job can run.

4 The number of retries for a job.

5 The template for the pod the controller creates.

6 The restart policy of the pod.

Additional resources

- Jobs in the Kubernetes documentation

5.2.1. Understanding jobs and cron jobs

A job tracks the overall progress of a task and updates its status with information about active, succeeded, and failed pods. Deleting a job cleans up any pods it created. Jobs are part of the Kubernetes API, which can be managed with **oc** commands like other object types.

There are two possible resource types that allow creating run-once objects in Red Hat OpenShift Service on AWS:

Job

A regular job is a run-once object that creates a task and ensures the job finishes.
There are three main types of task suitable to run as a job:

- Non-parallel jobs:
  - A job that starts only one pod, unless the pod fails.
  - The job is complete as soon as its pod terminates successfully.
- Parallel jobs with a fixed completion count:
  - a job that starts multiple pods.
  - The job represents the overall task and is complete when there is one successful pod for each value in the range **1** to the **completions** value.
- Parallel jobs with a work queue:
  - A job with multiple parallel worker processes in a given pod.
  - Red Hat OpenShift Service on AWS coordinates pods to determine what each should work on or use an external queue service.
  - Each pod is independently capable of determining whether or not all peer pods are complete and that the entire job is done.
  - When any pod from the job terminates with success, no new pods are created.
  - When at least one pod has terminated with success and all pods are terminated, the job is successfully completed.
  - When any pod has exited with success, no other pod should be doing any work for this task or writing any output. Pods should all be in the process of exiting.
    For more information about how to make use of the different types of job, see Job Patterns in the Kubernetes documentation.

Cron job

A job can be scheduled to run multiple times, using a cron job.
A *cron job* builds on a regular job by allowing you to specify how the job should be run. Cron jobs are part of the Kubernetes API, which can be managed with **oc** commands like other object types.

Cron jobs are useful for creating periodic and recurring tasks, like running backups or sending emails. Cron jobs can also schedule individual tasks for a specific time, such as if you want to schedule a job for a low activity period. A cron job creates a **Job** object based on the timezone configured on the control plane node that runs the cronjob controller.

> **WARNING**
>
> A cron job creates a **Job** object approximately once per execution time of its schedule, but there are circumstances in which it fails to create a job or two jobs might be created. Therefore, jobs must be idempotent and you must configure history limits.

5.2.1.1. Understanding how to create jobs

Both resource types require a job configuration that consists of the following key parts:

- A pod template, which describes the pod that Red Hat OpenShift Service on AWS creates.
- The **parallelism** parameter, which specifies how many pods running in parallel at any point in time should execute a job.
  - For non-parallel jobs, leave unset. When unset, defaults to **1**.
- The **completions** parameter, specifying how many successful pod completions are needed to finish a job.
  - For non-parallel jobs, leave unset. When unset, defaults to **1**.
  - For parallel jobs with a fixed completion count, specify a value.
  - For parallel jobs with a work queue, leave unset. When unset defaults to the **parallelism** value.

5.2.1.2. Understanding how to set a maximum duration for jobs

When defining a job, you can define its maximum duration by setting the **activeDeadlineSeconds** field. It is specified in seconds and is not set by default. When not set, there is no maximum duration enforced.

The maximum duration is counted from the time when a first pod gets scheduled in the system, and defines how long a job can be active. It tracks overall time of an execution. After reaching the specified timeout, the job is terminated by Red Hat OpenShift Service on AWS.

5.2.1.3. Understanding how to set a job back off policy for pod failure

A job can be considered failed, after a set amount of retries due to a logical error in configuration or other similar reasons. Failed pods associated with the job are recreated by the controller with an exponential back off delay (**10s**, **20s**, **40s** …) capped at six minutes. The limit is reset if no new failed pods appear between controller checks.

Use the **spec.backoffLimit** parameter to set the number of retries for a job.

5.2.1.4. Understanding how to configure a cron job to remove artifacts

Cron jobs can leave behind artifact resources such as jobs or pods. As a user it is important to configure history limits so that old jobs and their pods are properly cleaned. There are two fields within cron job's spec responsible for that:

- **.spec.successfulJobsHistoryLimit**. The number of successful finished jobs to retain (defaults to 3).
- **.spec.failedJobsHistoryLimit**. The number of failed finished jobs to retain (defaults to 1).

5.2.1.5. Known limitations

The job specification restart policy only applies to the *pods*, and not the *job controller*. However, the job controller is hard-coded to keep retrying jobs to completion.

As such, **restartPolicy: Never** or **--restart=Never** results in the same behavior as **restartPolicy: OnFailure** or **--restart=OnFailure**. That is, when a job fails it is restarted automatically until it succeeds (or is manually discarded). The policy only sets which subsystem performs the restart.

With the **Never** policy, the *job controller* performs the restart. With each attempt, the job controller increments the number of failures in the job status and create new pods. This means that with each failed attempt, the number of pods increases.

With the **OnFailure** policy, *kubelet* performs the restart. Each attempt does not increment the number of failures in the job status. In addition, kubelet will retry failed jobs starting pods on the same nodes.

5.2.2. Creating jobs

You create a job in Red Hat OpenShift Service on AWS by creating a job object.

Procedure

To create a job:

1. Create a YAML file similar to the following:

```
apiVersion: batch/v1
kind: Job
metadata:
  name: pi
spec:
  parallelism: 1    ①
  completions: 1    ②
  activeDeadlineSeconds: 1800 ③
  backoffLimit: 6   ④
  template:         ⑤
    metadata:
      name: pi
    spec:
      containers:
      - name: pi
        image: perl
        command: ["perl",  "-Mbignum=bpi", "-wle", "print bpi(2000)"]
      restartPolicy: OnFailure  6
#...
```

1. Optional: Specify how many pod replicas a job should run in parallel; defaults to **1**.
   - For non-parallel jobs, leave unset. When unset, defaults to **1**.
2. Optional: Specify how many successful pod completions are needed to mark a job completed.
   - For non-parallel jobs, leave unset. When unset, defaults to **1**.
   - For parallel jobs with a fixed completion count, specify the number of completions.
   - For parallel jobs with a work queue, leave unset. When unset defaults to the **parallelism** value.
3. Optional: Specify the maximum duration the job can run.
4. Optional: Specify the number of retries for a job. This field defaults to six.
5. Specify the template for the pod the controller creates.
6. Specify the restart policy of the pod:
   - **Never**. Do not restart the job.
   - **OnFailure**. Restart the job only if it fails.
   - **Always**. Always restart the job.
     For details on how Red Hat OpenShift Service on AWS uses restart policy with failed containers, see the Example States in the Kubernetes documentation.

2. Create the job:

```
$ oc create -f <file-name>.yaml
```

NOTE

You can also create and launch a job from a single command using **oc create job**. The following command creates and launches a job similar to the one specified in the previous example:

```
$ oc create job pi --image=perl -- perl -Mbignum=bpi -wle 'print bpi(2000)'
```

5.2.3. Creating cron jobs

You create a cron job in Red Hat OpenShift Service on AWS by creating a job object.

Procedure

To create a cron job:

1. Create a YAML file similar to the following:

```
apiVersion: batch/v1
kind: CronJob
metadata:
  name: pi
spec:
  schedule: "*/1 * * * *"  1
  concurrencyPolicy: "Replace"  2
  startingDeadlineSeconds: 200  3
  suspend: true  4
  successfulJobsHistoryLimit: 3  5
  failedJobsHistoryLimit: 1  6
  jobTemplate:  7
    spec:
      template:
        metadata:
          labels:  8
            parent: "cronjobpi"
        spec:
          containers:
          - name: pi
            image: perl
            command: ["perl",  "-Mbignum=bpi", "-wle", "print bpi(2000)"]
          restartPolicy: OnFailure 9
```

1 Schedule for the job specified in cron format. In this example, the job will run every minute.

2 An optional concurrency policy, specifying how to treat concurrent jobs within a cron job. Only one of the following concurrent policies may be specified. If not specified, this defaults to allowing concurrent executions.

- **Allow** allows cron jobs to run concurrently.
- **Forbid** forbids concurrent runs, skipping the next run if the previous has not finished yet.
- **Replace** cancels the currently running job and replaces it with a new one.

3 An optional deadline (in seconds) for starting the job if it misses its scheduled time for any reason. Missed jobs executions will be counted as failed ones. If not specified, there is no deadline.

4 An optional flag allowing the suspension of a cron job. If set to **true**, all subsequent executions will be suspended.

5 The number of successful finished jobs to retain (defaults to 3).

6 The number of failed finished jobs to retain (defaults to 1).

7 Job template. This is similar to the job example.

8 Sets a label for jobs spawned by this cron job.

9 The restart policy of the pod. This does not apply to the job controller.

NOTE

The **.spec.successfulJobsHistoryLimit** and **.spec.failedJobsHistoryLimit** fields are optional. These fields specify how many completed and failed jobs should be kept. By default, they are set to **3** and **1** respectively. Setting a limit to **0** corresponds to keeping none of the corresponding kind of jobs after they finish.

2. Create the cron job:

```
$ oc create -f <file-name>.yaml
```

NOTE

You can also create and launch a cron job from a single command using **oc create cronjob**. The following command creates and launches a cron job similar to the one specified in the previous example:

```
$ oc create cronjob pi --image=perl --schedule='*/1 * * * *' -- perl -Mbignum=bpi -wle
'print bpi(2000)'
```

With **oc create cronjob**, the **--schedule** option accepts schedules in cron format.

CHAPTER 6. WORKING WITH NODES

6.1. VIEWING AND LISTING THE NODES IN YOUR RED HAT OPENSHIFT SERVICE ON AWS CLUSTER

You can list all the nodes in your cluster to obtain information such as status, age, memory usage, and details about the nodes.

When you perform node management operations, the CLI interacts with node objects that are representations of actual node hosts. The master uses the information from node objects to validate nodes with health checks.

6.1.1. About listing all the nodes in a cluster

You can get detailed information on the nodes in the cluster.

- The following command lists all nodes:

```
$ oc get nodes
```

  The following example is a cluster with healthy nodes:

```
$ oc get nodes
```

  Example output

```
NAME                 STATUS    ROLES     AGE       VERSION
master.example.com     Ready     master    7h        v1.28.5
node1.example.com      Ready     worker    7h        v1.28.5
node2.example.com      Ready     worker    7h        v1.28.5
```

  The following example is a cluster with one unhealthy node:

```
$ oc get nodes
```

  Example output

```
NAME                 STATUS                      ROLES     AGE       VERSION
master.example.com     Ready                       master    7h        v1.28.5
node1.example.com      NotReady,SchedulingDisabled worker    7h        v1.28.5
node2.example.com      Ready                       worker    7h        v1.28.5
```

  The conditions that trigger a **NotReady** status are shown later in this section.

- The **-o wide** option provides additional information on nodes.

```
$ oc get nodes -o wide
```

  Example output

```
NAME                STATUS   ROLES    AGE    VERSION   INTERNAL-IP    EXTERNAL-IP
```

```
OS-IMAGE                                    KERNEL-VERSION          CONTAINER-
RUNTIME
master.example.com  Ready   master  171m  v1.28.5  10.0.129.108  <none>      Red Hat
Enterprise Linux CoreOS 48.83.202103210901-0 (Ootpa)  4.18.0-240.15.1.el8_3.x86_64
cri-o://1.28.5-30.rhaos4.10.gitf2f339d.el8-dev
node1.example.com   Ready   worker  72m   v1.28.5  10.0.129.222  <none>      Red Hat
Enterprise Linux CoreOS 48.83.202103210901-0 (Ootpa)  4.18.0-240.15.1.el8_3.x86_64
cri-o://1.28.5-30.rhaos4.10.gitf2f339d.el8-dev
node2.example.com   Ready   worker  164m  v1.28.5  10.0.142.150  <none>      Red Hat
Enterprise Linux CoreOS 48.83.202103210901-0 (Ootpa)  4.18.0-240.15.1.el8_3.x86_64
cri-o://1.28.5-30.rhaos4.10.gitf2f339d.el8-dev
```

- The following command lists information about a single node:

  ```
  $ oc get node <node>
  ```

  For example:

  ```
  $ oc get node node1.example.com
  ```

  Example output

  ```
  NAME                STATUS    ROLES     AGE      VERSION
  node1.example.com      Ready     worker    7h       v1.28.5
  ```

- The following command provides more detailed information about a specific node, including the reason for the current condition:

  ```
  $ oc describe node <node>
  ```

  For example:

  ```
  $ oc describe node node1.example.com
  ```

  Example output

  ```
  Name:               node1.example.com (1)
  Roles:              worker (2)
  Labels:             kubernetes.io/os=linux
                      kubernetes.io/hostname=ip-10-0-131-14
                      kubernetes.io/arch=amd64 (3)
                      node-role.kubernetes.io/worker=
                      node.kubernetes.io/instance-type=m4.large
                      node.openshift.io/os_id=rhcos
                      node.openshift.io/os_version=4.5
                      region=east
                      topology.kubernetes.io/region=us-east-1
                      topology.kubernetes.io/zone=us-east-1a
  Annotations:        cluster.k8s.io/machine: openshift-machine-api/ahardin-worker-us-east-2a-
  q5dzc (4)
                      machineconfiguration.openshift.io/currentConfig: worker-
  309c228e8b3a92e2235edd544c62fea8
                      machineconfiguration.openshift.io/desiredConfig: worker-
  ```

```
309c228e8b3a92e2235edd544c62fea8
                    machineconfiguration.openshift.io/state: Done
                    volumes.kubernetes.io/controller-managed-attach-detach: true
CreationTimestamp:  Wed, 13 Feb 2019 11:05:57 -0500
Taints:             <none> 5
Unschedulable:      false
Conditions:                6
  Type             Status  LastHeartbeatTime                 LastTransitionTime                Reason
Message
  ----             ------  -----------------                 ------------------                ------                       -------
  OutOfDisk        False   Wed, 13 Feb 2019 15:09:42 -0500   Wed, 13 Feb 2019 11:05:57 -
0500   KubeletHasSufficientDisk     kubelet has sufficient disk space available
  MemoryPressure   False   Wed, 13 Feb 2019 15:09:42 -0500   Wed, 13 Feb 2019 11:05:57
-0500   KubeletHasSufficientMemory   kubelet has sufficient memory available
  DiskPressure     False   Wed, 13 Feb 2019 15:09:42 -0500   Wed, 13 Feb 2019 11:05:57 -
0500   KubeletHasNoDiskPressure     kubelet has no disk pressure
  PIDPressure      False   Wed, 13 Feb 2019 15:09:42 -0500   Wed, 13 Feb 2019 11:05:57 -
0500   KubeletHasSufficientPID      kubelet has sufficient PID available
  Ready            True    Wed, 13 Feb 2019 15:09:42 -0500   Wed, 13 Feb 2019 11:07:09 -0500
KubeletReady                 kubelet is posting ready status
Addresses:     7
  InternalIP:   10.0.140.16
  InternalDNS:  ip-10-0-140-16.us-east-2.compute.internal
  Hostname:     ip-10-0-140-16.us-east-2.compute.internal
Capacity:    8
 attachable-volumes-aws-ebs:  39
 cpu:                         2
 hugepages-1Gi:               0
 hugepages-2Mi:               0
 memory:                      8172516Ki
 pods:                        250
Allocatable:
 attachable-volumes-aws-ebs:  39
 cpu:                         1500m
 hugepages-1Gi:               0
 hugepages-2Mi:               0
 memory:                      7558116Ki
 pods:                        250
System Info:     9
 Machine ID:                              63787c9534c24fde9a0cde35c13f1f66
 System UUID:                             EC22BF97-A006-4A58-6AF8-0A38DEEA122A
 Boot ID:                                 f24ad37d-2594-46b4-8830-7f7555918325
 Kernel Version:                          3.10.0-957.5.1.el7.x86_64
 OS Image:                                Red Hat Enterprise Linux CoreOS 410.8.20190520.0 (Ootpa)
 Operating System:                        linux
 Architecture:                            amd64
 Container Runtime Version:               cri-o://1.28.5-0.6.dev.rhaos4.3.git9ad059b.el8-rc2
 Kubelet Version:                         v1.28.5
 Kube-Proxy Version:                      v1.28.5
PodCIDR:                                  10.128.4.0/24
ProviderID:                               aws:///us-east-2a/i-04e87b31dc6b3e171
Non-terminated Pods:                      (12 in total) 10
  Namespace                               Name                              CPU Requests  CPU Limits
Memory Requests  Memory Limits
  ---------                               ----                              ------------  ----------  ---------------  -------
```

```
------
  openshift-cluster-node-tuning-operator  tuned-hdl5q                           0 (0%)        0 (0%)       0
(0%)           0 (0%)
  openshift-dns                              dns-default-l69zr                    0 (0%)        0 (0%)       0 (0%)
0 (0%)
  openshift-image-registry               node-ca-9hmcg                          0 (0%)        0 (0%)       0
(0%)           0 (0%)
  openshift-ingress                          router-default-76455c45c-c5ptv        0 (0%)        0 (0%)       0
(0%)           0 (0%)
  openshift-machine-config-operator      machine-config-daemon-cvqw9           20m (1%)       0
(0%)       50Mi (0%)        0 (0%)
  openshift-marketplace                   community-operators-f67fh             0 (0%)        0 (0%)
0 (0%)           0 (0%)
  openshift-monitoring                    alertmanager-main-0                   50m (3%)      50m (3%)
210Mi (2%)       10Mi (0%)
  openshift-monitoring                    node-exporter-l7q8d                   10m (0%)      20m (1%)
20Mi (0%)        40Mi (0%)
  openshift-monitoring                    prometheus-adapter-75d769c874-hvb85   0 (0%)        0
(0%)       0 (0%)           0 (0%)
  openshift-multus                         multus-kw8w5                          0 (0%)        0 (0%)       0 (0%)
0 (0%)
  openshift-sdn                            ovs-t4dsn                             100m (6%)     0 (0%)      300Mi
(4%)       0 (0%)
  openshift-sdn                            sdn-g79hg                             100m (6%)     0 (0%)      200Mi
(2%)       0 (0%)
Allocated resources:
  (Total limits may be over 100 percent, i.e., overcommitted.)
  Resource                    Requests     Limits
  --------                    --------     ------
  cpu                         380m (25%)   270m (18%)
  memory                      880Mi (11%)  250Mi (3%)
  attachable-volumes-aws-ebs  0            0
Events:   (11)
  Type     Reason                   Age              From                        Message
  ----     ------                   ----             ----                        -------
  Normal   NodeHasSufficientPID     6d (x5 over 6d)   kubelet, m01.example.com  Node
m01.example.com status is now: NodeHasSufficientPID
  Normal   NodeAllocatableEnforced  6d                kubelet, m01.example.com  Updated Node
Allocatable limit across pods
  Normal   NodeHasSufficientMemory  6d (x6 over 6d)   kubelet, m01.example.com  Node
m01.example.com status is now: NodeHasSufficientMemory
  Normal   NodeHasNoDiskPressure    6d (x6 over 6d)   kubelet, m01.example.com  Node
m01.example.com status is now: NodeHasNoDiskPressure
  Normal   NodeHasSufficientDisk    6d (x6 over 6d)   kubelet, m01.example.com  Node
m01.example.com status is now: NodeHasSufficientDisk
  Normal   NodeHasSufficientPID     6d                kubelet, m01.example.com  Node
m01.example.com status is now: NodeHasSufficientPID
  Normal   Starting                 6d                kubelet, m01.example.com  Starting kubelet.
#...
```

1 The name of the node.

2 The role of the node, either **master** or **worker**.

3 The labels applied to the node.

4 The annotations applied to the node.

5 The taints applied to the node.

6 The node conditions and status. The **conditions** stanza lists the **Ready**, **PIDPressure**, **PIDPressure**, **MemoryPressure**, **DiskPressure** and **OutOfDisk** status. These condition are described later in this section.

7 The IP address and hostname of the node.

8 The pod resources and allocatable resources.

9 Information about the node host.

10 The pods on the node.

11 The events reported by the node.

Among the information shown for nodes, the following node conditions appear in the output of the commands shown in this section:

Table 6.1. Node Conditions

Condition	Description
Ready	If **true**, the node is healthy and ready to accept pods. If**false**, the node is not healthy and is not accepting pods. If **unknown**, the node controller has not received a heartbeat from the node for the **node-monitor-grace-period** (the default is 40 seconds).
DiskPressure	If **true**, the disk capacity is low.
MemoryPressure	If **true**, the node memory is low.
PIDPressure	If **true**, there are too many processes on the node.
OutOfDisk	If **true**, the node has insufficient free space on the node for adding new pods.
NetworkUnavailable	If **true**, the network for the node is not correctly configured.
NotReady	If **true**, one of the underlying components, such as the container runtime or network, is experiencing issues or is not yet configured.
SchedulingDisabled	Pods cannot be scheduled for placement on the node.

6.1.2. Listing pods on a node in your cluster

You can list all the pods on a specific node.

Procedure

- To list all or selected pods on one or more nodes:

  ```
  $ oc describe node <node1> <node2>
  ```

  For example:

  ```
  $ oc describe node ip-10-0-128-218.ec2.internal
  ```

- To list all or selected pods on selected nodes:

  ```
  $ oc describe node --selector=<node_selector>
  ```

  ```
  $ oc describe node --selector=kubernetes.io/os
  ```

  Or:

  ```
  $ oc describe node -l=<pod_selector>
  ```

  ```
  $ oc describe node -l node-role.kubernetes.io/worker
  ```

- To list all pods on a specific node, including terminated pods:

  ```
  $ oc get pod --all-namespaces --field-selector=spec.nodeName=<nodename>
  ```

6.1.3. Viewing memory and CPU usage statistics on your nodes

You can display usage statistics about nodes, which provide the runtime environments for containers. These usage statistics include CPU, memory, and storage consumption.

Prerequisites

- You must have **cluster-reader** permission to view the usage statistics.
- Metrics must be installed to view the usage statistics.

Procedure

- To view the usage statistics:

  ```
  $ oc adm top nodes
  ```

  #### Example output

  ```
  NAME                                 CPU(cores)   CPU%      MEMORY(bytes)   MEMORY%
  ip-10-0-12-143.ec2.compute.internal    1503m        100%      4533Mi          61%
  ip-10-0-132-16.ec2.compute.internal    76m          5%        1391Mi          18%
  ip-10-0-140-137.ec2.compute.internal   398m         26%       2473Mi          33%
  ip-10-0-142-44.ec2.compute.internal    656m         43%       6119Mi          82%
  ip-10-0-146-165.ec2.compute.internal   188m         12%       3367Mi          45%
  ip-10-0-19-62.ec2.compute.internal     896m         59%       5754Mi          77%
  ip-10-0-44-193.ec2.compute.internal    632m         42%       5349Mi          72%
  ```

- To view the usage statistics for nodes with labels:

  ```
  $ oc adm top node --selector=''
  ```

  You must choose the selector (label query) to filter on. Supports **=**, **==**, and **!=**.

6.2. WORKING WITH NODES

As an administrator, you can perform several tasks to make your clusters more efficient. You can use the **oc adm** command to cordon, uncordon, and drain a specific node. This is available for both ROSA Classic and ROSA with HCP clusters.

NOTE

Cordoning and draining are only allowed on worker nodes that are part of Red Hat OpenShift Cluster Manager machine pools.

6.2.1. Understanding how to evacuate pods on nodes

Evacuating pods allows you to migrate all or selected pods from a given node or nodes.

You can only evacuate pods backed by a replication controller. The replication controller creates new pods on other nodes and removes the existing pods from the specified node(s).

Bare pods, meaning those not backed by a replication controller, are unaffected by default. You can evacuate a subset of pods by specifying a pod-selector. Pod selectors are based on labels, so all the pods with the specified label will be evacuated.

Procedure

1. Mark the nodes unschedulable before performing the pod evacuation.

   a. Mark the node as unschedulable:

   ```
   $ oc adm cordon <node1>
   ```

   Example output

   ```
   node/<node1> cordoned
   ```

   b. Check that the node status is **Ready,SchedulingDisabled**:

   ```
   $ oc get node <node1>
   ```

   Example output

   ```
   NAME        STATUS                     ROLES     AGE     VERSION
   <node1>     Ready,SchedulingDisabled   worker    1d      v1.28.5
   ```

2. Evacuate the pods using one of the following methods:

   - Evacuate all or selected pods on one or more nodes:

```
$ oc adm drain <node1> <node2> [--pod-selector=<pod_selector>]
```

- Force the deletion of bare pods using the **--force** option. When set to **true**, deletion continues even if there are pods not managed by a replication controller, replica set, job, daemon set, or stateful set:

```
$ oc adm drain <node1> <node2> --force=true
```

- Set a period of time in seconds for each pod to terminate gracefully, use **--grace-period**. If negative, the default value specified in the pod will be used:

```
$ oc adm drain <node1> <node2> --grace-period=-1
```

- Ignore pods managed by daemon sets using the **--ignore-daemonsets** flag set to **true**:

```
$ oc adm drain <node1> <node2> --ignore-daemonsets=true
```

- Set the length of time to wait before giving up using the **--timeout** flag. A value of **0** sets an infinite length of time:

```
$ oc adm drain <node1> <node2> --timeout=5s
```

- Delete pods even if there are pods using **emptyDir** volumes by setting the **--delete-emptydir-data** flag to **true**. Local data is deleted when the node is drained:

```
$ oc adm drain <node1> <node2> --delete-emptydir-data=true
```

- List objects that will be migrated without actually performing the evacuation, using the **--dry-run** option set to **true**:

```
$ oc adm drain <node1> <node2>  --dry-run=true
```

  Instead of specifying specific node names (for example, **<node1> <node2>**), you can use the **--selector=<node_selector>** option to evacuate pods on selected nodes.

3. Mark the node as schedulable when done.

```
$ oc adm uncordon <node1>
```

6.3. USING THE NODE TUNING OPERATOR

Learn about the Node Tuning Operator and how you can use it to manage node-level tuning by orchestrating the tuned daemon.

Purpose

The Node Tuning Operator helps you manage node-level tuning by orchestrating the TuneD daemon and achieves low latency performance by using the Performance Profile controller. The majority of high-performance applications require some level of kernel tuning. The Node Tuning Operator provides a unified management interface to users of node-level sysctls and more flexibility to add custom tuning specified by user needs.

The Operator manages the containerized TuneD daemon for Red Hat OpenShift Service on AWS as a

Kubernetes daemon set. It ensures the custom tuning specification is passed to all containerized TuneD daemons running in the cluster in the format that the daemons understand. The daemons run on all nodes in the cluster, one per node.

Node-level settings applied by the containerized TuneD daemon are rolled back on an event that triggers a profile change or when the containerized TuneD daemon is terminated gracefully by receiving and handling a termination signal.

The Node Tuning Operator uses the Performance Profile controller to implement automatic tuning to achieve low latency performance for Red Hat OpenShift Service on AWS applications.

The cluster administrator configures a performance profile to define node-level settings such as the following:

- Updating the kernel to kernel-rt.
- Choosing CPUs for housekeeping.
- Choosing CPUs for running workloads.

NOTE

Currently, disabling CPU load balancing is not supported by cgroup v2. As a result, you might not get the desired behavior from performance profiles if you have cgroup v2 enabled. Enabling cgroup v2 is not recommended if you are using performance profiles.

The Node Tuning Operator is part of a standard Red Hat OpenShift Service on AWS installation in version 4.1 and later.

NOTE

In earlier versions of Red Hat OpenShift Service on AWS, the Performance Addon Operator was used to implement automatic tuning to achieve low latency performance for OpenShift applications. In Red Hat OpenShift Service on AWS 4.11 and later, this functionality is part of the Node Tuning Operator.

6.3.1. Accessing an example Node Tuning Operator specification

Use this process to access an example Node Tuning Operator specification.

Procedure

- Run the following command to access an example Node Tuning Operator specification:

```
oc get tuned.tuned.openshift.io/default -o yaml -n openshift-cluster-node-tuning-operator
```

The default CR is meant for delivering standard node-level tuning for the Red Hat OpenShift Service on AWS platform and it can only be modified to set the Operator Management state. Any other custom changes to the default CR will be overwritten by the Operator. For custom tuning, create your own Tuned CRs. Newly created CRs will be combined with the default CR and custom tuning applied to Red Hat OpenShift Service on AWS nodes based on node or pod labels and profile priorities.

WARNING

While in certain situations the support for pod labels can be a convenient way of automatically delivering required tuning, this practice is discouraged and strongly advised against, especially in large-scale clusters. The default Tuned CR ships without pod label matching. If a custom profile is created with pod label matching, then the functionality will be enabled at that time. The pod label functionality will be deprecated in future versions of the Node Tuning Operator.

6.3.2. Custom tuning specification

The custom resource (CR) for the Operator has two major sections. The first section, **profile:**, is a list of TuneD profiles and their names. The second, **recommend:**, defines the profile selection logic.

Multiple custom tuning specifications can co-exist as multiple CRs in the Operator's namespace. The existence of new CRs or the deletion of old CRs is detected by the Operator. All existing custom tuning specifications are merged and appropriate objects for the containerized TuneD daemons are updated.

Management state

The Operator Management state is set by adjusting the default Tuned CR. By default, the Operator is in the Managed state and the **spec.managementState** field is not present in the default Tuned CR. Valid values for the Operator Management state are as follows:

- Managed: the Operator will update its operands as configuration resources are updated
- Unmanaged: the Operator will ignore changes to the configuration resources
- Removed: the Operator will remove its operands and resources the Operator provisioned

Profile data

The **profile:** section lists TuneD profiles and their names.

```
profile:
- name: tuned_profile_1
  data: |
    # TuneD profile specification
    [main]
    summary=Description of tuned_profile_1 profile

    [sysctl]
    net.ipv4.ip_forward=1
    # ... other sysctl's or other TuneD daemon plugins supported by the containerized TuneD

# ...

- name: tuned_profile_n
  data: |
    # TuneD profile specification
    [main]
    summary=Description of tuned_profile_n profile

    # tuned_profile_n profile settings
```

Recommended profiles

The **profile:** selection logic is defined by the **recommend:** section of the CR. The **recommend:** section is a list of items to recommend the profiles based on a selection criteria.

```
recommend:
<recommend-item-1>
# ...
<recommend-item-n>
```

The individual items of the list:

```
- machineConfigLabels: 1
    <mcLabels> 2
  match: 3
    <match> 4
  priority: <priority> 5
  profile: <tuned_profile_name> 6
  operand: 7
    debug: <bool> 8
    tunedConfig:
      reapply_sysctl: <bool> 9
```

1. Optional.
2. A dictionary of key/value **MachineConfig** labels. The keys must be unique.
3. If omitted, profile match is assumed unless a profile with a higher priority matches first or **machineConfigLabels** is set.
4. An optional list.
5. Profile ordering priority. Lower numbers mean higher priority (**0** is the highest priority).
6. A TuneD profile to apply on a match. For example **tuned_profile_1**.
7. Optional operand configuration.
8. Turn debugging on or off for the TuneD daemon. Options are **true** for on or **false** for off. The default is **false**.
9. Turn **reapply_sysctl** functionality on or off for the TuneD daemon. Options are **true** for on and **false** for off.

<match> is an optional list recursively defined as follows:

```
- label: <label_name> 1
  value: <label_value> 2
  type: <label_type> 3
```

```
    <match> (4)
```

1. Node or pod label name.
2. Optional node or pod label value. If omitted, the presence of **<label_name>** is enough to match.
3. Optional object type (**node** or **pod**). If omitted, **node** is assumed.
4. An optional **<match>** list.

If **<match>** is not omitted, all nested **<match>** sections must also evaluate to **true**. Otherwise, **false** is assumed and the profile with the respective **<match>** section will not be applied or recommended. Therefore, the nesting (child **<match>** sections) works as logical AND operator. Conversely, if any item of the **<match>** list matches, the entire **<match>** list evaluates to **true**. Therefore, the list acts as logical OR operator.

If **machineConfigLabels** is defined, machine config pool based matching is turned on for the given **recommend:** list item. **<mcLabels>** specifies the labels for a machine config. The machine config is created automatically to apply host settings, such as kernel boot parameters, for the profile **<tuned_profile_name>**. This involves finding all machine config pools with machine config selector matching **<mcLabels>** and setting the profile **<tuned_profile_name>** on all nodes that are assigned the found machine config pools. To target nodes that have both master and worker roles, you must use the master role.

The list items **match** and **machineConfigLabels** are connected by the logical OR operator. The **match** item is evaluated first in a short-circuit manner. Therefore, if it evaluates to **true**, the **machineConfigLabels** item is not considered.

IMPORTANT

When using machine config pool based matching, it is advised to group nodes with the same hardware configuration into the same machine config pool. Not following this practice might result in TuneD operands calculating conflicting kernel parameters for two or more nodes sharing the same machine config pool.

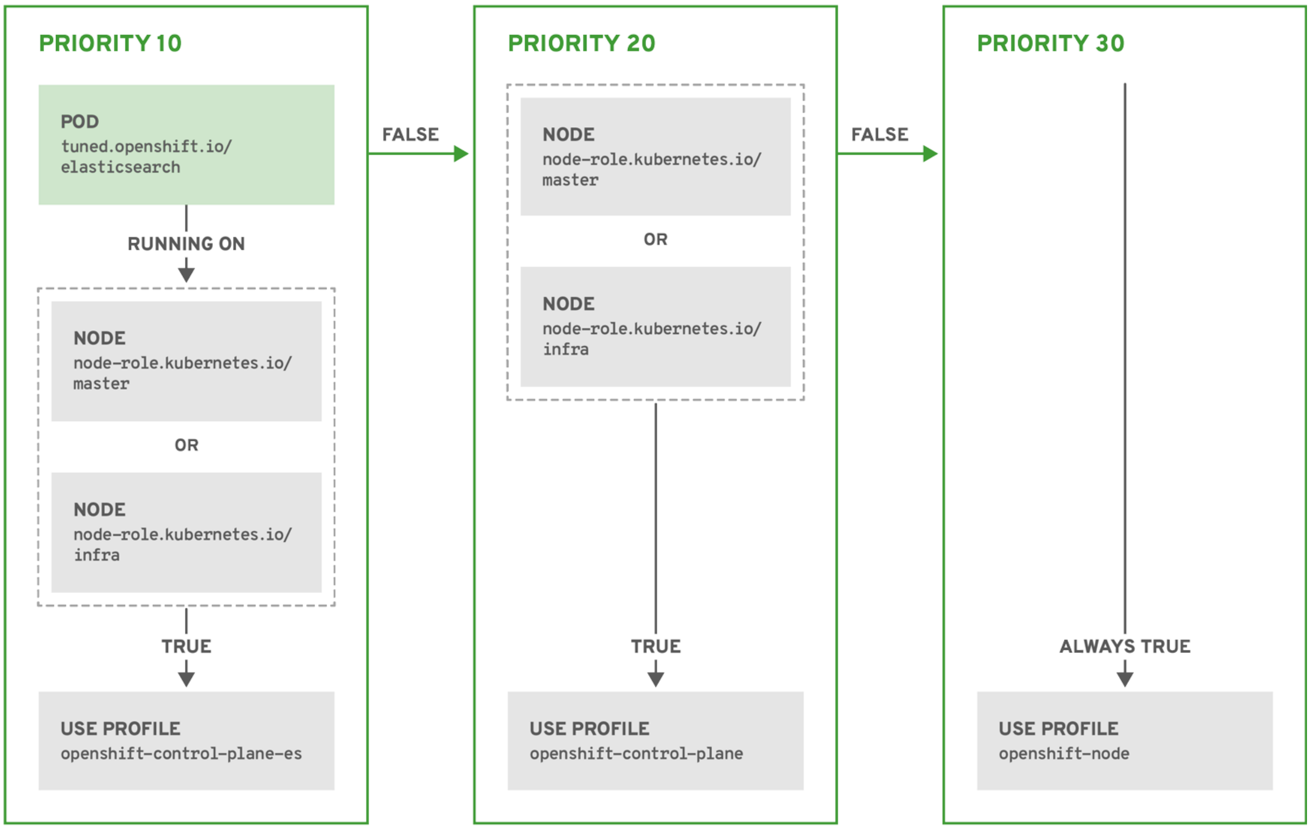
Example: Node or pod label based matching

```
- match:
  - label: tuned.openshift.io/elasticsearch
    match:
    - label: node-role.kubernetes.io/master
    - label: node-role.kubernetes.io/infra
    type: pod
  priority: 10
  profile: openshift-control-plane-es
- match:
  - label: node-role.kubernetes.io/master
  - label: node-role.kubernetes.io/infra
  priority: 20
  profile: openshift-control-plane
- priority: 30
  profile: openshift-node
```

The CR above is translated for the containerized TuneD daemon into its **recommend.conf** file based on the profile priorities. The profile with the highest priority (**10**) is **openshift-control-plane-es** and, therefore, it is considered first. The containerized TuneD daemon running on a given node looks to see if there is a pod running on the same node with the **tuned.openshift.io/elasticsearch** label set. If not, the entire **<match>** section evaluates as **false**. If there is such a pod with the label, in order for the **<match>** section to evaluate to **true**, the node label also needs to be **node-role.kubernetes.io/master** or **node-role.kubernetes.io/infra**.

If the labels for the profile with priority **10** matched, **openshift-control-plane-es** profile is applied and no other profile is considered. If the node/pod label combination did not match, the second highest priority profile (**openshift-control-plane**) is considered. This profile is applied if the containerized TuneD pod runs on a node with labels **node-role.kubernetes.io/master** or **node-role.kubernetes.io/infra**.

Finally, the profile **openshift-node** has the lowest priority of **30**. It lacks the **<match>** section and, therefore, will always match. It acts as a profile catch-all to set **openshift-node** profile, if no other profile with higher priority matches on a given node.


PRIORITY 10
POD
tuned.openshift.io/elasticsearch
RUNNING ON
NODE
node-role.kubernetes.io/master
OR
NODE
node-role.kubernetes.io/infra
TRUE
USE PROFILE
openshift-control-plane-es
FALSE
PRIORITY 20
NODE
node-role.kubernetes.io/master
OR
NODE
node-role.kubernetes.io/infra
TRUE
USE PROFILE
openshift-control-plane
FALSE
PRIORITY 30
ALWAYS TRUE
USE PROFILE
openshift-node

OPENSHIFT_10_0319

Example: Machine config pool based matching

```
apiVersion: tuned.openshift.io/v1
kind: Tuned
metadata:
  name: openshift-node-custom
  namespace: openshift-cluster-node-tuning-operator
spec:
  profile:
  - data: |
      [main]
      summary=Custom OpenShift node profile with an additional kernel parameter
      include=openshift-node
      [bootloader]
      cmdline_openshift_node_custom=+skew_tick=1
    name: openshift-node-custom

  recommend:
  - machineConfigLabels:
      machineconfiguration.openshift.io/role: "worker-custom"
    priority: 20
    profile: openshift-node-custom
```

To minimize node reboots, label the target nodes with a label the machine config pool's node selector will match, then create the Tuned CR above and finally create the custom machine config pool itself.

Cloud provider-specific TuneD profiles

With this functionality, all Cloud provider-specific nodes can conveniently be assigned a TuneD profile specifically tailored to a given Cloud provider on a Red Hat OpenShift Service on AWS cluster. This can be accomplished without adding additional node labels or grouping nodes into machine config pools.

This functionality takes advantage of **spec.providerID** node object values in the form of **<cloud-provider>://<cloud-provider-specific-id>** and writes the file **/var/lib/tuned/provider** with the value **<cloud-provider>** in NTO operand containers. The content of this file is then used by TuneD to load **provider-<cloud-provider>** profile if such profile exists.

The **openshift** profile that both **openshift-control-plane** and **openshift-node** profiles inherit settings from is now updated to use this functionality through the use of conditional profile loading. Neither NTO nor TuneD currently include any Cloud provider-specific profiles. However, it is possible to create a custom profile **provider-<cloud-provider>** that will be applied to all Cloud provider-specific cluster nodes.

Example GCE Cloud provider profile

```
apiVersion: tuned.openshift.io/v1
kind: Tuned
metadata:
  name: provider-gce
  namespace: openshift-cluster-node-tuning-operator
spec:
  profile:
  - data: |
      [main]
      summary=GCE Cloud provider-specific profile
      # Your tuning for GCE Cloud provider goes here.
    name: provider-gce
```

NOTE

Due to profile inheritance, any setting specified in the **provider-<cloud-provider>** profile will be overwritten by the **openshift** profile and its child profiles.

6.3.3. Default profiles set on a cluster

The following are the default profiles set on a cluster.

```
apiVersion: tuned.openshift.io/v1
kind: Tuned
metadata:
  name: default
  namespace: openshift-cluster-node-tuning-operator
spec:
  profile:
  - data: |
      [main]
      summary=Optimize systems running OpenShift (provider specific parent profile)
      include=-provider-${f:exec:cat:/var/lib/tuned/provider},openshift
    name: openshift
  recommend:
  - profile: openshift-control-plane
    priority: 30
    match:
    - label: node-role.kubernetes.io/master
    - label: node-role.kubernetes.io/infra
  - profile: openshift-node
    priority: 40
```

Starting with Red Hat OpenShift Service on AWS 4.9, all OpenShift TuneD profiles are shipped with the TuneD package. You can use the **oc exec** command to view the contents of these profiles:

```
$ oc exec $tuned_pod -n openshift-cluster-node-tuning-operator -- find /usr/lib/tuned/openshift{,-
control-plane,-node} -name tuned.conf -exec grep -H ^ {} \;
```

6.3.4. Supported TuneD daemon plugins

Excluding the **[main]** section, the following TuneD plugins are supported when using custom profiles defined in the **profile:** section of the Tuned CR:

- audio
- cpu
- disk
- eeepc_she
- modules
- mounts
- net
- scheduler
- scsi_host
- selinux
- sysctl
- sysfs

- usb
- video
- vm
- bootloader

There is some dynamic tuning functionality provided by some of these plugins that is not supported. The following TuneD plugins are currently not supported:

- script
- systemd

NOTE

The TuneD bootloader plugin only supports Red Hat Enterprise Linux CoreOS (RHCOS) worker nodes.

Additional resources

- Available TuneD Plugins
- Getting Started with TuneD

6.4. REMEDIATING, FENCING, AND MAINTAINING NODES

When node-level failures occur, such as the kernel hangs or network interface controllers (NICs) fail, the work required from the cluster does not decrease, and workloads from affected nodes need to be restarted somewhere. Failures affecting these workloads risk data loss, corruption, or both. It is important to isolate the node, known as **fencing**, before initiating recovery of the workload, known as **remediation**, and recovery of the node.

For more information on remediation, fencing, and maintaining nodes, see the Workload Availability for Red Hat OpenShift documentation.

6.5. MACHINE CONFIG DAEMON METRICS

The Machine Config Daemon is a part of the Machine Config Operator. It runs on every node in the cluster. The Machine Config Daemon manages configuration changes and updates on each of the nodes.

6.5.1. Machine Config Daemon metrics

Beginning with Red Hat OpenShift Service on AWS 4.3, the Machine Config Daemon provides a set of metrics. These metrics can be accessed using the Prometheus Cluster Monitoring stack.

The following table describes this set of metrics. Some entries contain commands for getting specific logs. Hpwever, the most comprehensive set of logs is available using the **oc adm must-gather** command.

NOTE

Metrics marked with * in the **Name** and **Description** columns represent serious errors that might cause performance problems. Such problems might prevent updates and upgrades from proceeding.

Table 6.2. MCO metrics

Name	Format	Description	Notes
mcd_host_os_and_version	**[]string{"os", "version"}**	Shows the OS that MCD is running on, such as RHCOS or RHEL. In case of RHCOS, the version is provided.	
mcd_drain_err*		Logs errors received during failed drain. *	While drains might need multiple tries to succeed, terminal failed drains prevent updates from proceeding. The **drain_time** metric, which shows how much time the drain took, might help with troubleshooting. For further investigation, see the logs by running: **$ oc logs -f -n openshift-machine-config-operator machine-config-daemon-<hash> -c machine-config-daemon**
mcd_pivot_err*	**[]string{"err", "node", "pivot_target"}**	Logs errors encountered during pivot. *	Pivot errors might prevent OS upgrades from proceeding. For further investigation, run this command to see the logs from the **machine-config-daemon** container: **$ oc logs -f -n openshift-machine-config-operator machine-config-daemon-<hash> -c machine-config-daemon**
mcd_state	**[]string{"state", "reason"}**	State of Machine Config Daemon for the indicated node. Possible states are "Done", "Working", and "Degraded". In case of "Degraded", the reason is included.	For further investigation, see the logs by running: **$ oc logs -f -n openshift-machine-config-operator machine-config-daemon-<hash> -c machine-config-daemon**

Name	Format	Description	Notes
mcd_kubelet_state*		Logs kubelet health failures. *	This is expected to be empty, with failure count of 0. If failure count exceeds 2, the error indicating threshold is exceeded. This indicates a possible issue with the health of the kubelet. For further investigation, run this command to access the node and see all its logs: **$ oc debug node/<node> — chroot /host journalctl -u kubelet**
mcd_reboot_err*	**[]string{"message", "err", "node"}**	Logs the failed reboots and the corresponding errors. *	This is expected to be empty, which indicates a successful reboot. For further investigation, see the logs by running: **$ oc logs -f -n openshift-machine-config-operator machine-config-daemon-<hash> -c machine-config-daemon**
mcd_update_state	**[]string{"config", "err"}**	Logs success or failure of configuration updates and the corresponding errors.	The expected value is **rendered-master/rendered-worker-XXXX**. If the update fails, an error is present. For further investigation, see the logs by running: **$ oc logs -f -n openshift-machine-config-operator machine-config-daemon-<hash> -c machine-config-daemon**

Additional resources

- Understanding the monitoring stack

CHAPTER 7. WORKING WITH CONTAINERS

7.1. UNDERSTANDING CONTAINERS

The basic units of Red Hat OpenShift Service on AWS applications are called *containers*. Linux container technologies are lightweight mechanisms for isolating running processes so that they are limited to interacting with only their designated resources.

Many application instances can be running in containers on a single host without visibility into each others' processes, files, network, and so on. Typically, each container provides a single service (often called a "micro-service"), such as a web server or a database, though containers can be used for arbitrary workloads.

The Linux kernel has been incorporating capabilities for container technologies for years. Red Hat OpenShift Service on AWS and Kubernetes add the ability to orchestrate containers across multi-host installations.

7.1.1. About containers and RHEL kernel memory

Due to Red Hat Enterprise Linux (RHEL) behavior, a container on a node with high CPU usage might seem to consume more memory than expected. The higher memory consumption could be caused by the **kmem_cache** in the RHEL kernel. The RHEL kernel creates a **kmem_cache** for each cgroup. For added performance, the **kmem_cache** contains a **cpu_cache**, and a node cache for any NUMA nodes. These caches all consume kernel memory.

The amount of memory stored in those caches is proportional to the number of CPUs that the system uses. As a result, a higher number of CPUs results in a greater amount of kernel memory being held in these caches. Higher amounts of kernel memory in these caches can cause Red Hat OpenShift Service on AWS containers to exceed the configured memory limits, resulting in the container being killed.

To avoid losing containers due to kernel memory issues, ensure that the containers request sufficient memory. You can use the following formula to estimate the amount of memory consumed by the **kmem_cache**, where **nproc** is the number of processing units available that are reported by the **nproc** command. The lower limit of container requests should be this value plus the container memory requirements:

```
$(nproc) X 1/2 MiB
```

7.1.2. About the container engine and container runtime

A *container engine* is a piece of software that processes user requests, including command line options and image pulls. The container engine uses a *container runtime*, also called a *lower-level container runtime*, to run and manage the components required to deploy and operate containers. You likely will not need to interact with the container engine or container runtime.

NOTE

The Red Hat OpenShift Service on AWS documentation uses the term *container runtime* to refer to the lower-level container runtime. Other documentation can refer to the container engine as the container runtime.

Red Hat OpenShift Service on AWS uses CRI-O as the container engine and runC or crun as the container runtime. The default container runtime is runC.

7.2. USING INIT CONTAINERS TO PERFORM TASKS BEFORE A POD IS DEPLOYED

Red Hat OpenShift Service on AWS provides *init containers*, which are specialized containers that run before application containers and can contain utilities or setup scripts not present in an app image.

7.2.1. Understanding Init Containers

You can use an Init Container resource to perform tasks before the rest of a pod is deployed.

A pod can have Init Containers in addition to application containers. Init containers allow you to reorganize setup scripts and binding code.

An Init Container can:

- Contain and run utilities that are not desirable to include in the app Container image for security reasons.
- Contain utilities or custom code for setup that is not present in an app image. For example, there is no requirement to make an image FROM another image just to use a tool like sed, awk, python, or dig during setup.
- Use Linux namespaces so that they have different filesystem views from app containers, such as access to secrets that application containers are not able to access.

Each Init Container must complete successfully before the next one is started. So, Init Containers provide an easy way to block or delay the startup of app containers until some set of preconditions are met.

For example, the following are some ways you can use Init Containers:

- Wait for a service to be created with a shell command like:

  ```
  for i in {1..100}; do sleep 1; if dig myservice; then exit 0; fi; done; exit 1
  ```

- Register this pod with a remote server from the downward API with a command like:

  ```
  $ curl -X POST
  http://$MANAGEMENT_SERVICE_HOST:$MANAGEMENT_SERVICE_PORT/register -d
  ‘instance=$()&ip=$()’
  ```

- Wait for some time before starting the app Container with a command like **sleep 60**.
- Clone a git repository into a volume.
- Place values into a configuration file and run a template tool to dynamically generate a configuration file for the main app Container. For example, place the POD_IP value in a configuration and generate the main app configuration file using Jinja.

See the Kubernetes documentation for more information.

7.2.2. Creating Init Containers

The following example outlines a simple pod which has two Init Containers. The first waits for **myservice** and the second waits for **mydb**. After both containers complete, the pod begins.

Procedure

1. Create the pod for the Init Container:

   a. Create a YAML file similar to the following:

```
apiVersion: v1
kind: Pod
metadata:
  name: myapp-pod
  labels:
    app: myapp
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: myapp-container
    image: registry.access.redhat.com/ubi9/ubi:latest
    command: ['sh', '-c', 'echo The app is running! && sleep 3600']
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
  initContainers:
  - name: init-myservice
    image: registry.access.redhat.com/ubi9/ubi:latest
    command: ['sh', '-c', 'until getent hosts myservice; do echo waiting for myservice; sleep
2; done;']
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
  - name: init-mydb
    image: registry.access.redhat.com/ubi9/ubi:latest
    command: ['sh', '-c', 'until getent hosts mydb; do echo waiting for mydb; sleep 2;
done;']
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
```

   b. Create the pod:

```
$ oc create -f myapp.yaml
```

   c. View the status of the pod:

```
$ oc get pods
```

Example output

```
NAME                    READY     STATUS            RESTARTS   AGE
myapp-pod                0/1       Init:0/2          0          5s
```

The pod status, **Init:0/2**, indicates it is waiting for the two services.

2. Create the **myservice** service.

   a. Create a YAML file similar to the following:

```
kind: Service
apiVersion: v1
metadata:
  name: myservice
spec:
  ports:
  - protocol: TCP
    port: 80
    targetPort: 9376
```

   b. Create the pod:

```
$ oc create -f myservice.yaml
```

   c. View the status of the pod:

```
$ oc get pods
```

Example output

```
NAME                    READY     STATUS            RESTARTS   AGE
myapp-pod                 0/1       Init:1/2          0          5s
```

The pod status, **Init:1/2**, indicates it is waiting for one service, in this case the **mydb** service.

3. Create the **mydb** service:

   a. Create a YAML file similar to the following:

```
kind: Service
apiVersion: v1
metadata:
  name: mydb
spec:
  ports:
  - protocol: TCP
    port: 80
    targetPort: 9377
```

   b. Create the pod:

```
$ oc create -f mydb.yaml
```

   c. View the status of the pod:

```
$ oc get pods
```

Example output

```
NAME                      READY     STATUS            RESTARTS   AGE
myapp-pod                   1/1      Running          0          2m
```

The pod status indicated that it is no longer waiting for the services and is running.

7.3. USING VOLUMES TO PERSIST CONTAINER DATA

Files in a container are ephemeral. As such, when a container crashes or stops, the data is lost. You can use *volumes* to persist the data used by the containers in a pod. A volume is directory, accessible to the Containers in a pod, where data is stored for the life of the pod.

7.3.1. Understanding volumes

Volumes are mounted file systems available to pods and their containers which may be backed by a number of host-local or network attached storage endpoints. Containers are not persistent by default; on restart, their contents are cleared.

To ensure that the file system on the volume contains no errors and, if errors are present, to repair them when possible, Red Hat OpenShift Service on AWS invokes the **fsck** utility prior to the **mount** utility. This occurs when either adding a volume or updating an existing volume.

The simplest volume type is **emptyDir**, which is a temporary directory on a single machine. Administrators may also allow you to request a persistent volume that is automatically attached to your pods.

NOTE

emptyDir volume storage may be restricted by a quota based on the pod's FSGroup, if the FSGroup parameter is enabled by your cluster administrator.

7.3.2. Working with volumes using the Red Hat OpenShift Service on AWS CLI

You can use the CLI command **oc set volume** to add and remove volumes and volume mounts for any object that has a pod template like replication controllers or deployment configs. You can also list volumes in pods or any object that has a pod template.

The **oc set volume** command uses the following general syntax:

```
$ oc set volume <object_selection> <operation> <mandatory_parameters> <options>
```

Object selection

Specify one of the following for the **object_selection** parameter in the **oc set volume** command:

Table 7.1. Object Selection

Syntax	Description	Example
<object_type> <name>	Selects ***<name>*** of type ***<object_type>***.	**deploymentConfig registry**

Syntax	Description	Example
<object_type>*/*<name>	Selects ***<name>*** of type ***<object_type>***.	**deploymentConfig/registry**
<object_type>*--selector=*<object_label_selector>	Selects resources of type ***<object_type>*** that matched the given label selector.	**deploymentConfig--selector="name=registry"**
***<object_type>* --all**	Selects all resources of type ***<object_type>***.	**deploymentConfig --all**
-f or **--filename=*<file_name>***	File name, directory, or URL to file to use to edit the resource.	**-f registry-deployment-config.json**

Operation

Specify **--add** or **--remove** for the **operation** parameter in the **oc set volume** command.

Mandatory parameters

Any mandatory parameters are specific to the selected operation and are discussed in later sections.

Options

Any options are specific to the selected operation and are discussed in later sections.

7.3.3. Listing volumes and volume mounts in a pod

You can list volumes and volume mounts in pods or pod templates:

Procedure

To list volumes:

```
$ oc set volume <object_type>/<name> [options]
```

List volume supported options:

Option	Description	Default
--name	Name of the volume.	
-c, --containers	Select containers by name. It can also take wildcard **'*'** that matches any character.	**'*'**

For example:

- To list all volumes for pod **p1**:

  ```
  $ oc set volume pod/p1
  ```

- To list volume **v1** defined on all deployment configs:

```
$ oc set volume dc --all --name=v1
```

7.3.4. Adding volumes to a pod

You can add volumes and volume mounts to a pod.

Procedure

To add a volume, a volume mount, or both to pod templates:

```
$ oc set volume <object_type>/<name> --add [options]
```

Table 7.2. Supported Options for Adding Volumes

Option	Description	Default
--name	Name of the volume.	Automatically generated, if not specified.
-t, --type	Name of the volume source. Supported values: **emptyDir**, **hostPath**, **secret**, **configmap**, **persistentVolumeClaim** or **projected**.	**emptyDir**
-c, --containers	Select containers by name. It can also take wildcard **'*'** that matches any character.	**'*'**
-m, --mount-path	Mount path inside the selected containers. Do not mount to the container root, /, or any path that is the same in the host and the container. This can corrupt your host system if the container is sufficiently privileged, such as the host **/dev/pts** files. It is safe to mount the host by using **/host**.	
--path	Host path. Mandatory parameter for **--type=hostPath**. Do not mount to the container root, /, or any path that is the same in the host and the container. This can corrupt your host system if the container is sufficiently privileged, such as the host **/dev/pts** files. It is safe to mount the host by using **/host**.	

Option	Description	Default
--secret-name	Name of the secret. Mandatory parameter for **--type=secret**.	
--configmap-name	Name of the configmap. Mandatory parameter for **--type=configmap**.	
--claim-name	Name of the persistent volume claim. Mandatory parameter for **--type=persistentVolumeClaim**.	
--source	Details of volume source as a JSON string. Recommended if the desired volume source is not supported by **--type**.	
-o, --output	Display the modified objects instead of updating them on the server. Supported values: **json**, **yaml**.	
--output-version	Output the modified objects with the given version.	**api-version**

For example:

- To add a new volume source **emptyDir** to the **registry DeploymentConfig** object:

```
$ oc set volume dc/registry --add
```

TIP

You can alternatively apply the following YAML to add the volume:

Example 7.1. Sample deployment config with an added volume

```
kind: DeploymentConfig
apiVersion: apps.openshift.io/v1
metadata:
  name: registry
  namespace: registry
spec:
  replicas: 3
  selector:
    app: httpd
  template:
    metadata:
      labels:
        app: httpd
    spec:
      volumes: 1
        - name: volume-pppsw
          emptyDir: {}
      containers:
        - name: httpd
          image: >-
            image-registry.openshift-image-registry.svc:5000/openshift/httpd:latest
          ports:
            - containerPort: 8080
              protocol: TCP
```

1 Add the volume source **emptyDir**.

- To add volume **v1** with secret **secret1** for replication controller **r1** and mount inside the containers at ***/data***:

```
$ oc set volume rc/r1 --add --name=v1 --type=secret --secret-name='secret1' --mount-path=/data
```

TIP

You can alternatively apply the following YAML to add the volume:

Example 7.2. Sample replication controller with added volume and secret

```
kind: ReplicationController
apiVersion: v1
metadata:
  name: example-1
  namespace: example
spec:
  replicas: 0
  selector:
    app: httpd
    deployment: example-1
    deploymentconfig: example
  template:
    metadata:
      creationTimestamp: null
      labels:
        app: httpd
        deployment: example-1
        deploymentconfig: example
    spec:
      volumes: 1
        - name: v1
          secret:
            secretName: secret1
            defaultMode: 420
      containers:
        - name: httpd
          image: >-
            image-registry.openshift-image-registry.svc:5000/openshift/httpd:latest
          volumeMounts: 2
            - name: v1
              mountPath: /data
```

1 Add the volume and secret.
2 Add the container mount path.

- To add existing persistent volume **v1** with claim name **pvc1** to deployment configuration ***dc.json*** on disk, mount the volume on container **c1** at ***/data***, and update the **DeploymentConfig** object on the server:

```
$ oc set volume -f dc.json --add --name=v1 --type=persistentVolumeClaim \
  --claim-name=pvc1 --mount-path=/data --containers=c1
```

TIP

You can alternatively apply the following YAML to add the volume:

Example 7.3. Sample deployment config with persistent volume added

```
kind: DeploymentConfig
apiVersion: apps.openshift.io/v1
metadata:
  name: example
  namespace: example
spec:
  replicas: 3
  selector:
    app: httpd
  template:
    metadata:
      labels:
        app: httpd
    spec:
      volumes:
        - name: volume-pppsw
          emptyDir: {}
        - name: v1 (1)
          persistentVolumeClaim:
            claimName: pvc1
      containers:
        - name: httpd
          image: >-
            image-registry.openshift-image-registry.svc:5000/openshift/httpd:latest
          ports:
            - containerPort: 8080
              protocol: TCP
          volumeMounts: (2)
            - name: v1
              mountPath: /data
```

(1) Add the persistent volume claim named `pvc1.
(2) Add the container mount path.

- To add a volume **v1** based on Git repository **https://github.com/namespace1/project1** with revision **5125c45f9f563** for all replication controllers:

```
$ oc set volume rc --all --add --name=v1 \
  --source='{"gitRepo": {
              "repository": "https://github.com/namespace1/project1",
              "revision": "5125c45f9f563"
          }}'
```

7.3.5. Updating volumes and volume mounts in a pod

You can modify the volumes and volume mounts in a pod.

Procedure

Updating existing volumes using the **--overwrite** option:

```
$ oc set volume <object_type>/<name> --add --overwrite [options]
```

For example:

- To replace existing volume **v1** for replication controller **r1** with existing persistent volume claim **pvc1**:

  ```
  $ oc set volume rc/r1 --add --overwrite --name=v1 --type=persistentVolumeClaim --claim-name=pvc1
  ```

TIP

You can alternatively apply the following YAML to replace the volume:

Example 7.4. Sample replication controller with persistent volume claim named pvc1

```
kind: ReplicationController
apiVersion: v1
metadata:
  name: example-1
  namespace: example
spec:
  replicas: 0
  selector:
    app: httpd
    deployment: example-1
    deploymentconfig: example
  template:
    metadata:
      labels:
        app: httpd
        deployment: example-1
        deploymentconfig: example
    spec:
      volumes:
        - name: v1 (1)
          persistentVolumeClaim:
            claimName: pvc1
      containers:
        - name: httpd
          image: >-
            image-registry.openshift-image-registry.svc:5000/openshift/httpd:latest
          ports:
            - containerPort: 8080
              protocol: TCP
          volumeMounts:
            - name: v1
              mountPath: /data
```

1 Set persistent volume claim to **pvc1**.

- To change the **DeploymentConfig** object **d1** mount point to ***/opt*** for volume **v1**:

```
$ oc set volume dc/d1 --add --overwrite --name=v1 --mount-path=/opt
```

TIP

You can alternatively apply the following YAML to change the mount point:

Example 7.5. Sample deployment config with mount point set toopt.

```
kind: DeploymentConfig
apiVersion: apps.openshift.io/v1
metadata:
  name: example
  namespace: example
spec:
  replicas: 3
  selector:
    app: httpd
  template:
    metadata:
      labels:
        app: httpd
    spec:
      volumes:
        - name: volume-pppsw
          emptyDir: {}
        - name: v2
          persistentVolumeClaim:
            claimName: pvc1
        - name: v1
          persistentVolumeClaim:
            claimName: pvc1
      containers:
        - name: httpd
          image: >-
            image-registry.openshift-image-registry.svc:5000/openshift/httpd:latest
          ports:
            - containerPort: 8080
              protocol: TCP
          volumeMounts: (1)
            - name: v1
              mountPath: /opt
```

(1) Set the mount point to /**opt**.

7.3.6. Removing volumes and volume mounts from a pod

You can remove a volume or volume mount from a pod.

Procedure

To remove a volume from pod templates:

```
$ oc set volume <object_type>/<name> --remove [options]
```

Table 7.3. Supported options for removing volumes

Option	Description	Default
--name	Name of the volume.	
-c, --containers	Select containers by name. It can also take wildcard **'*'** that matches any character.	**'*'**
--confirm	Indicate that you want to remove multiple volumes at once.	
-o, --output	Display the modified objects instead of updating them on the server. Supported values: **json**, **yaml**.	
--output-version	Output the modified objects with the given version.	**api-version**

For example:

- To remove a volume **v1** from the **DeploymentConfig** object **d1**:

```
$ oc set volume dc/d1 --remove --name=v1
```

- To unmount volume **v1** from container **c1** for the **DeploymentConfig** object **d1** and remove the volume **v1** if it is not referenced by any containers on **d1**:

```
$ oc set volume dc/d1 --remove --name=v1 --containers=c1
```

- To remove all volumes for replication controller **r1**:

```
$ oc set volume rc/r1 --remove --confirm
```

7.3.7. Configuring volumes for multiple uses in a pod

You can configure a volume to allows you to share one volume for multiple uses in a single pod using the **volumeMounts.subPath** property to specify a **subPath** value inside a volume instead of the volume's root.

NOTE

You cannot add a **subPath** parameter to an existing scheduled pod.

Procedure

1. To view the list of files in the volume, run the **oc rsh** command:

```
$ oc rsh <pod>
```

Example output

```
sh-4.2$ ls /path/to/volume/subpath/mount
example_file1 example_file2 example_file3
```

2. Specify the **subPath**:

Example Pod spec with subPath parameter

```
apiVersion: v1
kind: Pod
metadata:
  name: my-site
spec:
    securityContext:
      runAsNonRoot: true
      seccompProfile:
        type: RuntimeDefault
    containers:
    - name: mysql
      image: mysql
      volumeMounts:
      - mountPath: /var/lib/mysql
        name: site-data
        subPath: mysql (1)
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
    - name: php
      image: php
      volumeMounts:
      - mountPath: /var/www/html
        name: site-data
        subPath: html (2)
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
    volumes:
    - name: site-data
      persistentVolumeClaim:
        claimName: my-site-data
```

(1) Databases are stored in the **mysql** folder.

(2) HTML content is stored in the **html** folder.

7.4. MAPPING VOLUMES USING PROJECTED VOLUMES

A *projected volume* maps several existing volume sources into the same directory.

The following types of volume sources can be projected:

- Secrets
- Config Maps
- Downward API

NOTE

All sources are required to be in the same namespace as the pod.

7.4.1. Understanding projected volumes

Projected volumes can map any combination of these volume sources into a single directory, allowing the user to:

- automatically populate a single volume with the keys from multiple secrets, config maps, and with downward API information, so that I can synthesize a single directory with various sources of information;
- populate a single volume with the keys from multiple secrets, config maps, and with downward API information, explicitly specifying paths for each item, so that I can have full control over the contents of that volume.

IMPORTANT

When the **RunAsUser** permission is set in the security context of a Linux-based pod, the projected files have the correct permissions set, including container user ownership. However, when the Windows equivalent **RunAsUsername** permission is set in a Windows pod, the kubelet is unable to correctly set ownership on the files in the projected volume.

Therefore, the **RunAsUsername** permission set in the security context of a Windows pod is not honored for Windows projected volumes running in Red Hat OpenShift Service on AWS.

The following general scenarios show how you can use projected volumes.

Config map, secrets, Downward API.

Projected volumes allow you to deploy containers with configuration data that includes passwords. An application using these resources could be deploying Red Hat OpenStack Platform (RHOSP) on Kubernetes. The configuration data might have to be assembled differently depending on if the services are going to be used for production or for testing. If a pod is labeled with production or testing, the downward API selector **metadata.labels** can be used to produce the correct RHOSP configs.

Config map + secrets.

Projected volumes allow you to deploy containers involving configuration data and passwords. For example, you might execute a config map with some sensitive encrypted tasks that are decrypted using a vault password file.

ConfigMap + Downward API.

Projected volumes allow you to generate a config including the pod name (available via the **metadata.name** selector). This application can then pass the pod name along with requests to easily determine the source without using IP tracking.

Secrets + Downward API.

Projected volumes allow you to use a secret as a public key to encrypt the namespace of the pod (available via the **metadata.namespace** selector). This example allows the Operator to use the application to deliver the namespace information securely without using an encrypted transport.

7.4.1.1. Example Pod specs

The following are examples of **Pod** specs for creating projected volumes.

Pod with a secret, a Downward API, and a config map

```
apiVersion: v1
kind: Pod
metadata:
  name: volume-test
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: container-test
    image: busybox
    volumeMounts: 1
    - name: all-in-one
      mountPath: "/projected-volume" 2
      readOnly: true 3
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
  volumes: 4
  - name: all-in-one 5
    projected:
      defaultMode: 0400 6
      sources:
      - secret:
          name: mysecret 7
          items:
            - key: username
              path: my-group/my-username 8
      - downwardAPI: 9
          items:
            - path: "labels"
              fieldRef:
                fieldPath: metadata.labels
            - path: "cpu_limit"
              resourceFieldRef:
                containerName: container-test
                resource: limits.cpu
      - configMap: 10
          name: myconfigmap
          items:
```

```
          - key: config
            path: my-group/my-config
            mode: 0777 (11)
```

1. Add a **volumeMounts** section for each container that needs the secret.
2. Specify a path to an unused directory where the secret will appear.
3. Set **readOnly** to **true**.
4. Add a **volumes** block to list each projected volume source.
5. Specify any name for the volume.
6. Set the execute permission on the files.
7. Add a secret. Enter the name of the secret object. Each secret you want to use must be listed.
8. Specify the path to the secrets file under the **mountPath**. Here, the secrets file is in ***/projected-volume/my-group/my-username***.
9. Add a Downward API source.
10. Add a ConfigMap source.
11. Set the mode for the specific projection

NOTE

If there are multiple containers in the pod, each container needs a **volumeMounts** section, but only one **volumes** section is needed.

Pod with multiple secrets with a non-default permission mode set

```
apiVersion: v1
kind: Pod
metadata:
  name: volume-test
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: container-test
    image: busybox
    volumeMounts:
    - name: all-in-one
      mountPath: "/projected-volume"
      readOnly: true
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
```

```
volumes:
- name: all-in-one
  projected:
    defaultMode: 0755
    sources:
    - secret:
        name: mysecret
        items:
          - key: username
            path: my-group/my-username
    - secret:
        name: mysecret2
        items:
          - key: password
            path: my-group/my-password
            mode: 511
```

NOTE

The **defaultMode** can only be specified at the projected level and not for each volume source. However, as illustrated above, you can explicitly set the **mode** for each individual projection.

7.4.1.2. Pathing Considerations

Collisions Between Keys when Configured Paths are Identical

If you configure any keys with the same path, the pod spec will not be accepted as valid. In the following example, the specified path for **mysecret** and **myconfigmap** are the same:

```
apiVersion: v1
kind: Pod
metadata:
  name: volume-test
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: container-test
    image: busybox
    volumeMounts:
    - name: all-in-one
      mountPath: "/projected-volume"
      readOnly: true
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
  volumes:
  - name: all-in-one
    projected:
      sources:
      - secret:
          name: mysecret
```

```
            items:
              - key: username
                path: my-group/data
        - configMap:
            name: myconfigmap
            items:
              - key: config
                path: my-group/data
```

Consider the following situations related to the volume file paths.

Collisions Between Keys without Configured Paths

The only run-time validation that can occur is when all the paths are known at pod creation, similar to the above scenario. Otherwise, when a conflict occurs the most recent specified resource will overwrite anything preceding it (this is true for resources that are updated after pod creation as well).

Collisions when One Path is Explicit and the Other is Automatically Projected

In the event that there is a collision due to a user specified path matching data that is automatically projected, the latter resource will overwrite anything preceding it as before

7.4.2. Configuring a Projected Volume for a Pod

When creating projected volumes, consider the volume file path situations described in *Understanding projected volumes*.

The following example shows how to use a projected volume to mount an existing secret volume source. The steps can be used to create a user name and password secrets from local files. You then create a pod that runs one container, using a projected volume to mount the secrets into the same shared directory.

The user name and password values can be any valid string that is **base64** encoded.

The following example shows **admin** in base64:

```
$ echo -n "admin" | base64
```

Example output

```
YWRtaW4=
```

The following example shows the password **1f2d1e2e67df** in base64:

```
$ echo -n "1f2d1e2e67df" | base64
```

Example output

```
MWYyZDFlMmU2N2Rm
```

Procedure

To use a projected volume to mount an existing secret volume source.

1. Create the secret:

   a. Create a YAML file similar to the following, replacing the password and user information as appropriate:

   ```
   apiVersion: v1
   kind: Secret
   metadata:
     name: mysecret
   type: Opaque
   data:
     pass: MWYyZDFlMmU2N2Rm
     user: YWRtaW4=
   ```

   b. Use the following command to create the secret:

   ```
   $ oc create -f <secrets-filename>
   ```

   For example:

   ```
   $ oc create -f secret.yaml
   ```

   Example output

   ```
   secret "mysecret" created
   ```

   c. You can check that the secret was created using the following commands:

   ```
   $ oc get secret <secret-name>
   ```

   For example:

   ```
   $ oc get secret mysecret
   ```

   Example output

   ```
   NAME       TYPE     DATA     AGE
   mysecret   Opaque   2        17h
   ```

   ```
   $ oc get secret <secret-name> -o yaml
   ```

   For example:

   ```
   $ oc get secret mysecret -o yaml
   ```

   ```
   apiVersion: v1
   data:
     pass: MWYyZDFlMmU2N2Rm
     user: YWRtaW4=
   kind: Secret
   metadata:
     creationTimestamp: 2017-05-30T20:21:38Z
   ```

```
  name: mysecret
  namespace: default
  resourceVersion: "2107"
  selfLink: /api/v1/namespaces/default/secrets/mysecret
  uid: 959e0424-4575-11e7-9f97-fa163e4bd54c
type: Opaque
```

2. Create a pod with a projected volume.

   a. Create a YAML file similar to the following, including a **volumes** section:

```
kind: Pod
metadata:
  name: test-projected-volume
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: test-projected-volume
    image: busybox
    args:
    - sleep
    - "86400"
    volumeMounts:
    - name: all-in-one
      mountPath: "/projected-volume"
      readOnly: true
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
  volumes:
  - name: all-in-one
    projected:
      sources:
      - secret:
          name: mysecret (1)
```

   (1) The name of the secret you created.

   b. Create the pod from the configuration file:

```
$ oc create -f <your_yaml_file>.yaml
```

   For example:

```
$ oc create -f secret-pod.yaml
```

   Example output

```
pod "test-projected-volume" created
```

3. Verify that the pod container is running, and then watch for changes to the pod:

```
$ oc get pod <name>
```

For example:

```
$ oc get pod test-projected-volume
```

The output should appear similar to the following:

Example output

```
NAME                  READY     STATUS    RESTARTS   AGE
test-projected-volume   1/1       Running   0          14s
```

4. In another terminal, use the **oc exec** command to open a shell to the running container:

```
$ oc exec -it <pod> <command>
```

For example:

```
$ oc exec -it test-projected-volume -- /bin/sh
```

5. In your shell, verify that the **projected-volumes** directory contains your projected sources:

```
/ # ls
```

Example output

```
bin             home             root             tmp
dev              proc             run              usr
etc             projected-volume  sys              var
```

7.5. ALLOWING CONTAINERS TO CONSUME API OBJECTS

The *Downward API* is a mechanism that allows containers to consume information about API objects without coupling to Red Hat OpenShift Service on AWS. Such information includes the pod's name, namespace, and resource values. Containers can consume information from the downward API using environment variables or a volume plugin.

7.5.1. Expose pod information to Containers using the Downward API

The Downward API contains such information as the pod's name, project, and resource values. Containers can consume information from the downward API using environment variables or a volume plugin.

Fields within the pod are selected using the **FieldRef** API type. **FieldRef** has two fields:

Field	Description
fieldPath	The path of the field to select, relative to the pod.
apiVersion	The API version to interpret the **fieldPath** selector within.

Currently, the valid selectors in the v1 API include:

Selector	Description
metadata.name	The pod's name. This is supported in both environment variables and volumes.
metadata.namespace	The pod's namespace.This is supported in both environment variables and volumes.
metadata.labels	The pod's labels. This is only supported in volumes and not in environment variables.
metadata.annotations	The pod's annotations. This is only supported in volumes and not in environment variables.
status.podIP	The pod's IP. This is only supported in environment variables and not volumes.

The **apiVersion** field, if not specified, defaults to the API version of the enclosing pod template.

7.5.2. Understanding how to consume container values using the downward API

You containers can consume API values using environment variables or a volume plugin. Depending on the method you choose, containers can consume:

- Pod name
- Pod project/namespace
- Pod annotations
- Pod labels

Annotations and labels are available using only a volume plugin.

7.5.2.1. Consuming container values using environment variables

When using a container's environment variables, use the **EnvVar** type's **valueFrom** field (of type **EnvVarSource**) to specify that the variable's value should come from a **FieldRef** source instead of the literal value specified by the **value** field.

Only constant attributes of the pod can be consumed this way, as environment variables cannot be updated once a process is started in a way that allows the process to be notified that the value of a variable has changed. The fields supported using environment variables are:

- Pod name
- Pod project/namespace

Procedure

1. Create a new pod spec that contains the environment variables you want the container to consume:

   a. Create a **pod.yaml** file similar to the following:

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: dapi-env-test-pod
   spec:
     securityContext:
       runAsNonRoot: true
       seccompProfile:
         type: RuntimeDefault
     containers:
       - name: env-test-container
         image: gcr.io/google_containers/busybox
         command: [ "/bin/sh", "-c", "env" ]
         env:
           - name: MY_POD_NAME
             valueFrom:
               fieldRef:
                 fieldPath: metadata.name
           - name: MY_POD_NAMESPACE
             valueFrom:
               fieldRef:
                 fieldPath: metadata.namespace
         securityContext:
           allowPrivilegeEscalation: false
           capabilities:
             drop: [ALL]
     restartPolicy: Never
   # ...
   ```

   b. Create the pod from the **pod.yaml** file:

   ```
   $ oc create -f pod.yaml
   ```

Verification

- Check the container's logs for the **MY_POD_NAME** and **MY_POD_NAMESPACE** values:

  ```
  $ oc logs -p dapi-env-test-pod
  ```

7.5.2.2. Consuming container values using a volume plugin

You containers can consume API values using a volume plugin.

Containers can consume:

- Pod name
- Pod project/namespace
- Pod annotations
- Pod labels

Procedure

To use the volume plugin:

1. Create a new pod spec that contains the environment variables you want the container to consume:

   a. Create a **volume-pod.yaml** file similar to the following:

```
kind: Pod
apiVersion: v1
metadata:
  labels:
    zone: us-east-coast
    cluster: downward-api-test-cluster1
    rack: rack-123
  name: dapi-volume-test-pod
  annotations:
    annotation1: "345"
    annotation2: "456"
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - name: volume-test-container
      image: gcr.io/google_containers/busybox
      command: ["sh", "-c", "cat /tmp/etc/pod_labels /tmp/etc/pod_annotations"]
      volumeMounts:
        - name: podinfo
          mountPath: /tmp/etc
          readOnly: false
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
  volumes:
  - name: podinfo
    downwardAPI:
      defaultMode: 420
      items:
      - fieldRef:
          fieldPath: metadata.name
        path: pod_name
      - fieldRef:
          fieldPath: metadata.namespace
        path: pod_namespace
      - fieldRef:
          fieldPath: metadata.labels
        path: pod_labels
      - fieldRef:
          fieldPath: metadata.annotations
        path: pod_annotations
  restartPolicy: Never
# ...
```

b. Create the pod from the **volume-pod.yaml** file:

```
$ oc create -f volume-pod.yaml
```

Verification

- Check the container's logs and verify the presence of the configured fields:

```
$ oc logs -p dapi-volume-test-pod
```

Example output

```
cluster=downward-api-test-cluster1
rack=rack-123
zone=us-east-coast
annotation1=345
annotation2=456
kubernetes.io/config.source=api
```

7.5.3. Understanding how to consume container resources using the Downward API

When creating pods, you can use the Downward API to inject information about computing resource requests and limits so that image and application authors can correctly create an image for specific environments.

You can do this using environment variable or a volume plugin.

7.5.3.1. Consuming container resources using environment variables

When creating pods, you can use the Downward API to inject information about computing resource requests and limits using environment variables.

When creating the pod configuration, specify environment variables that correspond to the contents of the **resources** field in the **spec.container** field.

NOTE

If the resource limits are not included in the container configuration, the downward API defaults to the node's CPU and memory allocatable values.

Procedure

1. Create a new pod spec that contains the resources you want to inject:

   a. Create a **pod.yaml** file similar to the following:

```
apiVersion: v1
kind: Pod
metadata:
  name: dapi-env-test-pod
spec:
  containers:
    - name: test-container
      image: gcr.io/google_containers/busybox:1.24
      command: [ "/bin/sh", "-c", "env" ]
      resources:
        requests:
          memory: "32Mi"
          cpu: "125m"
        limits:
          memory: "64Mi"
          cpu: "250m"
      env:
        - name: MY_CPU_REQUEST
          valueFrom:
            resourceFieldRef:
              resource: requests.cpu
        - name: MY_CPU_LIMIT
          valueFrom:
            resourceFieldRef:
              resource: limits.cpu
        - name: MY_MEM_REQUEST
          valueFrom:
            resourceFieldRef:
              resource: requests.memory
        - name: MY_MEM_LIMIT
          valueFrom:
            resourceFieldRef:
              resource: limits.memory
# ...
```

   b. Create the pod from the **pod.yaml** file:

```
$ oc create -f pod.yaml
```

7.5.3.2. Consuming container resources using a volume plugin

When creating pods, you can use the Downward API to inject information about computing resource requests and limits using a volume plugin.

When creating the pod configuration, use the **spec.volumes.downwardAPI.items** field to describe the desired resources that correspond to the **spec.resources** field.

NOTE

If the resource limits are not included in the container configuration, the Downward API defaults to the node's CPU and memory allocatable values.

Procedure

1. Create a new pod spec that contains the resources you want to inject:

   a. Create a **pod.yaml** file similar to the following:

```
apiVersion: v1
kind: Pod
metadata:
  name: dapi-env-test-pod
spec:
  containers:
    - name: client-container
      image: gcr.io/google_containers/busybox:1.24
      command: ["sh", "-c", "while true; do echo; if [[ -e /etc/cpu_limit ]]; then cat
/etc/cpu_limit; fi; if [[ -e /etc/cpu_request ]]; then cat /etc/cpu_request; fi; if [[ -e
/etc/mem_limit ]]; then cat /etc/mem_limit; fi; if [[ -e /etc/mem_request ]]; then cat
/etc/mem_request; fi; sleep 5; done"]
      resources:
        requests:
          memory: "32Mi"
          cpu: "125m"
        limits:
          memory: "64Mi"
          cpu: "250m"
      volumeMounts:
        - name: podinfo
          mountPath: /etc
          readOnly: false
  volumes:
    - name: podinfo
      downwardAPI:
        items:
          - path: "cpu_limit"
            resourceFieldRef:
              containerName: client-container
              resource: limits.cpu
          - path: "cpu_request"
            resourceFieldRef:
              containerName: client-container
              resource: requests.cpu
          - path: "mem_limit"
            resourceFieldRef:
              containerName: client-container
              resource: limits.memory
          - path: "mem_request"
            resourceFieldRef:
              containerName: client-container
              resource: requests.memory
# ...
```

b. Create the pod from the ***volume-pod.yaml*** file:

```
$ oc create -f volume-pod.yaml
```

7.5.4. Consuming secrets using the Downward API

When creating pods, you can use the downward API to inject secrets so image and application authors can create an image for specific environments.

Procedure

1. Create a secret to inject:

   a. Create a **secret.yaml** file similar to the following:

```
apiVersion: v1
kind: Secret
metadata:
  name: mysecret
data:
  password: <password>
  username: <username>
type: kubernetes.io/basic-auth
```

   b. Create the secret object from the **secret.yaml** file:

```
$ oc create -f secret.yaml
```

2. Create a pod that references the **username** field from the above **Secret** object:

   a. Create a **pod.yaml** file similar to the following:

```
apiVersion: v1
kind: Pod
metadata:
  name: dapi-env-test-pod
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - name: env-test-container
      image: gcr.io/google_containers/busybox
      command: [ "/bin/sh", "-c", "env" ]
      env:
        - name: MY_SECRET_USERNAME
          valueFrom:
            secretKeyRef:
              name: mysecret
              key: username
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
```

```
        drop: [ALL]
  restartPolicy: Never
# ...
```

b. Create the pod from the **pod.yaml** file:

```
$ oc create -f pod.yaml
```

Verification

- Check the container's logs for the **MY_SECRET_USERNAME** value:

```
$ oc logs -p dapi-env-test-pod
```

7.5.5. Consuming configuration maps using the Downward API

When creating pods, you can use the Downward API to inject configuration map values so image and application authors can create an image for specific environments.

Procedure

1. Create a config map with the values to inject:

   a. Create a ***configmap.yaml*** file similar to the following:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: myconfigmap
data:
  mykey: myvalue
```

   b. Create the config map from the **configmap.yaml** file:

```
$ oc create -f configmap.yaml
```

2. Create a pod that references the above config map:

   a. Create a **pod.yaml** file similar to the following:

```
apiVersion: v1
kind: Pod
metadata:
  name: dapi-env-test-pod
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - name: env-test-container
      image: gcr.io/google_containers/busybox
      command: [ "/bin/sh", "-c", "env" ]
      env:
        - name: MY_CONFIGMAP_VALUE
          valueFrom:
            configMapKeyRef:
              name: myconfigmap
              key: mykey
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
  restartPolicy: Always
# ...
```

b. Create the pod from the **pod.yaml** file:

```
$ oc create -f pod.yaml
```

Verification

- Check the container's logs for the **MY_CONFIGMAP_VALUE** value:

```
$ oc logs -p dapi-env-test-pod
```

7.5.6. Referencing environment variables

When creating pods, you can reference the value of a previously defined environment variable by using the **$()** syntax. If the environment variable reference can not be resolved, the value will be left as the provided string.

Procedure

1. Create a pod that references an existing environment variable:

   a. Create a **pod.yaml** file similar to the following:

```
apiVersion: v1
kind: Pod
metadata:
  name: dapi-env-test-pod
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - name: env-test-container
      image: gcr.io/google_containers/busybox
      command: [ "/bin/sh", "-c", "env" ]
      env:
        - name: MY_EXISTING_ENV
          value: my_value
        - name: MY_ENV_VAR_REF_ENV
          value: $(MY_EXISTING_ENV)
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
  restartPolicy: Never
# ...
```

b. Create the pod from the ***pod.yaml*** file:

```
$ oc create -f pod.yaml
```

Verification

- Check the container’s logs for the **MY_ENV_VAR_REF_ENV** value:

```
$ oc logs -p dapi-env-test-pod
```

7.5.7. Escaping environment variable references

When creating a pod, you can escape an environment variable reference by using a double dollar sign. The value will then be set to a single dollar sign version of the provided value.

Procedure

1. Create a pod that references an existing environment variable:

   a. Create a **pod.yaml** file similar to the following:

```
apiVersion: v1
kind: Pod
metadata:
  name: dapi-env-test-pod
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
    - name: env-test-container
      image: gcr.io/google_containers/busybox
      command: [ "/bin/sh", "-c", "env" ]
      env:
        - name: MY_NEW_ENV
          value: $$(SOME_OTHER_ENV)
      securityContext:
        allowPrivilegeEscalation: false
        capabilities:
          drop: [ALL]
  restartPolicy: Never
# ...
```

   b. Create the pod from the ***pod.yaml*** file:

```
$ oc create -f pod.yaml
```

Verification

- Check the container's logs for the **MY_NEW_ENV** value:

  ```
  $ oc logs -p dapi-env-test-pod
  ```

7.6. COPYING FILES TO OR FROM AN RED HAT OPENSHIFT SERVICE ON AWS CONTAINER

You can use the CLI to copy local files to or from a remote directory in a container using the **rsync** command.

7.6.1. Understanding how to copy files

The **oc rsync** command, or remote sync, is a useful tool for copying database archives to and from your pods for backup and restore purposes. You can also use **oc rsync** to copy source code changes into a running pod for development debugging, when the running pod supports hot reload of source files.

```
$ oc rsync <source> <destination> [-c <container>]
```

7.6.1.1. Requirements

Specifying the Copy Source

The source argument of the **oc rsync** command must point to either a local directory or a pod directory. Individual files are not supported.
When specifying a pod directory the directory name must be prefixed with the pod name:

```
<pod name>:<dir>
```

If the directory name ends in a path separator (/), only the contents of the directory are copied to the destination. Otherwise, the directory and its contents are copied to the destination.

Specifying the Copy Destination

The destination argument of the **oc rsync** command must point to a directory. If the directory does not exist, but **rsync** is used for copy, the directory is created for you.

Deleting Files at the Destination

The **--delete** flag may be used to delete any files in the remote directory that are not in the local directory.

Continuous Syncing on File Change

Using the **--watch** option causes the command to monitor the source path for any file system changes, and synchronizes changes when they occur. With this argument, the command runs forever.
Synchronization occurs after short quiet periods to ensure a rapidly changing file system does not result in continuous synchronization calls.

When using the **--watch** option, the behavior is effectively the same as manually invoking **oc rsync** repeatedly, including any arguments normally passed to **oc rsync**. Therefore, you can control the behavior via the same flags used with manual invocations of **oc rsync**, such as **--delete**.

7.6.2. Copying files to and from containers

Support for copying local files to or from a container is built into the CLI.

Prerequisites

When working with **oc rsync**, note the following:

- rsync must be installed. The **oc rsync** command uses the local **rsync** tool, if present on the client machine and the remote container.
  If **rsync** is not found locally or in the remote container, a **tar** archive is created locally and sent to the container where the **tar** utility is used to extract the files. If **tar** is not available in the remote container, the copy will fail.

  The **tar** copy method does not provide the same functionality as **oc rsync**. For example, **oc rsync** creates the destination directory if it does not exist and only sends files that are different between the source and the destination.

  > **NOTE**
  >
  > In Windows, the **cwRsync** client should be installed and added to the PATH for use with the **oc rsync** command.

Procedure

- To copy a local directory to a pod directory:

  ```
  $ oc rsync <local-dir> <pod-name>:/<remote-dir> -c <container-name>
  ```

  For example:

  ```
  $ oc rsync /home/user/source devpod1234:/src -c user-container
  ```

- To copy a pod directory to a local directory:

  ```
  $ oc rsync devpod1234:/src /home/user/source
  ```

  #### Example output

  ```
  $ oc rsync devpod1234:/src/status.txt /home/user/
  ```

7.6.3. Using advanced Rsync features

The **oc rsync** command exposes fewer command line options than standard **rsync**. In the case that you want to use a standard **rsync** command line option that is not available in **oc rsync**, for example the **--exclude-from=FILE** option, it might be possible to use standard **rsync** 's **--rsh** (**-e**) option or **RSYNC_RSH** environment variable as a workaround, as follows:

```
$ rsync --rsh='oc rsh' --exclude-from=<file_name> <local-dir> <pod-name>:/<remote-dir>
```

or:

Export the **RSYNC_RSH** variable:

```
$ export RSYNC_RSH='oc rsh'
```

Then, run the rsync command:

```
$ rsync --exclude-from=<file_name> <local-dir> <pod-name>:/<remote-dir>
```

Both of the above examples configure standard **rsync** to use **oc rsh** as its remote shell program to enable it to connect to the remote pod, and are an alternative to running **oc rsync**.

7.7. EXECUTING REMOTE COMMANDS IN AN RED HAT OPENSHIFT SERVICE ON AWS CONTAINER

You can use the CLI to execute remote commands in an Red Hat OpenShift Service on AWS container.

7.7.1. Executing remote commands in containers

Support for remote container command execution is built into the CLI.

Procedure

To run a command in a container:

```
$ oc exec <pod> [-c <container>] -- <command> [<arg_1> ... <arg_n>]
```

For example:

```
$ oc exec mypod date
```

Example output

```
Thu Apr  9 02:21:53 UTC 2015
```

IMPORTANT

For security purposes, the **oc exec** command does not work when accessing privileged containers except when the command is executed by a **cluster-admin** user.

7.7.2. Protocol for initiating a remote command from a client

Clients initiate the execution of a remote command in a container by issuing a request to the Kubernetes API server:

```
/proxy/nodes/<node_name>/exec/<namespace>/<pod>/<container>?command=<command>
```

In the above URL:

- **<node_name>** is the FQDN of the node.
- **<namespace>** is the project of the target pod.
- **<pod>** is the name of the target pod.
- **<container>** is the name of the target container.

- **<command>** is the desired command to be executed.

For example:

```
/proxy/nodes/node123.openshift.com/exec/myns/mypod/mycontainer?command=date
```

Additionally, the client can add parameters to the request to indicate if:

- the client should send input to the remote container's command (stdin).
- the client's terminal is a TTY.
- the remote container's command should send output from stdout to the client.
- the remote container's command should send output from stderr to the client.

After sending an **exec** request to the API server, the client upgrades the connection to one that supports multiplexed streams; the current implementation uses **HTTP/2**.

The client creates one stream each for stdin, stdout, and stderr. To distinguish among the streams, the client sets the **streamType** header on the stream to one of **stdin**, **stdout**, or **stderr**.

The client closes all streams, the upgraded connection, and the underlying connection when it is finished with the remote command execution request.

7.8. USING PORT FORWARDING TO ACCESS APPLICATIONS IN A CONTAINER

Red Hat OpenShift Service on AWS supports port forwarding to pods.

7.8.1. Understanding port forwarding

You can use the CLI to forward one or more local ports to a pod. This allows you to listen on a given or random port locally, and have data forwarded to and from given ports in the pod.

Support for port forwarding is built into the CLI:

```
$ oc port-forward <pod> [<local_port>:]<remote_port> [...[<local_port_n>:]<remote_port_n>]
```

The CLI listens on each local port specified by the user, forwarding using the protocol described below.

Ports may be specified using the following formats:

5000	The client listens on port 5000 locally and forwards to 5000 in the pod.
6000:5000	The client listens on port 6000 locally and forwards to 5000 in the pod.
:5000 or **0:5000**	The client selects a free local port and forwards to 5000 in the pod.

Red Hat OpenShift Service on AWS handles port-forward requests from clients. Upon receiving a request, Red Hat OpenShift Service on AWS upgrades the response and waits for the client to create port-forwarding streams. When Red Hat OpenShift Service on AWS receives a new stream, it copies data between the stream and the pod's port.

Architecturally, there are options for forwarding to a pod's port. The supported Red Hat OpenShift Service on AWS implementation invokes **nsenter** directly on the node host to enter the pod's network namespace, then invokes **socat** to copy data between the stream and the pod's port. However, a custom implementation could include running a *helper* pod that then runs **nsenter** and **socat**, so that those binaries are not required to be installed on the host.

7.8.2. Using port forwarding

You can use the CLI to port-forward one or more local ports to a pod.

Procedure

Use the following command to listen on the specified port in a pod:

```
$ oc port-forward <pod> [<local_port>:]<remote_port> [...[<local_port_n>:]<remote_port_n>]
```

For example:

- Use the following command to listen on ports **5000** and **6000** locally and forward data to and from ports **5000** and **6000** in the pod:

  ```
  $ oc port-forward <pod> 5000 6000
  ```

  #### Example output

  ```
  Forwarding from 127.0.0.1:5000 -> 5000
  Forwarding from [::1]:5000 -> 5000
  Forwarding from 127.0.0.1:6000 -> 6000
  Forwarding from [::1]:6000 -> 6000
  ```

- Use the following command to listen on port **8888** locally and forward to **5000** in the pod:

  ```
  $ oc port-forward <pod> 8888:5000
  ```

  #### Example output

  ```
  Forwarding from 127.0.0.1:8888 -> 5000
  Forwarding from [::1]:8888 -> 5000
  ```

- Use the following command to listen on a free port locally and forward to **5000** in the pod:

  ```
  $ oc port-forward <pod> :5000
  ```

  #### Example output

  ```
  Forwarding from 127.0.0.1:42390 -> 5000
  Forwarding from [::1]:42390 -> 5000
  ```

  Or:

```
$ oc port-forward <pod> 0:5000
```

7.8.3. Protocol for initiating port forwarding from a client

Clients initiate port forwarding to a pod by issuing a request to the Kubernetes API server:

```
/proxy/nodes/<node_name>/portForward/<namespace>/<pod>
```

In the above URL:

- **<node_name>** is the FQDN of the node.
- **<namespace>** is the namespace of the target pod.
- **<pod>** is the name of the target pod.

For example:

```
/proxy/nodes/node123.openshift.com/portForward/myns/mypod
```

After sending a port forward request to the API server, the client upgrades the connection to one that supports multiplexed streams; the current implementation uses **Hyptertext Transfer Protocol Version 2 (HTTP/2)**.

The client creates a stream with the **port** header containing the target port in the pod. All data written to the stream is delivered via the kubelet to the target pod and port. Similarly, all data sent from the pod for that forwarded connection is delivered back to the same stream in the client.

The client closes all streams, the upgraded connection, and the underlying connection when it is finished with the port forwarding request.

CHAPTER 8. WORKING WITH CLUSTERS

8.1. VIEWING SYSTEM EVENT INFORMATION IN AN RED HAT OPENSHIFT SERVICE ON AWS CLUSTER

Events in Red Hat OpenShift Service on AWS are modeled based on events that happen to API objects in an Red Hat OpenShift Service on AWS cluster.

8.1.1. Understanding events

Events allow Red Hat OpenShift Service on AWS to record information about real-world events in a resource-agnostic manner. They also allow developers and administrators to consume information about system components in a unified way.

8.1.2. Viewing events using the CLI

You can get a list of events in a given project using the CLI.

Procedure

- To view events in a project use the following command:

  ```
  $ oc get events [-n <project>] (1)
  ```

  (1) The name of the project.

  For example:

  ```
  $ oc get events -n openshift-config
  ```

  Example output

  ```
  LAST SEEN   TYPE      REASON                   OBJECT                      MESSAGE
  97m         Normal    Scheduled                pod/dapi-env-test-pod       Successfully assigned
  openshift-config/dapi-env-test-pod to ip-10-0-171-202.ec2.internal
  97m         Normal    Pulling                  pod/dapi-env-test-pod       pulling image
  "gcr.io/google_containers/busybox"
  97m         Normal    Pulled                   pod/dapi-env-test-pod       Successfully pulled image
  "gcr.io/google_containers/busybox"
  97m         Normal    Created                  pod/dapi-env-test-pod       Created container
  9m5s        Warning   FailedCreatePodSandBox   pod/dapi-volume-test-pod    Failed create
  pod sandbox: rpc error: code = Unknown desc = failed to create pod network sandbox
  k8s_dapi-volume-test-pod_openshift-config_6bc60c1f-452e-11e9-9140-
  0eec59c23068_0(748c7a40db3d08c07fb4f9eba774bd5effe5f0d5090a242432a73eee66ba9e22
  ): Multus: Err adding pod to network "openshift-sdn": cannot set "openshift-sdn" ifname to
  "eth0": no netns: failed to Statfs "/proc/33366/ns/net": no such file or directory
  8m31s       Normal    Scheduled                pod/dapi-volume-test-pod    Successfully assigned
  openshift-config/dapi-volume-test-pod to ip-10-0-171-202.ec2.internal
  ```

- To view events in your project from the Red Hat OpenShift Service on AWS console.

  1. Launch the Red Hat OpenShift Service on AWS console.

2. Click **Home** → **Events** and select your project.

3. Move to resource that you want to see events. For example: **Home** → **Projects** → <project-name> → <resource-name>.
   Many objects, such as pods and deployments, have their own **Events** tab as well, which shows events related to that object.

8.1.3. List of events

This section describes the events of Red Hat OpenShift Service on AWS.

Table 8.1. Configuration events

Name	Description
FailedValidation	Failed pod configuration validation.

Table 8.2. Container events

Name	Description
BackOff	Back-off restarting failed the container.
Created	Container created.
Failed	Pull/Create/Start failed.
Killing	Killing the container.
Started	Container started.
Preempting	Preempting other pods.
ExceededGrace Period	Container runtime did not stop the pod within specified grace period.

Table 8.3. Health events

Name	Description
Unhealthy	Container is unhealthy.

Table 8.4. Image events

Name	Description
BackOff	Back off Ctr Start, image pull.

Name	Description
ErrImageNeverPull	The image's **NeverPull Policy** is violated.
Failed	Failed to pull the image.
InspectFailed	Failed to inspect the image.
Pulled	Successfully pulled the image or the container image is already present on the machine.
Pulling	Pulling the image.

Table 8.5. Image Manager events

Name	Description
FreeDiskSpaceFailed	Free disk space failed.
InvalidDiskCapacity	Invalid disk capacity.

Table 8.6. Node events

Name	Description
FailedMount	Volume mount failed.
HostNetworkNotSupported	Host network not supported.
HostPortConflict	Host/port conflict.
KubeletSetupFailed	Kubelet setup failed.
NilShaper	Undefined shaper.
NodeNotReady	Node is not ready.
NodeNotSchedulable	Node is not schedulable.
NodeReady	Node is ready.

Name	Description
NodeSchedulable	Node is schedulable.
NodeSelectorMismatching	Node selector mismatch.
OutOfDisk	Out of disk.
Rebooted	Node rebooted.
Starting	Starting kubelet.
FailedAttachVolume	Failed to attach volume.
FailedDetachVolume	Failed to detach volume.
VolumeResizeFailed	Failed to expand/reduce volume.
VolumeResizeSuccessful	Successfully expanded/reduced volume.
FileSystemResizeFailed	Failed to expand/reduce file system.
FileSystemResizeSuccessful	Successfully expanded/reduced file system.
FailedUnMount	Failed to unmount volume.
FailedMapVolume	Failed to map a volume.
FailedUnmapDevice	Failed unmaped device.
AlreadyMountedVolume	Volume is already mounted.
SuccessfulDetachVolume	Volume is successfully detached.
SuccessfulMountVolume	Volume is successfully mounted.

Name	Description
SuccessfulUnMountVolume	Volume is successfully unmounted.
ContainerGCFailed	Container garbage collection failed.
ImageGCFailed	Image garbage collection failed.
FailedNodeAllocatableEnforcement	Failed to enforce System Reserved Cgroup limit.
NodeAllocatableEnforced	Enforced System Reserved Cgroup limit.
UnsupportedMountOption	Unsupported mount option.
SandboxChanged	Pod sandbox changed.
FailedCreatePodSandBox	Failed to create pod sandbox.
FailedPodSandBoxStatus	Failed pod sandbox status.

Table 8.7. Pod worker events

Name	Description
FailedSync	Pod sync failed.

Table 8.8. System Events

Name	Description
SystemOOM	There is an OOM (out of memory) situation on the cluster.

Table 8.9. Pod events

Name	Description
FailedKillPod	Failed to stop a pod.

Name	Description
FailedCreatePodContainer	Failed to create a pod container.
Failed	Failed to make pod data directories.
NetworkNotReady	Network is not ready.
FailedCreate	Error creating: **<error-msg>**.
SuccessfulCreate	Created pod: **<pod-name>**.
FailedDelete	Error deleting: **<error-msg>**.
SuccessfulDelete	Deleted pod: **<pod-id>**.

Table 8.10. Horizontal Pod AutoScaler events

Name	Description
SelectorRequired	Selector is required.
InvalidSelector	Could not convert selector into a corresponding internal selector object.
FailedGetObjectMetric	HPA was unable to compute the replica count.
InvalidMetricSourceType	Unknown metric source type.
ValidMetricFound	HPA was able to successfully calculate a replica count.
FailedConvertHPA	Failed to convert the given HPA.
FailedGetScale	HPA controller was unable to get the target's current scale.
SucceededGetScale	HPA controller was able to get the target's current scale.
FailedComputeMetricsReplicas	Failed to compute desired number of replicas based on listed metrics.

Name	Description
FailedRescale	New size: **<size>**; reason: **<msg>**; error: **<error-msg>**.
SuccessfulRescale	New size: **<size>**; reason: **<msg>**.
FailedUpdateStatus	Failed to update status.

Table 8.11. Network events (openshift-sdn)

Name	Description
Starting	Starting OpenShift SDN.
NetworkFailed	The pod's network interface has been lost and the pod will be stopped.

Table 8.12. Network events (kube-proxy)

Name	Description
NeedPods	The service-port **<serviceName>:<port>** needs pods.

Table 8.13. Volume events

Name	Description
FailedBinding	There are no persistent volumes available and no storage class is set.
VolumeMismatch	Volume size or class is different from what is requested in claim.
VolumeFailedRecycle	Error creating recycler pod.
VolumeRecycled	Occurs when volume is recycled.
RecyclerPod	Occurs when pod is recycled.
VolumeDelete	Occurs when volume is deleted.
VolumeFailedDelete	Error when deleting the volume.

Name	Description
ExternalProvisioning	Occurs when volume for the claim is provisioned either manually or via external software.
ProvisioningFailed	Failed to provision volume.
ProvisioningCleanupFailed	Error cleaning provisioned volume.
ProvisioningSucceeded	Occurs when the volume is provisioned successfully.
WaitForFirstConsumer	Delay binding until pod scheduling.

Table 8.14. Lifecycle hooks

Name	Description
FailedPostStartHook	Handler failed for pod start.
FailedPreStopHook	Handler failed for pre-stop.
UnfinishedPreStopHook	Pre-stop hook unfinished.

Table 8.15. Deployments

Name	Description
DeploymentCancellationFailed	Failed to cancel deployment.
DeploymentCancelled	Canceled deployment.
DeploymentCreated	Created new replication controller.
IngressIPRangeFull	No available Ingress IP to allocate to service.

Table 8.16. Scheduler events

Name	Description
FailedScheduling	Failed to schedule pod: **<pod-namespace>/<pod-name>**. This event is raised for multiple reasons, for example: **AssumePodVolumes** failed, Binding rejected etc.
Preempted	By **<preemptor-namespace>/<preemptor-name>** on node **<node-name>**.
Scheduled	Successfully assigned **<pod-name>** to **<node-name>**.

Table 8.17. Daemon set events

Name	Description
SelectingAll	This daemon set is selecting all pods. A non-empty selector is required.
FailedPlacement	Failed to place pod on **<node-name>**.
FailedDaemonPod	Found failed daemon pod **<pod-name>** on node **<node-name>**, will try to kill it.

Table 8.18. LoadBalancer service events

Name	Description
CreatingLoadBalancerFailed	Error creating load balancer.
DeletingLoadBalancer	Deleting load balancer.
EnsuringLoadBalancer	Ensuring load balancer.
EnsuredLoadBalancer	Ensured load balancer.
UnAvailableLoadBalancer	There are no available nodes for **LoadBalancer** service.
LoadBalancerSourceRanges	Lists the new **LoadBalancerSourceRanges**. For example, **<old-source-range> → <new-source-range>**.
LoadbalancerIP	Lists the new IP address. For example, **<old-ip> → <new-ip>**.
ExternalIP	Lists external IP address. For example, **Added: <external-ip>**.

Name	Description
UID	Lists the new UID. For example, **<old-service-uid> → <new-service-uid>**.
ExternalTrafficPolicy	Lists the new **ExternalTrafficPolicy**. For example,**<old-policy> → <new-policy>**.
HealthCheckNodePort	Lists the new **HealthCheckNodePort**. For example,**<old-node-port> → new-node-port>**.
UpdatedLoadBalancer	Updated load balancer with new hosts.
LoadBalancerUpdateFailed	Error updating load balancer with new hosts.
DeletingLoadBalancer	Deleting load balancer.
DeletingLoadBalancerFailed	Error deleting load balancer.
DeletedLoadBalancer	Deleted load balancer.

8.2. ESTIMATING THE NUMBER OF PODS YOUR RED HAT OPENSHIFT SERVICE ON AWS NODES CAN HOLD

As a cluster administrator, you can use the OpenShift Cluster Capacity Tool to view the number of pods that can be scheduled to increase the current resources before they become exhausted, and to ensure any future pods can be scheduled. This capacity comes from an individual node host in a cluster, and includes CPU, memory, disk space, and others.

8.2.1. Understanding the OpenShift Cluster Capacity Tool

The OpenShift Cluster Capacity Tool simulates a sequence of scheduling decisions to determine how many instances of an input pod can be scheduled on the cluster before it is exhausted of resources to provide a more accurate estimation.

NOTE

The remaining allocatable capacity is a rough estimation, because it does not count all of the resources being distributed among nodes. It analyzes only the remaining resources and estimates the available capacity that is still consumable in terms of a number of instances of a pod with given requirements that can be scheduled in a cluster.

Also, pods might only have scheduling support on particular sets of nodes based on its selection and affinity criteria. As a result, the estimation of which remaining pods a cluster can schedule can be difficult.

You can run the OpenShift Cluster Capacity Tool as a stand-alone utility from the command line, or as a job in a pod inside an Red Hat OpenShift Service on AWS cluster. Running the tool as job inside of a pod enables you to run it multiple times without intervention.

8.2.2. Running the OpenShift Cluster Capacity Tool on the command line

You can run the OpenShift Cluster Capacity Tool from the command line to estimate the number of pods that can be scheduled onto your cluster.

You create a sample pod spec file, which the tool uses for estimating resource usage. The pod spec specifies its resource requirements as **limits** or **requests**. The cluster capacity tool takes the pod's resource requirements into account for its estimation analysis.

Prerequisites

1. Run the OpenShift Cluster Capacity Tool , which is available as a container image from the Red Hat Ecosystem Catalog.

2. Create a sample pod spec file:

    a. Create a YAML file similar to the following:

    ```
    apiVersion: v1
    kind: Pod
    metadata:
      name: small-pod
      labels:
        app: guestbook
        tier: frontend
    spec:
      securityContext:
        runAsNonRoot: true
        seccompProfile:
          type: RuntimeDefault
      containers:
      - name: php-redis
        image: gcr.io/google-samples/gb-frontend:v4
        imagePullPolicy: Always
        resources:
          limits:
            cpu: 150m
            memory: 100Mi
          requests:
            cpu: 150m
            memory: 100Mi
        securityContext:
          allowPrivilegeEscalation: false
          capabilities:
            drop: [ALL]
    ```

    b. Create the cluster role:

    ```
    $ oc create -f <file_name>.yaml
    ```

    For example:

```
$ oc create -f pod-spec.yaml
```

Procedure

To use the cluster capacity tool on the command line:

1. From the terminal, log in to the Red Hat Registry:

```
$ podman login registry.redhat.io
```

2. Pull the cluster capacity tool image:

```
$ podman pull registry.redhat.io/openshift4/ose-cluster-capacity
```

3. Run the cluster capacity tool:

```
$ podman run -v $HOME/.kube:/kube:Z -v $(pwd):/cc:Z  ose-cluster-capacity \
/bin/cluster-capacity --kubeconfig /kube/config --<pod_spec>.yaml /cc/<pod_spec>.yaml \
--verbose
```

where:

<pod_spec>.yaml
Specifies the pod spec to use.

verbose
Outputs a detailed description of how many pods can be scheduled on each node in the cluster.

Example output

```
small-pod pod requirements:
 - CPU: 150m
 - Memory: 100Mi

The cluster can schedule 88 instance(s) of the pod small-pod.

Termination reason: Unschedulable: 0/5 nodes are available: 2 Insufficient cpu,
3 node(s) had taint {node-role.kubernetes.io/master: }, that the pod didn't
tolerate.

Pod distribution among nodes:
small-pod
 - 192.168.124.214: 45 instance(s)
 - 192.168.124.120: 43 instance(s)
```

In the above example, the number of estimated pods that can be scheduled onto the cluster is 88.

8.2.3. Running the OpenShift Cluster Capacity Tool as a job inside a pod

Running the OpenShift Cluster Capacity Tool as a job inside of a pod allows you to run the tool multiple times without needing user intervention. You run the OpenShift Cluster Capacity Tool as a job by using a **ConfigMap** object.

Prerequisites

Download and install OpenShift Cluster Capacity Tool .

Procedure

To run the cluster capacity tool:

1. Create the cluster role:

   a. Create a YAML file similar to the following:

   ```
   kind: ClusterRole
   apiVersion: rbac.authorization.k8s.io/v1
   metadata:
     name: cluster-capacity-role
   rules:
   - apiGroups: [""]
     resources: ["pods", "nodes", "persistentvolumeclaims", "persistentvolumes", "services",
   "replicationcontrollers"]
     verbs: ["get", "watch", "list"]
   - apiGroups: ["apps"]
     resources: ["replicasets", "statefulsets"]
     verbs: ["get", "watch", "list"]
   - apiGroups: ["policy"]
     resources: ["poddisruptionbudgets"]
     verbs: ["get", "watch", "list"]
   - apiGroups: ["storage.k8s.io"]
     resources: ["storageclasses"]
     verbs: ["get", "watch", "list"]
   ```

   b. Create the cluster role by running the following command:

   ```
   $ oc create -f <file_name>.yaml
   ```

   For example:

   ```
   $ oc create sa cluster-capacity-sa
   ```

2. Create the service account:

   ```
   $ oc create sa cluster-capacity-sa -n default
   ```

3. Add the role to the service account:

   ```
   $ oc adm policy add-cluster-role-to-user cluster-capacity-role \
       system:serviceaccount:<namespace>:cluster-capacity-sa
   ```

   where:

   <namespace>

   Specifies the namespace where the pod is located.

4. Define and create the pod spec:

   a. Create a YAML file similar to the following:

a. Create a YAML file similar to the following:

```
apiVersion: v1
kind: Pod
metadata:
  name: small-pod
  labels:
    app: guestbook
    tier: frontend
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: php-redis
    image: gcr.io/google-samples/gb-frontend:v4
    imagePullPolicy: Always
    resources:
      limits:
        cpu: 150m
        memory: 100Mi
      requests:
        cpu: 150m
        memory: 100Mi
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
```

b. Create the pod by running the following command:

```
$ oc create -f <file_name>.yaml
```

For example:

```
$ oc create -f pod.yaml
```

5. Created a config map object by running the following command:

```
$ oc create configmap cluster-capacity-configmap \
    --from-file=pod.yaml=pod.yaml
```

The cluster capacity analysis is mounted in a volume using a config map object named **cluster-capacity-configmap** to mount the input pod spec file **pod.yaml** into a volume **test-volume** at the path **/test-pod**.

6. Create the job using the below example of a job specification file:

a. Create a YAML file similar to the following:

```
apiVersion: batch/v1
kind: Job
metadata:
  name: cluster-capacity-job
```

```
spec:
  parallelism: 1
  completions: 1
  template:
    metadata:
      name: cluster-capacity-pod
    spec:
        containers:
        - name: cluster-capacity
          image: openshift/origin-cluster-capacity
          imagePullPolicy: "Always"
          volumeMounts:
          - mountPath: /test-pod
            name: test-volume
          env:
          - name: CC_INCLUSTER 1
            value: "true"
          command:
          - "/bin/sh"
          - "-ec"
          - |
            /bin/cluster-capacity --podspec=/test-pod/pod.yaml --verbose
        restartPolicy: "Never"
        serviceAccountName: cluster-capacity-sa
        volumes:
        - name: test-volume
          configMap:
            name: cluster-capacity-configmap
```

1 A required environment variable letting the cluster capacity tool know that it is running inside a cluster as a pod.
The **pod.yaml** key of the **ConfigMap** object is the same as the **Pod** spec file name, though it is not required. By doing this, the input pod spec file can be accessed inside the pod as **/test-pod/pod.yaml**.

b. Run the cluster capacity image as a job in a pod by running the following command:

```
$ oc create -f cluster-capacity-job.yaml
```

Verification

1. Check the job logs to find the number of pods that can be scheduled in the cluster:

```
$ oc logs jobs/cluster-capacity-job
```

Example output

```
small-pod pod requirements:
        - CPU: 150m
        - Memory: 100Mi

The cluster can schedule 52 instance(s) of the pod small-pod.

Termination reason: Unschedulable: No nodes are available that match all of the
```

```
following predicates:: Insufficient cpu (2).

Pod distribution among nodes:
small-pod
        - 192.168.124.214: 26 instance(s)
        - 192.168.124.120: 26 instance(s)
```

8.3. RESTRICT RESOURCE CONSUMPTION WITH LIMIT RANGES

By default, containers run with unbounded compute resources on an Red Hat OpenShift Service on AWS cluster. With limit ranges, you can restrict resource consumption for specific objects in a project:

- pods and containers: You can set minimum and maximum requirements for CPU and memory for pods and their containers.
- Image streams: You can set limits on the number of images and tags in an **ImageStream** object.
- Images: You can limit the size of images that can be pushed to an internal registry.
- Persistent volume claims (PVC): You can restrict the size of the PVCs that can be requested.

If a pod does not meet the constraints imposed by the limit range, the pod cannot be created in the namespace.

8.3.1. About limit ranges

A limit range, defined by a **LimitRange** object, restricts resource consumption in a project. In the project you can set specific resource limits for a pod, container, image, image stream, or persistent volume claim (PVC).

All requests to create and modify resources are evaluated against each **LimitRange** object in the project. If the resource violates any of the enumerated constraints, the resource is rejected.

The following shows a limit range object for all components: pod, container, image, image stream, or PVC. You can configure limits for any or all of these components in the same object. You create a different limit range object for each project where you want to control resources.

Sample limit range object for a container

```
apiVersion: "v1"
kind: "LimitRange"
metadata:
  name: "resource-limits"
spec:
  limits:
    - type: "Container"
      max:
        cpu: "2"
        memory: "1Gi"
      min:
        cpu: "100m"
        memory: "4Mi"
      default:
        cpu: "300m"
        memory: "200Mi"
    defaultRequest:
      cpu: "200m"
      memory: "100Mi"
    maxLimitRequestRatio:
      cpu: "10"
```

8.3.1.1. About component limits

The following examples show limit range parameters for each component. The examples are broken out for clarity. You can create a single **LimitRange** object for any or all components as necessary.

8.3.1.1.1. Container limits

A limit range allows you to specify the minimum and maximum CPU and memory that each container in a pod can request for a specific project. If a container is created in the project, the container CPU and memory requests in the **Pod** spec must comply with the values set in the **LimitRange** object. If not, the pod does not get created.

- The container CPU or memory request and limit must be greater than or equal to the **min** resource constraint for containers that are specified in the **LimitRange** object.

- The container CPU or memory request and limit must be less than or equal to the **max** resource constraint for containers that are specified in the **LimitRange** object.
  If the **LimitRange** object defines a **max** CPU, you do not need to define a CPU **request** value in the **Pod** spec. But you must specify a CPU **limit** value that satisfies the maximum CPU constraint specified in the limit range.

- The ratio of the container limits to requests must be less than or equal to the **maxLimitRequestRatio** value for containers that is specified in the **LimitRange** object.
  If the **LimitRange** object defines a **maxLimitRequestRatio** constraint, any new containers must have both a **request** and a **limit** value. Red Hat OpenShift Service on AWS calculates the limit-to-request ratio by dividing the **limit** by the **request**. This value should be a non-negative integer greater than 1.

  For example, if a container has **cpu: 500** in the **limit** value, and **cpu: 100** in the **request** value, the limit-to-request ratio for **cpu** is **5**. This ratio must be less than or equal to the **maxLimitRequestRatio**.

If the **Pod** spec does not specify a container resource memory or limit, the **default** or **defaultRequest** CPU and memory values for containers specified in the limit range object are assigned to the container.

Container LimitRange object definition

```
apiVersion: "v1"
kind: "LimitRange"
metadata:
  name: "resource-limits" 1
spec:
  limits:
    - type: "Container"
      max:
        cpu: "2" 2
        memory: "1Gi" 3
      min:
        cpu: "100m" 4
      memory: "4Mi" (5)
    default:
      cpu: "300m" (6)
      memory: "200Mi" (7)
    defaultRequest:
      cpu: "200m" (8)
      memory: "100Mi" (9)
    maxLimitRequestRatio:
      cpu: "10" (10)
```

1. The name of the LimitRange object.
2. The maximum amount of CPU that a single container in a pod can request.
3. The maximum amount of memory that a single container in a pod can request.
4. The minimum amount of CPU that a single container in a pod can request.
5. The minimum amount of memory that a single container in a pod can request.
6. The default amount of CPU that a container can use if not specified in the **Pod** spec.
7. The default amount of memory that a container can use if not specified in the **Pod** spec.
8. The default amount of CPU that a container can request if not specified in the **Pod** spec.
9. The default amount of memory that a container can request if not specified in the **Pod** spec.
10. The maximum limit-to-request ratio for a container.

8.3.1.1.2. Pod limits

A limit range allows you to specify the minimum and maximum CPU and memory limits for all containers across a pod in a given project. To create a container in the project, the container CPU and memory requests in the **Pod** spec must comply with the values set in the **LimitRange** object. If not, the pod does not get created.

If the **Pod** spec does not specify a container resource memory or limit, the **default** or **defaultRequest** CPU and memory values for containers specified in the limit range object are assigned to the container.

Across all containers in a pod, the following must hold true:

- The container CPU or memory request and limit must be greater than or equal to the **min** resource constraints for pods that are specified in the **LimitRange** object.
- The container CPU or memory request and limit must be less than or equal to the **max** resource constraints for pods that are specified in the **LimitRange** object.
- The ratio of the container limits to requests must be less than or equal to the **maxLimitRequestRatio** constraint specified in the **LimitRange** object.

Pod LimitRange object definition

```
apiVersion: "v1"
kind: "LimitRange"
```

```
metadata:
  name: "resource-limits" 1
spec:
  limits:
    - type: "Pod"
      max:
        cpu: "2" 2
        memory: "1Gi" 3
      min:
        cpu: "200m" 4
        memory: "6Mi" 5
      maxLimitRequestRatio:
        cpu: "10" 6
```

1 The name of the limit range object.

2 The maximum amount of CPU that a pod can request across all containers.

3 The maximum amount of memory that a pod can request across all containers.

4 The minimum amount of CPU that a pod can request across all containers.

5 The minimum amount of memory that a pod can request across all containers.

6 The maximum limit-to-request ratio for a container.

8.3.1.1.3. Image limits

A **LimitRange** object allows you to specify the maximum size of an image that can be pushed to an OpenShift image registry.

When pushing images to an OpenShift image registry, the following must hold true:

- The size of the image must be less than or equal to the **max** size for images that is specified in the **LimitRange** object.

Image LimitRange object definition

```
apiVersion: "v1"
kind: "LimitRange"
metadata:
  name: "resource-limits" 1
spec:
  limits:
    - type: openshift.io/Image
      max:
        storage: 1Gi 2
```

1 The name of the **LimitRange** object.

2 The maximum size of an image that can be pushed to an OpenShift image registry.

WARNING

The image size is not always available in the manifest of an uploaded image. This is especially the case for images built with Docker 1.10 or higher and pushed to a v2 registry. If such an image is pulled with an older Docker daemon, the image manifest is converted by the registry to schema v1 lacking all the size information. No storage limit set on images prevent it from being uploaded.

The issue is being addressed.

8.3.1.1.4. Image stream limits

A **LimitRange** object allows you to specify limits for image streams.

For each image stream, the following must hold true:

- The number of image tags in an **ImageStream** specification must be less than or equal to the **openshift.io/image-tags** constraint in the **LimitRange** object.
- The number of unique references to images in an **ImageStream** specification must be less than or equal to the **openshift.io/images** constraint in the limit range object.

Imagestream LimitRange object definition

```
apiVersion: "v1"
kind: "LimitRange"
metadata:
  name: "resource-limits" 1
spec:
  limits:
    - type: openshift.io/ImageStream
      max:
        openshift.io/image-tags: 20 2
        openshift.io/images: 30 3
```

1 The name of the **LimitRange** object.

2 The maximum number of unique image tags in the **imagestream.spec.tags** parameter in imagestream spec.

3 The maximum number of unique image references in the **imagestream.status.tags** parameter in the **imagestream** spec.

The **openshift.io/image-tags** resource represents unique image references. Possible references are an **ImageStreamTag**, an **ImageStreamImage** and a **DockerImage**. Tags can be created using the **oc tag** and **oc import-image** commands. No distinction is made between internal and external references. However, each unique reference tagged in an **ImageStream** specification is counted just once. It does not restrict pushes to an internal container image registry in any way, but is useful for tag restriction.

The **openshift.io/images** resource represents unique image names recorded in image stream status. It allows for restriction of a number of images that can be pushed to the OpenShift image registry. Internal and external references are not distinguished.

8.3.1.1.5. Persistent volume claim limits

A **LimitRange** object allows you to restrict the storage requested in a persistent volume claim (PVC).

Across all persistent volume claims in a project, the following must hold true:

- The resource request in a persistent volume claim (PVC) must be greater than or equal the **min** constraint for PVCs that is specified in the **LimitRange** object.
- The resource request in a persistent volume claim (PVC) must be less than or equal the **max** constraint for PVCs that is specified in the **LimitRange** object.

PVC LimitRange object definition

```
apiVersion: "v1"
kind: "LimitRange"
metadata:
  name: "resource-limits" (1)
spec:
  limits:
    - type: "PersistentVolumeClaim"
      min:
        storage: "2Gi" (2)
      max:
        storage: "50Gi" (3)
```

(1) The name of the **LimitRange** object.

(2) The minimum amount of storage that can be requested in a persistent volume claim.

(3) The maximum amount of storage that can be requested in a persistent volume claim.

8.3.2. Creating a Limit Range

To apply a limit range to a project:

1. Create a **LimitRange** object with your required specifications:

```
apiVersion: "v1"
kind: "LimitRange"
metadata:
  name: "resource-limits" (1)
spec:
  limits:
    - type: "Pod" (2)
      max:
        cpu: "2"
        memory: "1Gi"
      min:
        cpu: "200m"
      memory: "6Mi"
  - type: "Container" (3)
    max:
      cpu: "2"
      memory: "1Gi"
    min:
      cpu: "100m"
      memory: "4Mi"
    default: (4)
      cpu: "300m"
      memory: "200Mi"
    defaultRequest: (5)
      cpu: "200m"
      memory: "100Mi"
    maxLimitRequestRatio: (6)
      cpu: "10"
  - type: openshift.io/Image (7)
    max:
      storage: 1Gi
  - type: openshift.io/ImageStream (8)
    max:
      openshift.io/image-tags: 20
      openshift.io/images: 30
  - type: "PersistentVolumeClaim" (9)
    min:
      storage: "2Gi"
    max:
      storage: "50Gi"
```

1. Specify a name for the **LimitRange** object.
2. To set limits for a pod, specify the minimum and maximum CPU and memory requests as needed.
3. To set limits for a container, specify the minimum and maximum CPU and memory requests as needed.
4. Optional. For a container, specify the default amount of CPU or memory that a container can use, if not specified in the **Pod** spec.
5. Optional. For a container, specify the default amount of CPU or memory that a container can request, if not specified in the **Pod** spec.
6. Optional. For a container, specify the maximum limit-to-request ratio that can be specified in the **Pod** spec.
7. To set limits for an Image object, set the maximum size of an image that can be pushed to an OpenShift image registry.
8. To set limits for an image stream, set the maximum number of image tags and references that can be in the **ImageStream** object file, as needed.
9. To set limits for a persistent volume claim, set the minimum and maximum amount of storage that can be requested.

2. Create the object:

```
$ oc create -f <limit_range_file> -n <project> (1)
```

(1) Specify the name of the YAML file you created and the project where you want the limits to apply.

8.3.3. Viewing a limit

You can view any limits defined in a project by navigating in the web console to the project's **Quota** page.

You can also use the CLI to view limit range details:

1. Get the list of **LimitRange** object defined in the project. For example, for a project called **demoproject**:

```
$ oc get limits -n demoproject
```

```
NAME              CREATED AT
resource-limits   2020-07-15T17:14:23Z
```

2. Describe the **LimitRange** object you are interested in, for example the **resource-limits** limit range:

```
$ oc describe limits resource-limits -n demoproject
```

```
Name:                           resource-limits
Namespace:                           demoproject
Type                           Resource                Min     Max     Default Request Default Limit   Max
Limit/Request Ratio
----                          --------                ---     ---     --------------- -------------    -----------------------
Pod                          cpu                     200m    2       -               -               -
Pod                          memory                  6Mi     1Gi     -               -               -
Container                    cpu                     100m    2       200m            300m            10
Container                    memory                  4Mi     1Gi     100Mi           200Mi           -
openshift.io/Image           storage                 -       1Gi     -               -               -
openshift.io/ImageStream     openshift.io/image      -       12      -               -               -
openshift.io/ImageStream     openshift.io/image-tags -       10      -               -               -
PersistentVolumeClaim        storage                 -       50Gi    -               -               -
```

8.3.4. Deleting a Limit Range

To remove any active **LimitRange** object to no longer enforce the limits in a project:

- Run the following command:

```
$ oc delete limits <limit_name>
```

8.4. CONFIGURING CLUSTER MEMORY TO MEET CONTAINER MEMORY AND RISK REQUIREMENTS

As a cluster administrator, you can help your clusters operate efficiently through managing application memory by:

- Determining the memory and risk requirements of a containerized application component and configuring the container memory parameters to suit those requirements.
- Configuring containerized application runtimes (for example, OpenJDK) to adhere optimally to the configured container memory parameters.
- Diagnosing and resolving memory-related error conditions associated with running in a container.

8.4.1. Understanding managing application memory

It is recommended to fully read the overview of how Red Hat OpenShift Service on AWS manages Compute Resources before proceeding.

For each kind of resource (memory, CPU, storage), Red Hat OpenShift Service on AWS allows optional **request** and **limit** values to be placed on each container in a pod.

Note the following about memory requests and memory limits:

- **Memory request**
  - The memory request value, if specified, influences the Red Hat OpenShift Service on AWS scheduler. The scheduler considers the memory request when scheduling a container to a node, then fences off the requested memory on the chosen node for the use of the container.
  - If a node’s memory is exhausted, Red Hat OpenShift Service on AWS prioritizes evicting its containers whose memory usage most exceeds their memory request. In serious cases of memory exhaustion, the node OOM killer may select and kill a process in a container based on a similar metric.
  - The cluster administrator can assign quota or assign default values for the memory request value.
  - The cluster administrator can override the memory request values that a developer specifies, to manage cluster overcommit.
- **Memory limit**
  - The memory limit value, if specified, provides a hard limit on the memory that can be allocated across all the processes in a container.
  - If the memory allocated by all of the processes in a container exceeds the memory limit, the node Out of Memory (OOM) killer will immediately select and kill a process in the container.
  - If both memory request and limit are specified, the memory limit value must be greater than or equal to the memory request.
  - The cluster administrator can assign quota or assign default values for the memory limit value.
  - The minimum memory limit is 12 MB. If a container fails to start due to a **Cannot allocate memory** pod event, the memory limit is too low. Either increase or remove the memory limit. Removing the limit allows pods to consume unbounded node resources.

8.4.1.1. Managing application memory strategy

The steps for sizing application memory on Red Hat OpenShift Service on AWS are as follows:

1. **Determine expected container memory usage**
   Determine expected mean and peak container memory usage, empirically if necessary (for example, by separate load testing). Remember to consider all the processes that may potentially run in parallel in the container: for example, does the main application spawn any ancillary scripts?

2. **Determine risk appetite**
   Determine risk appetite for eviction. If the risk appetite is low, the container should request memory according to the expected peak usage plus a percentage safety margin. If the risk appetite is higher, it may be more appropriate to request memory according to the expected mean usage.

3. **Set container memory request**
   Set container memory request based on the above. The more accurately the request represents the application memory usage, the better. If the request is too high, cluster and quota usage will be inefficient. If the request is too low, the chances of application eviction increase.

4. **Set container memory limit, if required**
   Set container memory limit, if required. Setting a limit has the effect of immediately killing a container process if the combined memory usage of all processes in the container exceeds the limit, and is therefore a mixed blessing. On the one hand, it may make unanticipated excess memory usage obvious early ("fail fast"); on the other hand it also terminates processes abruptly.

   Note that some Red Hat OpenShift Service on AWS clusters may require a limit value to be set; some may override the request based on the limit; and some application images rely on a limit value being set as this is easier to detect than a request value.

   If the memory limit is set, it should not be set to less than the expected peak container memory usage plus a percentage safety margin.

5. **Ensure application is tuned**
   Ensure application is tuned with respect to configured request and limit values, if appropriate. This step is particularly relevant to applications which pool memory, such as the JVM. The rest of this page discusses this.

8.4.2. Understanding OpenJDK settings for Red Hat OpenShift Service on AWS

The default OpenJDK settings do not work well with containerized environments. As a result, some additional Java memory settings must always be provided whenever running the OpenJDK in a container.

The JVM memory layout is complex, version dependent, and describing it in detail is beyond the scope of this documentation. However, as a starting point for running OpenJDK in a container, at least the following three memory-related tasks are key:

1. Overriding the JVM maximum heap size.

2. Encouraging the JVM to release unused memory to the operating system, if appropriate.

3. Ensuring all JVM processes within a container are appropriately configured.

Optimally tuning JVM workloads for running in a container is beyond the scope of this documentation, and may involve setting multiple additional JVM options.

8.4.2.1. Understanding how to override the JVM maximum heap size

For many Java workloads, the JVM heap is the largest single consumer of memory. Currently, the OpenJDK defaults to allowing up to 1/4 (1/**-XX:MaxRAMFraction**) of the compute node's memory to be used for the heap, regardless of whether the OpenJDK is running in a container or not. It is therefore **essential** to override this behavior, especially if a container memory limit is also set.

There are at least two ways the above can be achieved:

- If the container memory limit is set and the experimental options are supported by the JVM, set **-XX:+UnlockExperimentalVMOptions -XX:+UseCGroupMemoryLimitForHeap**.

  NOTE

  The **UseCGroupMemoryLimitForHeap** option has been removed in JDK 11. Use **-XX:+UseContainerSupport** instead.

  This sets **-XX:MaxRAM** to the container memory limit, and the maximum heap size (**-XX:MaxHeapSize** / **-Xmx**) to 1/ **-XX:MaxRAMFraction** (1/4 by default).

- Directly override one of **-XX:MaxRAM**, **-XX:MaxHeapSize** or **-Xmx**.
  This option involves hard-coding a value, but has the advantage of allowing a safety margin to be calculated.

8.4.2.2. Understanding how to encourage the JVM to release unused memory to the operating system

By default, the OpenJDK does not aggressively return unused memory to the operating system. This may be appropriate for many containerized Java workloads, but notable exceptions include workloads where additional active processes co-exist with a JVM within a container, whether those additional processes are native, additional JVMs, or a combination of the two.

Java-based agents can use the following JVM arguments to encourage the JVM to release unused memory to the operating system:

```
-XX:+UseParallelGC
-XX:MinHeapFreeRatio=5 -XX:MaxHeapFreeRatio=10 -XX:GCTimeRatio=4
-XX:AdaptiveSizePolicyWeight=90.
```

These arguments are intended to return heap memory to the operating system whenever allocated memory exceeds 110% of in-use memory (**-XX:MaxHeapFreeRatio**), spending up to 20% of CPU time in the garbage collector (**-XX:GCTimeRatio**). At no time will the application heap allocation be less than the initial heap allocation (overridden by **-XX:InitialHeapSize** / **-Xms**). Detailed additional information is available Tuning Java's footprint in OpenShift (Part 1) , Tuning Java's footprint in OpenShift (Part 2) , and at OpenJDK and Containers.

8.4.2.3. Understanding how to ensure all JVM processes within a container are appropriately configured

In the case that multiple JVMs run in the same container, it is essential to ensure that they are all configured appropriately. For many workloads it will be necessary to grant each JVM a percentage memory budget, leaving a perhaps substantial additional safety margin.

Many Java tools use different environment variables (**JAVA_OPTS**, **GRADLE_OPTS**, and so on) to configure their JVMs and it can be challenging to ensure that the right settings are being passed to the right JVM.

The **JAVA_TOOL_OPTIONS** environment variable is always respected by the OpenJDK, and values specified in **JAVA_TOOL_OPTIONS** will be overridden by other options specified on the JVM command line. By default, to ensure that these options are used by default for all JVM workloads run in the Java-based agent image, the Red Hat OpenShift Service on AWS Jenkins Maven agent image sets:

```
JAVA_TOOL_OPTIONS="-XX:+UnlockExperimentalVMOptions
-XX:+UseCGroupMemoryLimitForHeap -Dsun.zip.disableMemoryMapping=true"
```

NOTE

The **UseCGroupMemoryLimitForHeap** option has been removed in JDK 11. Use **-XX:+UseContainerSupport** instead.

This does not guarantee that additional options are not required, but is intended to be a helpful starting point.

8.4.3. Finding the memory request and limit from within a pod

An application wishing to dynamically discover its memory request and limit from within a pod should use the Downward API.

Procedure

1. Configure the pod to add the **MEMORY_REQUEST** and **MEMORY_LIMIT** stanzas:

    a. Create a YAML file similar to the following:

```
apiVersion: v1
kind: Pod
metadata:
  name: test
spec:
  securityContext:
    runAsNonRoot: true
    seccompProfile:
      type: RuntimeDefault
  containers:
  - name: test
    image: fedora:latest
    command:
    - sleep
    - "3600"
    env:
    - name: MEMORY_REQUEST (1)
      valueFrom:
        resourceFieldRef:
          containerName: test
          resource: requests.memory
    - name: MEMORY_LIMIT (2)
      valueFrom:
        resourceFieldRef:
          containerName: test
          resource: limits.memory
    resources:
      requests:
        memory: 384Mi
      limits:
        memory: 512Mi
    securityContext:
      allowPrivilegeEscalation: false
      capabilities:
        drop: [ALL]
```

(1) Add this stanza to discover the application memory request value.

(2) Add this stanza to discover the application memory limit value.

b. Create the pod by running the following command:

```
$ oc create -f <file-name>.yaml
```

Verification

1. Access the pod using a remote shell:

```
$ oc rsh test
```

2. Check that the requested values were applied:

```
$ env | grep MEMORY | sort
```

Example output

```
MEMORY_LIMIT=536870912
MEMORY_REQUEST=402653184
```

NOTE

The memory limit value can also be read from inside the container by the **/sys/fs/cgroup/memory/memory.limit_in_bytes** file.

8.4.4. Understanding OOM kill policy

Red Hat OpenShift Service on AWS can kill a process in a container if the total memory usage of all the processes in the container exceeds the memory limit, or in serious cases of node memory exhaustion.

When a process is Out of Memory (OOM) killed, this might result in the container exiting immediately. If the container PID 1 process receives the **SIGKILL**, the container will exit immediately. Otherwise, the container behavior is dependent on the behavior of the other processes.

For example, a container process exited with code 137, indicating it received a SIGKILL signal.

If the container does not exit immediately, an OOM kill is detectable as follows:

1. Access the pod using a remote shell:

   ```
   # oc rsh test
   ```

2. Run the following command to see the current OOM kill count in **/sys/fs/cgroup/memory/memory.oom_control**:

   ```
   $ grep '^oom_kill ' /sys/fs/cgroup/memory/memory.oom_control
   ```

   Example output

   ```
   oom_kill 0
   ```

3. Run the following command to provoke an OOM kill:

   ```
   $ sed -e '' </dev/zero
   ```

   Example output

   ```
   Killed
   ```

4. Run the following command to view the exit status of the **sed** command:

   ```
   $ echo $?
   ```

   Example output

   ```
   137
   ```

   The **137** code indicates the container process exited with code 137, indicating it received a SIGKILL signal.

5. Run the following command to see that the OOM kill counter in **/sys/fs/cgroup/memory/memory.oom_control** incremented:

   ```
   $ grep '^oom_kill ' /sys/fs/cgroup/memory/memory.oom_control
   ```

   Example output

   ```
   oom_kill 1
   ```

   If one or more processes in a pod are OOM killed, when the pod subsequently exits, whether immediately or not, it will have phase **Failed** and reason **OOMKilled**. An OOM-killed pod might be restarted depending on the value of **restartPolicy**. If not restarted, controllers such as the replication controller will notice the pod’s failed status and create a new pod to replace the old one.

Use the follwing command to get the pod status:

```
$ oc get pod test
```

Example output

```
NAME      READY     STATUS      RESTARTS   AGE
test      0/1       OOMKilled   0          1m
```

- If the pod has not restarted, run the following command to view the pod:

  ```
  $ oc get pod test -o yaml
  ```

  Example output

  ```
  ...
  status:
    containerStatuses:
    - name: test
      ready: false
      restartCount: 0
      state:
        terminated:
          exitCode: 137
          reason: OOMKilled
    phase: Failed
  ```

- If restarted, run the following command to view the pod:

  ```
  $ oc get pod test -o yaml
  ```

  Example output

  ```
  ...
  status:
    containerStatuses:
    - name: test
      ready: true
      restartCount: 1
      lastState:
        terminated:
          exitCode: 137
          reason: OOMKilled
      state:
        running:
    phase: Running
  ```

8.4.5. Understanding pod eviction

Red Hat OpenShift Service on AWS may evict a pod from its node when the node's memory is exhausted. Depending on the extent of memory exhaustion, the eviction may or may not be graceful. Graceful eviction implies the main process (PID 1) of each container receiving a SIGTERM signal, then some time later a SIGKILL signal if the process has not exited already. Non-graceful eviction implies the main process of each container immediately receiving a SIGKILL signal.

An evicted pod has phase **Failed** and reason **Evicted**. It will not be restarted, regardless of the value of **restartPolicy**. However, controllers such as the replication controller will notice the pod's failed status and create a new pod to replace the old one.

```
$ oc get pod test
```

Example output

```
NAME      READY     STATUS    RESTARTS   AGE
test      0/1       Evicted   0          1m
```

```
$ oc get pod test -o yaml
```

Example output

```
...
status:
  message: 'Pod The node was low on resource: [MemoryPressure].'
  phase: Failed
  reason: Evicted
```

8.5. CONFIGURING YOUR CLUSTER TO PLACE PODS ON OVERCOMMITTED NODES

In an *overcommitted* state, the sum of the container compute resource requests and limits exceeds the resources available on the system. For example, you might want to use overcommitment in development environments where a trade-off of guaranteed performance for capacity is acceptable.

Containers can specify compute resource requests and limits. Requests are used for scheduling your container and provide a minimum service guarantee. Limits constrain the amount of compute resource that can be consumed on your node.

The scheduler attempts to optimize the compute resource use across all nodes in your cluster. It places pods onto specific nodes, taking the pods' compute resource requests and nodes' available capacity into consideration.

Red Hat OpenShift Service on AWS administrators can control the level of overcommit and manage container density on nodes. You can configure cluster-level overcommit using the ClusterResourceOverride Operator to override the ratio between requests and limits set on developer containers. In conjunction with node overcommit, you can adjust the resource limit and request to achieve the desired level of overcommit.

NOTE

In Red Hat OpenShift Service on AWS, you must enable cluster-level overcommit. Node overcommitment is enabled by default. See Disabling overcommitment for a node .

8.5.1. Resource requests and overcommitment

For each compute resource, a container may specify a resource request and limit. Scheduling decisions are made based on the request to ensure that a node has enough capacity available to meet the requested value. If a container specifies limits, but omits requests, the requests are defaulted to the limits. A container is not able to exceed the specified limit on the node.

The enforcement of limits is dependent upon the compute resource type. If a container makes no request or limit, the container is scheduled to a node with no resource guarantees. In practice, the container is able to consume as much of the specified resource as is available with the lowest local priority. In low resource situations, containers that specify no resource requests are given the lowest quality of service.

Scheduling is based on resources requested, while quota and hard limits refer to resource limits, which can be set higher than requested resources. The difference between request and limit determines the level of overcommit; for instance, if a container is given a memory request of 1Gi and a memory limit of 2Gi, it is scheduled based on the 1Gi request being available on the node, but could use up to 2Gi; so it is 200% overcommitted.

8.5.2. Cluster-level overcommit using the Cluster Resource Override Operator

The Cluster Resource Override Operator is an admission webhook that allows you to control the level of overcommit and manage container density across all the nodes in your cluster. The Operator controls how nodes in specific projects can exceed defined memory and CPU limits.

You must install the Cluster Resource Override Operator using the Red Hat OpenShift Service on AWS console or CLI as shown in the following sections. During the installation, you create a **ClusterResourceOverride** custom resource (CR), where you set the level of overcommit, as shown in the following example:

```
apiVersion: operator.autoscaling.openshift.io/v1
kind: ClusterResourceOverride
metadata:
    name: cluster 1
spec:
  podResourceOverride:
    spec:
      memoryRequestToLimitPercent: 50 2
      cpuRequestToLimitPercent: 25 3
      limitCPUToMemoryPercent: 200 4
# ...
```

1. The name must be **cluster**.
2. Optional. If a container memory limit has been specified or defaulted, the memory request is overridden to this percentage of the limit, between 1-100. The default is 50.
3. Optional. If a container CPU limit has been specified or defaulted, the CPU request is overridden to this percentage of the limit, between 1-100. The default is 25.
4. Optional. If a container memory limit has been specified or defaulted, the CPU limit is overridden to a percentage of the memory limit, if specified. Scaling 1Gi of RAM at 100 percent is equal to 1 CPU core. This is processed prior to overriding the CPU request (if configured). The default is 200.

NOTE

The Cluster Resource Override Operator overrides have no effect if limits have not been set on containers. Create a **LimitRange** object with default limits per individual project or configure limits in **Pod** specs for the overrides to apply.

When configured, overrides can be enabled per-project by applying the following label to the Namespace object for each project:

```
apiVersion: v1
kind: Namespace
metadata:

# ...

  labels:
    clusterresourceoverrides.admission.autoscaling.openshift.io/enabled: "true"

# ...
```

The Operator watches for the **ClusterResourceOverride** CR and ensures that the **ClusterResourceOverride** admission webhook is installed into the same namespace as the operator.

8.5.2.1. Installing the Cluster Resource Override Operator using the web console

You can use the Red Hat OpenShift Service on AWS web console to install the Cluster Resource Override Operator to help control overcommit in your cluster.

Prerequisites

- The Cluster Resource Override Operator has no effect if limits have not been set on containers. You must specify default limits for a project using a **LimitRange** object or configure limits in **Pod** specs for the overrides to apply.

Procedure

To install the Cluster Resource Override Operator using the Red Hat OpenShift Service on AWS web console:

1. In the Red Hat OpenShift Service on AWS web console, navigate to **Home** → **Projects**
   a. Click **Create Project**.
   b. Specify **clusterresourceoverride-operator** as the name of the project.
   c. Click **Create**.
2. Navigate to **Operators** → **OperatorHub**.
   a. Choose **ClusterResourceOverride Operator** from the list of available Operators and click **Install**.
   b. On the **Install Operator** page, make sure **A specific Namespace on the cluster**is selected for **Installation Mode**.
   c. Make sure **clusterresourceoverride-operator** is selected for **Installed Namespace**.

   d. Select an **Update Channel** and **Approval Strategy**.

   e. Click **Install**.

3. On the **Installed Operators** page, click **ClusterResourceOverride**.

   a. On the **ClusterResourceOverride Operator** details page, click **Create ClusterResourceOverride**.

   b. On the **Create ClusterResourceOverride** page, click **YAML view** and edit the YAML template to set the overcommit values as needed:

```
apiVersion: operator.autoscaling.openshift.io/v1
kind: ClusterResourceOverride
metadata:
  name: cluster 1
spec:
  podResourceOverride:
    spec:
      memoryRequestToLimitPercent: 50 2
      cpuRequestToLimitPercent: 25 3
      limitCPUToMemoryPercent: 200 4
# ...
```

1 The name must be **cluster**.

2 Optional. Specify the percentage to override the container memory limit, if used, between 1-100. The default is 50.

3 Optional. Specify the percentage to override the container CPU limit, if used, between 1-100. The default is 25.

4 Optional. Specify the percentage to override the container memory limit, if used. Scaling 1Gi of RAM at 100 percent is equal to 1 CPU core. This is processed prior to overriding the CPU request, if configured. The default is 200.

   c. Click **Create**.

4. Check the current state of the admission webhook by checking the status of the cluster custom resource:

   a. On the **ClusterResourceOverride Operator** page, click **cluster**.

   b. On the **ClusterResourceOverride Details** page, click **YAML**. The **mutatingWebhookConfigurationRef** section appears when the webhook is called.

```
apiVersion: operator.autoscaling.openshift.io/v1
kind: ClusterResourceOverride
metadata:
  annotations:
    kubectl.kubernetes.io/last-applied-configuration: |

{"apiVersion":"operator.autoscaling.openshift.io/v1","kind":"ClusterResourceOverride","met
adata":{"annotations":{},"name":"cluster"},"spec":{"podResourceOverride":{"spec":
{"cpuRequestToLimitPercent":25,"limitCPUToMemoryPercent":200,"memoryRequestToLi
mitPercent":50}}}}
  creationTimestamp: "2019-12-18T22:35:02Z"
  generation: 1
  name: cluster
  resourceVersion: "127622"
  selfLink: /apis/operator.autoscaling.openshift.io/v1/clusterresourceoverrides/cluster
  uid: 978fc959-1717-4bd1-97d0-ae00ee111e8d
spec:
  podResourceOverride:
    spec:
      cpuRequestToLimitPercent: 25
      limitCPUToMemoryPercent: 200
      memoryRequestToLimitPercent: 50
status:

# ...

    mutatingWebhookConfigurationRef: (1)
      apiVersion: admissionregistration.k8s.io/v1
      kind: MutatingWebhookConfiguration
      name: clusterresourceoverrides.admission.autoscaling.openshift.io
      resourceVersion: "127621"
      uid: 98b3b8ae-d5ce-462b-8ab5-a729ea8f38f3

# ...
```

(1) Reference to the **ClusterResourceOverride** admission webhook.

8.5.2.2. Installing the Cluster Resource Override Operator using the CLI

You can use the Red Hat OpenShift Service on AWS CLI to install the Cluster Resource Override Operator to help control overcommit in your cluster.

Prerequisites

- The Cluster Resource Override Operator has no effect if limits have not been set on containers. You must specify default limits for a project using a **LimitRange** object or configure limits in **Pod** specs for the overrides to apply.

Procedure

To install the Cluster Resource Override Operator using the CLI:

1. Create a namespace for the Cluster Resource Override Operator:

   a. Create a **Namespace** object YAML file (for example, **cro-namespace.yaml**) for the Cluster Resource Override Operator:

   ```
   apiVersion: v1
   kind: Namespace
   metadata:
     name: clusterresourceoverride-operator
   ```

   b. Create the namespace:

```
$ oc create -f <file-name>.yaml
```

For example:

```
$ oc create -f cro-namespace.yaml
```

2. Create an Operator group:

   a. Create an **OperatorGroup** object YAML file (for example, cro-og.yaml) for the Cluster Resource Override Operator:

   ```
   apiVersion: operators.coreos.com/v1
   kind: OperatorGroup
   metadata:
     name: clusterresourceoverride-operator
     namespace: clusterresourceoverride-operator
   spec:
     targetNamespaces:
       - clusterresourceoverride-operator
   ```

   b. Create the Operator Group:

   ```
   $ oc create -f <file-name>.yaml
   ```

   For example:

   ```
   $ oc create -f cro-og.yaml
   ```

3. Create a subscription:

   a. Create a **Subscription** object YAML file (for example, cro-sub.yaml) for the Cluster Resource Override Operator:

   ```
   apiVersion: operators.coreos.com/v1alpha1
   kind: Subscription
   metadata:
     name: clusterresourceoverride
     namespace: clusterresourceoverride-operator
   spec:
     channel: "4"
     name: clusterresourceoverride
     source: redhat-operators
     sourceNamespace: openshift-marketplace
   ```

   b. Create the subscription:

   ```
   $ oc create -f <file-name>.yaml
   ```

   For example:

   ```
   $ oc create -f cro-sub.yaml
   ```

4. Create a **ClusterResourceOverride** custom resource (CR) object in the

4. Create a **ClusterResourceOverride** custom resource (CR) object in the **clusterresourceoverride-operator** namespace:

    a. Change to the **clusterresourceoverride-operator** namespace.

    ```
    $ oc project clusterresourceoverride-operator
    ```

    b. Create a **ClusterResourceOverride** object YAML file (for example, cro-cr.yaml) for the Cluster Resource Override Operator:

    ```
    apiVersion: operator.autoscaling.openshift.io/v1
    kind: ClusterResourceOverride
    metadata:
        name: cluster (1)
    spec:
      podResourceOverride:
        spec:
          memoryRequestToLimitPercent: 50 (2)
          cpuRequestToLimitPercent: 25 (3)
          limitCPUToMemoryPercent: 200 (4)
    ```

    (1) The name must be **cluster**.

    (2) Optional. Specify the percentage to override the container memory limit, if used, between 1-100. The default is 50.

    (3) Optional. Specify the percentage to override the container CPU limit, if used, between 1-100. The default is 25.

    (4) Optional. Specify the percentage to override the container memory limit, if used. Scaling 1Gi of RAM at 100 percent is equal to 1 CPU core. This is processed prior to overriding the CPU request, if configured. The default is 200.

    c. Create the **ClusterResourceOverride** object:

    ```
    $ oc create -f <file-name>.yaml
    ```

    For example:

    ```
    $ oc create -f cro-cr.yaml
    ```

5. Verify the current state of the admission webhook by checking the status of the cluster custom resource.

    ```
    $ oc get clusterresourceoverride cluster -n clusterresourceoverride-operator -o yaml
    ```

    The **mutatingWebhookConfigurationRef** section appears when the webhook is called.

    Example output

    ```
    apiVersion: operator.autoscaling.openshift.io/v1
    kind: ClusterResourceOverride
    metadata:
    ```

```
  annotations:
    kubectl.kubernetes.io/last-applied-configuration: |

{"apiVersion":"operator.autoscaling.openshift.io/v1","kind":"ClusterResourceOverride","metadat
a":{"annotations":{},"name":"cluster"},"spec":{"podResourceOverride":{"spec":
{"cpuRequestToLimitPercent":25,"limitCPUToMemoryPercent":200,"memoryRequestToLimitPe
rcent":50}}}}
  creationTimestamp: "2019-12-18T22:35:02Z"
  generation: 1
  name: cluster
  resourceVersion: "127622"
  selfLink: /apis/operator.autoscaling.openshift.io/v1/clusterresourceoverrides/cluster
  uid: 978fc959-1717-4bd1-97d0-ae00ee111e8d
spec:
  podResourceOverride:
    spec:
      cpuRequestToLimitPercent: 25
      limitCPUToMemoryPercent: 200
      memoryRequestToLimitPercent: 50
status:

# ...

    mutatingWebhookConfigurationRef: (1)
      apiVersion: admissionregistration.k8s.io/v1
      kind: MutatingWebhookConfiguration
      name: clusterresourceoverrides.admission.autoscaling.openshift.io
      resourceVersion: "127621"
      uid: 98b3b8ae-d5ce-462b-8ab5-a729ea8f38f3

# ...
```

(1) Reference to the **ClusterResourceOverride** admission webhook.

8.5.2.3. Configuring cluster-level overcommit

The Cluster Resource Override Operator requires a **ClusterResourceOverride** custom resource (CR) and a label for each project where you want the Operator to control overcommit.

Prerequisites

- The Cluster Resource Override Operator has no effect if limits have not been set on containers. You must specify default limits for a project using a **LimitRange** object or configure limits in **Pod** specs for the overrides to apply.

Procedure

To modify cluster-level overcommit:

1. Edit the **ClusterResourceOverride** CR:

```
apiVersion: operator.autoscaling.openshift.io/v1
kind: ClusterResourceOverride
metadata:
    name: cluster
```

```
spec:
  podResourceOverride:
    spec:
      memoryRequestToLimitPercent: 50 (1)
      cpuRequestToLimitPercent: 25 (2)
      limitCPUToMemoryPercent: 200 (3)
# ...
```

1 Optional. Specify the percentage to override the container memory limit, if used, between 1-100. The default is 50.

2 Optional. Specify the percentage to override the container CPU limit, if used, between 1-100. The default is 25.

3 Optional. Specify the percentage to override the container memory limit, if used. Scaling 1Gi of RAM at 100 percent is equal to 1 CPU core. This is processed prior to overriding the CPU request, if configured. The default is 200.

2. Ensure the following label has been added to the Namespace object for each project where you want the Cluster Resource Override Operator to control overcommit:

```
apiVersion: v1
kind: Namespace
metadata:

# ...

  labels:
    clusterresourceoverrides.admission.autoscaling.openshift.io/enabled: "true" (1)

# ...
```

1 Add this label to each project.

8.5.3. Node-level overcommit

You can use various ways to control overcommit on specific nodes, such as quality of service (QOS) guarantees, CPU limits, or reserve resources. You can also disable overcommit for specific nodes and specific projects.

8.5.3.1. Understanding compute resources and containers

The node-enforced behavior for compute resources is specific to the resource type.

8.5.3.1.1. Understanding container CPU requests

A container is guaranteed the amount of CPU it requests and is additionally able to consume excess CPU available on the node, up to any limit specified by the container. If multiple containers are attempting to use excess CPU, CPU time is distributed based on the amount of CPU requested by each container.

For example, if one container requested 500m of CPU time and another container requested 250m of CPU time, then any extra CPU time available on the node is distributed among the containers in a 2:1

ratio. If a container specified a limit, it will be throttled not to use more CPU than the specified limit. CPU requests are enforced using the CFS shares support in the Linux kernel. By default, CPU limits are enforced using the CFS quota support in the Linux kernel over a 100ms measuring interval, though this can be disabled.

8.5.3.1.2. Understanding container memory requests

A container is guaranteed the amount of memory it requests. A container can use more memory than requested, but once it exceeds its requested amount, it could be terminated in a low memory situation on the node. If a container uses less memory than requested, it will not be terminated unless system tasks or daemons need more memory than was accounted for in the node's resource reservation. If a container specifies a limit on memory, it is immediately terminated if it exceeds the limit amount.

8.5.3.2. Understanding overcomitment and quality of service classes

A node is *overcommitted* when it has a pod scheduled that makes no request, or when the sum of limits across all pods on that node exceeds available machine capacity.

In an overcommitted environment, it is possible that the pods on the node will attempt to use more compute resource than is available at any given point in time. When this occurs, the node must give priority to one pod over another. The facility used to make this decision is referred to as a Quality of Service (QoS) Class.

A pod is designated as one of three QoS classes with decreasing order of priority:

Table 8.19. Quality of Service Classes

Priority	Class Name	Description
1 (highest)	**Guaranteed**	If limits and optionally requests are set (not equal to 0) for all resources and they are equal, then the pod is classified as **Guaranteed**.
2	**Burstable**	If requests and optionally limits are set (not equal to 0) for all resources, and they are not equal, then the pod is classified as **Burstable**.
3 (lowest)	**BestEffort**	If requests and limits are not set for any of the resources, then the pod is classified as **BestEffort**.

Memory is an incompressible resource, so in low memory situations, containers that have the lowest priority are terminated first:

- **Guaranteed** containers are considered top priority, and are guaranteed to only be terminated if they exceed their limits, or if the system is under memory pressure and there are no lower priority containers that can be evicted.
- **Burstable** containers under system memory pressure are more likely to be terminated once they exceed their requests and no other **BestEffort** containers exist.
- **BestEffort** containers are treated with the lowest priority. Processes in these containers are first to be terminated if the system runs out of memory.

8.5.3.2.1. Understanding how to reserve memory across quality of service tiers

You can use the **qos-reserved** parameter to specify a percentage of memory to be reserved by a pod in a particular QoS level. This feature attempts to reserve requested resources to exclude pods from lower OoS classes from using resources requested by pods in higher QoS classes.

Red Hat OpenShift Service on AWS uses the **qos-reserved** parameter as follows:

- A value of **qos-reserved=memory=100%** will prevent the **Burstable** and **BestEffort** QoS classes from consuming memory that was requested by a higher QoS class. This increases the risk of inducing OOM on **BestEffort** and **Burstable** workloads in favor of increasing memory resource guarantees for **Guaranteed** and **Burstable** workloads.
- A value of **qos-reserved=memory=50%** will allow the **Burstable** and **BestEffort** QoS classes to consume half of the memory requested by a higher QoS class.
- A value of **qos-reserved=memory=0%** will allow a **Burstable** and **BestEffort** QoS classes to consume up to the full node allocatable amount if available, but increases the risk that a **Guaranteed** workload will not have access to requested memory. This condition effectively disables this feature.

8.5.3.3. Understanding swap memory and QOS

You can disable swap by default on your nodes to preserve quality of service (QOS) guarantees. Otherwise, physical resources on a node can oversubscribe, affecting the resource guarantees the Kubernetes scheduler makes during pod placement.

For example, if two guaranteed pods have reached their memory limit, each container could start using swap memory. Eventually, if there is not enough swap space, processes in the pods can be terminated due to the system being oversubscribed.

Failing to disable swap results in nodes not recognizing that they are experiencing **MemoryPressure**, resulting in pods not receiving the memory they made in their scheduling request. As a result, additional pods are placed on the node to further increase memory pressure, ultimately increasing your risk of experiencing a system out of memory (OOM) event.

IMPORTANT

If swap is enabled, any out-of-resource handling eviction thresholds for available memory will not work as expected. Take advantage of out-of-resource handling to allow pods to be evicted from a node when it is under memory pressure, and rescheduled on an alternative node that has no such pressure.

8.5.3.4. Understanding nodes overcommitment

In an overcommitted environment, it is important to properly configure your node to provide best system behavior.

When the node starts, it ensures that the kernel tunable flags for memory management are set properly. The kernel should never fail memory allocations unless it runs out of physical memory.

To ensure this behavior, Red Hat OpenShift Service on AWS configures the kernel to always overcommit memory by setting the **vm.overcommit_memory** parameter to **1**, overriding the default operating system setting.

Red Hat OpenShift Service on AWS also configures the kernel not to panic when it runs out of memory by setting the **vm.panic_on_oom** parameter to **0**. A setting of 0 instructs the kernel to call oom_killer in an Out of Memory (OOM) condition, which kills processes based on priority

You can view the current setting by running the following commands on your nodes:

```
$ sysctl -a |grep commit
```

Example output

```
#...
vm.overcommit_memory = 0
#...
```

```
$ sysctl -a |grep panic
```

Example output

```
#...
vm.panic_on_oom = 0
#...
```

NOTE

The above flags should already be set on nodes, and no further action is required.

You can also perform the following configurations for each node:

- Disable or enforce CPU limits using CPU CFS quotas
- Reserve resources for system processes
- Reserve memory across quality of service tiers

8.5.3.5. Disabling or enforcing CPU limits using CPU CFS quotas

Nodes by default enforce specified CPU limits using the Completely Fair Scheduler (CFS) quota support in the Linux kernel.

If you disable CPU limit enforcement, it is important to understand the impact on your node:

- If a container has a CPU request, the request continues to be enforced by CFS shares in the Linux kernel.
- If a container does not have a CPU request, but does have a CPU limit, the CPU request defaults to the specified CPU limit, and is enforced by CFS shares in the Linux kernel.
- If a container has both a CPU request and limit, the CPU request is enforced by CFS shares in the Linux kernel, and the CPU limit has no impact on the node.

Prerequisites

- Obtain the label associated with the static **MachineConfigPool** CRD for the type of node you want to configure by entering the following command:

  ```
  $ oc edit machineconfigpool <name>
  ```

For example:

```
$ oc edit machineconfigpool worker
```

Example output

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfigPool
metadata:
  creationTimestamp: "2022-11-16T15:34:25Z"
  generation: 4
  labels:
    pools.operator.machineconfiguration.openshift.io/worker: "" (1)
  name: worker
```

(1) The label appears under Labels.

TIP

If the label is not present, add a key/value pair such as:

```
$ oc label machineconfigpool worker custom-kubelet=small-pods
```

Procedure

1. Create a custom resource (CR) for your configuration change.

   Sample configuration for a disabling CPU limits

```
apiVersion: machineconfiguration.openshift.io/v1
kind: KubeletConfig
metadata:
  name: disable-cpu-units (1)
spec:
  machineConfigPoolSelector:
    matchLabels:
      pools.operator.machineconfiguration.openshift.io/worker: "" (2)
  kubeletConfig:
    cpuCfsQuota: false (3)
```

   (1) Assign a name to CR.

   (2) Specify the label from the machine config pool.

   (3) Set the **cpuCfsQuota** parameter to **false**.

2. Run the following command to create the CR:

```
$ oc create -f <file_name>.yaml
```

8.5.3.6. Reserving resources for system processes

To provide more reliable scheduling and minimize node resource overcommitment, each node can reserve a portion of its resources for use by system daemons that are required to run on your node for your cluster to function. In particular, it is recommended that you reserve resources for incompressible resources such as memory.

Procedure

To explicitly reserve resources for non-pod processes, allocate node resources by specifying resources available for scheduling. For more details, see Allocating Resources for Nodes.

8.5.3.7. Disabling overcommitment for a node

When enabled, overcommitment can be disabled on each node.

Procedure

To disable overcommitment in a node run the following command on that node:

```
$ sysctl -w vm.overcommit_memory=0
```

8.5.4. Project-level limits

To help control overcommit, you can set per-project resource limit ranges, specifying memory and CPU limits and defaults for a project that overcommit cannot exceed.

For information on project-level resource limits, see Additional resources.

Alternatively, you can disable overcommitment for specific projects.

8.5.4.1. Disabling overcommitment for a project

When enabled, overcommitment can be disabled per-project. For example, you can allow infrastructure components to be configured independently of overcommitment.

Procedure

To disable overcommitment in a project:

1. Edit the namespace object file.

2. Add the following annotation:

```
apiVersion: v1
kind: Namespace
metadata:
  annotations:
    quota.openshift.io/cluster-resource-override-enabled: "false" (1)
# ...
```

(1) Setting this annotation to **false** disables overcommit for this namespace.