



OpenShift Container Platform 3.3

Cluster Administration

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Abstract

OpenShift Cluster Administration topics cover the day to day tasks for managing your OpenShift cluster and other advanced configuration topics.

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CHAPTER 1. OVERVIEW

These Cluster Administration topics cover the day-to-day tasks for managing your OpenShift Container Platform cluster and other advanced configuration topics.

CHAPTER 2. MANAGING NODES

2.1. OVERVIEW

You can manage [nodes](#) in your instance using the [CLI](#).

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](#).

2.2. LISTING NODES

To list all nodes that are known to the master:

```
$ oc get nodes
NAME                                STATUS                                AGE
master.example.com                 Ready,SchedulingDisabled            165d
node1.example.com                  Ready                                165d
node2.example.com                  Ready                                165d
```

To only list information about a single node, replace **<node>** with the full node name:

```
$ oc get node <node>
```

The **STATUS** column in the output of these commands can show nodes with the following conditions:

Table 2.1. Node Conditions

Condition	Description
Ready	The node is passing the health checks performed from the master by returning StatusOK .
NotReady	The node is not passing the health checks performed from the master.
SchedulingDisabled	Pods cannot be scheduled for placement on the node.



NOTE

The **STATUS** column can also show **Unknown** for a node if the CLI cannot find any node condition.

To get 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
Name:    node1.example.com
```

```

Labels:    kubernetes.io/hostname=node1.example.com
CreationTimestamp: Wed, 10 Jun 2015 17:22:34 +0000
Conditions:
  Type      Status LastHeartbeatTime   LastTransitionTime  Reason           Message
  Ready     True   Wed, 10 Jun 2015 19:56:16 +0000   Wed, 10 Jun 2015 17:22:34
+0000      kubelet is posting ready status
Addresses: 127.0.0.1
Capacity:
  memory: 1017552Ki
  pods: 100
  cpu: 2
Version:
  Kernel Version: 3.17.4-301.fc21.x86_64
  OS Image: Fedora 21 (Twenty One)
  Container Runtime Version: docker://1.6.0
  Kubelet Version: v0.17.1-804-g496be63
  Kube-Proxy Version: v0.17.1-804-g496be63
ExternalID: node1.example.com
Pods:      (2 in total)
  docker-registry-1-9yyw5
  router-1-maytv
No events.

```

2.3. ADDING NODES

To add nodes to your existing OpenShift Container Platform cluster, you can run an Ansible playbook that handles installing the node components, generating the required certificates, and other important steps. See the [advanced installation](#) method for instructions on running the playbook directly.

Alternatively, if you used the quick installation method, you can [re-run the installer to add nodes](#), which performs the same steps.

2.4. DELETING NODES

When you delete a node using the CLI, the node object is deleted in Kubernetes, but the pods that exist on the node itself are not deleted. Any bare pods not backed by a replication controller would be inaccessible to OpenShift Container Platform, pods backed by replication controllers would be rescheduled to other available nodes, and [local manifest pods](#) would need to be manually deleted.

To delete a node from the OpenShift Container Platform cluster:

1. [Evacuate pods](#) from the node you are preparing to delete.
2. Delete the node object:

```
$ oc delete node <node>
```

3. Check that the node has been removed from the node list:

```
$ oc get nodes
```

Pods should now be only scheduled for the remaining nodes that are in **Ready** state.

4. If you want to uninstall all OpenShift Container Platform content from the node host, including all

Pods and containers, continue to [Uninstalling Nodes](#) and follow the procedure using the ***uninstall.yml*** playbook. The procedure assumes general understanding of the [advanced installation method](#) using Ansible.

2.5. UPDATING LABELS ON NODES

To add or update [labels](#) on a node:

```
$ oc label node <node> <key_1>=<value_1> ... <key_n>=<value_n>
```

To see more detailed usage:

```
$ oc label -h
```

2.6. LISTING PODS ON NODES

To list all or selected pods on one or more nodes:

```
$ oadm manage-node <node1> <node2> \
  --list-pods [--pod-selector=<pod_selector>] [-o json|yaml]
```

To list all or selected pods on selected nodes:

```
$ oadm manage-node --selector=<node_selector> \
  --list-pods [--pod-selector=<pod_selector>] [-o json|yaml]
```

2.7. MARKING NODES AS UNSCHEDULABLE OR SCHEDULABLE

By default, healthy nodes with a **Ready** [status](#) are marked as schedulable, meaning that new pods are allowed for placement on the node. Manually marking a node as unschedulable blocks any new pods from being scheduled on the node. Existing pods on the node are not affected.

To mark a node or nodes as unschedulable:

```
$ oadm manage-node <node1> <node2> --schedulable=false
```

For example:

```
$ oadm manage-node node1.example.com --schedulable=false
NAME                LABELS
STATUS
node1.example.com   kubernetes.io/hostname=node1.example.com
Ready,SchedulingDisabled
```

To mark a currently unschedulable node or nodes as schedulable:

```
$ oadm manage-node <node1> <node2> --schedulable
```

Alternatively, instead of specifying specific node names (e.g., **<node1>** **<node2>**), you can use the **--selector=<node_selector>** option to mark selected nodes as schedulable or unschedulable.

2.8. EVACUATING PODS ON NODES

Evacuating pods allows you to migrate all or selected pods from a given node or nodes. Nodes must first be [marked unschedulable](#) to perform pod evacuation.

Only pods backed by a [replication controller](#) can be evacuated; the replication controllers create new pods on other nodes and remove 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 selector is based on labels, so all the pods with the specified label will be evacuated.

To list pods that will be migrated without actually performing the evacuation, use the `--dry-run` option:

```
$ oadm manage-node <node1> <node2> \
  --evacuate --dry-run [--pod-selector=<pod_selector>]
```

To actually evacuate all or selected pods on one or more nodes:

```
$ oadm manage-node <node1> <node2> \
  --evacuate [--pod-selector=<pod_selector>]
```

You can force deletion of bare pods by using the `--force` option:

```
$ oadm manage-node <node1> <node2> \
  --evacuate --force [--pod-selector=<pod_selector>]
```

Alternatively, instead of specifying specific node names (e.g., `<node1> <node2>`), you can use the `--selector=<node_selector>` option to evacuate pods on selected nodes.

2.9. REBOOTING NODES

To reboot a node without causing an outage for applications running on the platform, it is important to first [evacuate the pods](#). For pods that are made highly available by the routing tier, nothing else needs to be done. For other pods needing storage, typically databases, it is critical to ensure that they can remain in operation with one pod temporarily going offline. While implementing resiliency for stateful pods is different for each application, in all cases it is important to configure the scheduler to use [node anti-affinity](#) to ensure that the pods are properly spread across available nodes.

Another challenge is how to handle nodes that are running critical infrastructure such as the router or the registry. The same node evacuation process applies, though it is important to understand certain edge cases.

2.9.1. Infrastructure Nodes

Infrastructure nodes are nodes that are labeled to run pieces of the OpenShift Container Platform environment. Currently, the easiest way to manage node reboots is to ensure that there are at least three nodes available to run infrastructure. The scenario below demonstrates a common mistake that can lead to service interruptions for the applications running on OpenShift Container Platform when only two nodes are available.

- Node A is marked unschedulable and all pods are evacuated.
- The registry pod running on that node is now redeployed on node B. This means node B is now running both registry pods.

- Node B is now marked unschedulable and is evacuated.
- The service exposing the two pod endpoints on node B, for a brief period of time, loses all endpoints until they are redeployed to node A.

The same process using three infrastructure nodes does not result in a service disruption. However, due to pod scheduling, the last node that is evacuated and brought back in to rotation is left running zero registries. The other two nodes will run two and one registries respectively. The best solution is to rely on pod anti-affinity. This is an alpha feature in Kubernetes that is available for testing now, but is not yet supported for production workloads.

2.9.2. Using Pod Anti-Affinity for the Docker Registry Pod

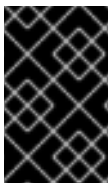
Pod anti-affinity is slightly different than [node anti-affinity](#). Node anti-affinity can be violated if there are no other suitable locations to deploy a pod. Pod anti-affinity can be set to either required or preferred.

Using the `docker-registry` pod as an example, the first step in enabling this feature is to set the `scheduler.alpha.kubernetes.io/affinity` on the pod. Since this pod uses a deployment configuration, the most appropriate place to add the annotation is to the pod template's metadata.

```
$ oc edit dc/docker-registry -o yaml

...
template:
  metadata:
    annotations:
      scheduler.alpha.kubernetes.io/affinity: |
        {
          "podAntiAffinity": {
            "requiredDuringSchedulingIgnoredDuringExecution": [{
              "labelSelector": {
                "matchExpressions": [{
                  "key": "docker-registry",
                  "operator": "In",
                  "values": ["default"]
                }]
              },
              "topologyKey": "kubernetes.io/hostname"
            }]
          }
        }

```



IMPORTANT

`scheduler.alpha.kubernetes.io/affinity` is internally stored as a string even though the contents are JSON. The above example shows how this string can be added as an annotation to a YAML deployment configuration.

This example assumes the Docker registry pod has a label of `docker-registry=default`. Pod anti-affinity can use any Kubernetes match expression.

The last required step is to enable the `MatchInterPodAffinity` scheduler predicate in `/etc/origin/master/scheduler.json`. With this in place, if only two infrastructure nodes are available and one is rebooted, the Docker registry pod is prevented from running on the other node. `oc get pods`

reports the pod as unready until a suitable node is available. Once a node is available and all pods are back in ready state, the next node can be restarted.

2.9.3. Handling Nodes Running Routers

In most cases, a pod running an OpenShift Container Platform router will expose a host port. The **PodFitsPorts** scheduler predicate ensures that no router pods using the same port can run on the same node, and pod anti-affinity is achieved. If the routers are relying on [IP failover](#) for high availability, there is nothing else that is needed. For router pods relying on an external service such as AWS Elastic Load Balancing for high availability, it is that service's responsibility to react to router pod restarts.

In rare cases, a router pod might not have a host port configured. In those cases, it is important to follow the [recommended restart process](#) for infrastructure nodes.

2.10. CONFIGURING NODE RESOURCES

You can configure node resources by adding kubelet arguments to the node configuration file (*/etc/origin/node/node-config.yaml*). Add the **kubeletArguments** section and include any desired options:

```
kubeletArguments:
  max-pods: 1
    - "40"
  resolv-conf: 2
    - "/etc/resolv.conf"
  image-gc-high-threshold: 3
    - "90"
  image-gc-low-threshold: 4
    - "80"
```

- 1 [Maximum number of pods that can run on this kubelet.](#)
- 2 [Resolver configuration file used as the basis for the container DNS resolution configuration.](#)
- 3 [The percent of disk usage after which image garbage collection is always run. Default: 90%](#)
- 4 [The percent of disk usage before which image garbage collection is never run. Lowest disk usage to garbage collect to. Default: 80%](#)

To view all available kubelet options:

```
$ kubelet -h
```

This can also be set during an [advanced installation](#) using the **openshift_node_kubelet_args** variable. For example:

```
openshift_node_kubelet_args={'max-pods': ['40'], 'resolv-conf':
['/etc/resolv.conf'], 'image-gc-high-threshold': ['90'], 'image-gc-low-
threshold': ['80']}
```

2.10.1. Setting Maximum Pods Per Node

In the `/etc/origin/node/node-config.yaml` file, two parameters control the maximum number of pods that can be scheduled to a node: **pods-per-core** and **max-pods** . When both options are in use, the lower of the two limits the number of pods on a node.

pods-per-core sets the number of pods the node can run based on the number of processor cores on the node. For example, if **pods-per-core** is set to **10** on a node with 4 processor cores, the maximum number of pods allowed on the node will be 40.

```
kubeletArguments:
  pods-per-core:
    - "10"
```

max-pods sets the number of pods the node can run to a fixed value, regardless of the properties of the node.

```
kubeletArguments:
  max-pods:
    - "250"
```

Using the above example, the default value for **pods-per-core** is **10** and the default value for **max-pods** is **250** . This means that unless the node has 25 cores or more, by default, **pods-per-core** will be the limiting factor.

2.11. CHANGING NODE TRAFFIC INTERFACE

By default, DNS routes all node traffic. During node registration, the master receives the node IP addresses from the DNS configuration, and therefore accessing nodes via DNS is the most flexible solution for most deployments.

If your deployment is using a cloud provider, then the node gets the IP information from the cloud provider. However, **openshift-sdn** attempts to determine the IP through a variety of methods, including a DNS lookup on the nodeName (if set), or on the system hostname (if nodeName is not set).

However, you may need to change the node traffic interface. For example, where:

- OpenShift Container Platform is installed in a cloud provider where internal hostnames are not configured/resolvable by all hosts.
- The node's IP from the master's perspective is not the same as the node's IP from its own perspective.

Configuring the **openshift_set_node_ip** Ansible variable forces node traffic through an interface other than the default network interface.

To change the node traffic interface:

1. Set the **openshift_set_node_ip** Ansible variable to **true** .
2. Set the **openshift_ip** to the IP address for the node you want to configure.

Although **openshift_set_node_ip** can be useful as a workaround for the cases stated in this section, it is generally not suited for production environments. This is because the node will no longer function properly if it receives a new IP address.

CHAPTER 3. MANAGING USERS

3.1. OVERVIEW

This topic describes the management of [user](#) accounts, including how new user accounts are created in OpenShift Container Platform and how they can be deleted.

3.2. ADDING A USER

After new users log in to OpenShift Container Platform, an account is created for that user per the [identity provider](#) configured on the master. The cluster administrator can [manage the access level of each user](#).

3.3. VIEWING USER AND IDENTITY LISTS

OpenShift Container Platform user configuration is stored in several locations within OpenShift Container Platform. Regardless of the identity provider, OpenShift Container Platform internally stores details like role-based access control (RBAC) information and group membership. To completely remove user information, this data must be removed in addition to the user account.

In OpenShift Container Platform, two object types contain user data outside the identification provider: **user** and **identity**.

To get the current list of users:

```
$ oc get user
NAME          UID                                FULL NAME    IDENTITIES
demo         75e4b80c-dbf1-11e5-8dc6-0e81e52cc949
htpasswd_auth:demo
```

To get the current list of identities:

```
$ oc get identity
NAME          IDP NAME          IDP USER NAME    USER NAME    USER
UID
htpasswd_auth:demo    htpasswd_auth    demo             demo
75e4b80c-dbf1-11e5-8dc6-0e81e52cc949
```

Note the matching UID between the two object types. If you attempt to change the authentication provider after starting to use OpenShift Container Platform, the user names that overlap will not work because of the entries in the identity list, which will still point to the old authentication method.

3.4. MANAGING USER AND GROUP LABELS

To add a label to a user or group:

```
$ oc label user/<user_name> <label_name>
```

For example, if the user name is **theuser** and the label is **level=gold**:

```
$ oc label user/theuser level=gold
```

To remove the label:

```
$ oc label user/<user_name> <label_name>-
```

To show labels for a user or group:

```
$ oc describe user/<user_name>
```

3.5. DELETING A USER

To delete a user:

1. Delete the user record:

```
$ oc delete user demo
user "demo" deleted
```

2. Delete the user identity.

The identity of the user is related to the identification provider you use. Get the provider name from the user record in `oc get user`.

In this example, the identity provider name is `htpasswd_auth`. The command is:

```
# oc delete identity htpasswd_auth:demo
identity "htpasswd_auth:demo" deleted
```

If you skip this step, the user will not be able to log in again.

After you complete these steps, a new account will be created in OpenShift Container Platform when the user logs in again.

If your intention is to prevent the user from being able to log in again (for example, if an employee has left the company and you want to permanently delete the account), you can also remove the user from your authentication back end (like `htpasswd`, `kerberos`, or others) for the configured identity provider.

For example, if you are using `htpasswd`, delete the entry in the `htpasswd` file that is configured for OpenShift Container Platform with the user name and password.

For external identification management like Lightweight Directory Access Protocol (LDAP) or Red Hat Identity Management (IdM), use the user management tools to remove the user entry.

CHAPTER 4. MANAGING PROJECTS

4.1. OVERVIEW

In OpenShift Container Platform, projects are used to group and isolate related objects. As an administrator, you can give developers access to certain projects, allow them to create their own, and give them administrative rights within individual projects.

4.2. SELF-PROVISIONING PROJECTS

You can allow developers to create their own projects. There is an endpoint that will provision a project according to a [template](#). The web console and `oc new-project` command use this endpoint when a developer [creates a new project](#).

4.2.1. Modifying the Template for New Projects

The API server automatically provisions projects based on the template that is identified by the `projectRequestTemplate` parameter of the `master-config.yaml` file. If the parameter is not defined, the API server creates a default template that creates a project with the requested name, and assigns the requesting user to the "admin" role for that project.

To create your own custom project template:

1. Start with the current default project template:

```
$ oadm create-bootstrap-project-template -o yaml > template.yaml
```

2. Use a text editor to modify the `template.yaml` file by adding objects or modifying existing objects.

3. Load the template:

```
$ oc create -f template.yaml -n default
```

4. Modify the `master-config.yaml` file to reference the loaded template:

```
...
projectConfig:
  projectRequestTemplate: "default/project-request"
...
```

When a project request is submitted, the API substitutes the following parameters into the template:

Parameter	Description
<code>PROJECT_NAME</code>	The name of the project. Required.
<code>PROJECT_DISPLAYNAME</code>	The display name of the project. May be empty.
<code>PROJECT_DESCRIPTION</code>	The description of the project. May be empty.

Parameter	Description
PROJECT_ADMIN_USER	The username of the administrating user.
PROJECT_REQUESTING_USER	The username of the requesting user.

Access to the API is granted to developers with the [self-provisioner role](#) and the **self-provisioners** cluster role binding. This role is available to all authenticated developers by default.

4.2.2. Disabling Self-provisioning

You can prevent an authenticated user group from self-provisioning new projects.

1. Log in as a user with [cluster-admin](#) privileges.
2. Remove the **self-provisioners** [cluster role](#) from the group.

```
$ oadm policy remove-cluster-role-from-group self-provisioner
system:authenticated system:authenticated:oauth
```

3. Set the **projectRequestMessage** parameter value in the *master-config.yaml* file to instruct developers how to request a new project. This parameter value is a string that will be presented to a user in the web console and command line when the user attempts to self-provision a project. You might use one of the following messages:
 - To request a project, contact your system administrator at projectname@example.com.
 - To request a new project, fill out the project request form located at <https://internal.example.com/openshift-project-request>.

Example YAML file

```
...
projectConfig:
  ProjectRequestMessage: "message"
...
```

4. Edit the **self-provisioners** cluster role to prevent [automatic updates](#) to the role. Automatic updates reset the cluster roles to the default state.

- To update the role from the command line:

- i. Run the following command:

```
$ oc edit clusterrole self-provisioner
```

- ii. In the displayed role, set the **openshift.io/reconcile-protect** parameter value to **true**, as shown in the following example:

```
apiVersion: authorization.openshift.io/v1
kind: ClusterRole
```



```

metadata:
  annotations:
    authorization.openshift.io/system-only: "true"
    openshift.io/description: A user that can request project.
    openshift.io/reconcile-protect: "true"
  ...

```

- To update the role by using automation, use the following command:

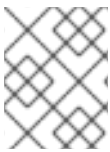
```

$ oc patch clusterrole self-provisioner -p '{ "metadata": {
"annotations": { "openshift.io/reconcile-protect": "true" } } }'

```

4.3. USING NODE SELECTORS

Node selectors are used in conjunction with labeled nodes to control pod placement.



NOTE

Labels can be assigned [during an advanced installation](#), or [added to a node after installation](#).

4.3.1. Setting the Cluster-wide Default Node Selector

As a cluster administrator, you can set the cluster-wide default node selector to restrict pod placement to specific nodes.

Edit the master configuration file at `/etc/origin/master/master-config.yaml` and add a value for a default node selector. This is applied to the pods created in all projects without a specified `nodeSelector` value:

```

...
projectConfig:
  defaultNodeSelector: "type=user-node,region=east"
...

```

Restart the OpenShift service for the changes to take effect:

```

# systemctl restart atomic-openshift-master

```

4.3.2. Setting the Project-wide Node Selector

To create an individual project with a node selector, use the `--node-selector` option when creating a project. For example, if you have an OpenShift Container Platform topology with multiple regions, you can use a node selector to restrict specific OpenShift Container Platform projects to only deploy pods onto nodes in a specific region.

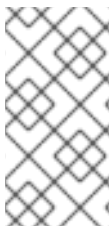
The following creates a new project named `myproject` and dictates that pods be deployed onto nodes labeled `user-node` and `east`:

```

$ oadm new-project myproject \
  --node-selector='type=user-node,region=east'

```

Once this command is run, this becomes the administrator-set node selector for all pods contained in the specified project.



NOTE

While the **new-project** subcommand is available for both **oadm** and **oc**, the cluster administrator and developer commands respectively, creating a new project with a node selector is only available with the **oadm** command. The **new-project** subcommand is not available to project developers when self-provisioning projects.

Using the **oadm new-project** command adds an **annotation** section to the project. You can edit a project, and change the **openshift.io/node-selector** value to override the default:

```
...
metadata:
  annotations:
    openshift.io/node-selector: type=user-node,region=east
...
```

If **openshift.io/node-selector** is set to an empty string (**oadm new-project --node-selector=""**), the project will not have an administrator-set node selector, even if the cluster-wide default has been set. This means that, as a cluster administrator, you can set a default to restrict developer projects to a subset of nodes and still enable infrastructure or other projects to schedule the entire cluster.

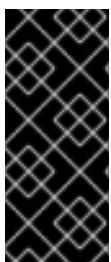
4.3.3. Developer-specified Node Selectors

OpenShift Container Platform developers [can set a node selector on their pod configuration](#) if they wish to restrict nodes even further. This will be in addition to the project node selector, meaning that you can still dictate node selector values for all projects that have a node selector value.

For example, if a project has been created with the above annotation (**openshift.io/node-selector: type=user-node,region=east**) and a developer sets another node selector on a pod in that project, for example **clearance=classified**, the pod will only ever be scheduled on nodes that have all three labels (**type=user-node**, **region=east**, and **clearance=classified**). If they set **region=west** on a pod, their pods would be demanding nodes with labels **region=east** and **region=west**, which cannot work. The pods will never be scheduled, because labels can only be set to one value.

4.4. LIMITING NUMBER OF SELF-PROVISIONED PROJECTS PER USER

The number of self-provisioned projects requested by a given user can be limited with the [ProjectRequestLimit admission control plug-in](#).



IMPORTANT

If your project request template was created in OpenShift Container Platform 3.1 or earlier using the process described in [Modifying the Template for New Projects](#), then the generated template does not include the annotation **openshift.io/requester: \${PROJECT_REQUESTING_USER}**, which is used for the **ProjectRequestLimitConfig**. You must add the annotation.

In order to specify limits for users, a configuration must be specified for the plug-in within the master configuration file (*/etc/origin/master/master-config.yaml*). The plug-in configuration takes a list of user label selectors and the associated maximum project requests.

Selectors are evaluated in order. The first one matching the current user will be used to determine the maximum number of projects. If a selector is not specified, a limit applies to all users. If a maximum number of projects is not specified, then an unlimited number of projects are allowed for a specific selector.

The following configuration sets a global limit of 2 projects per user while allowing 10 projects for users with a label of **level=advanced** and unlimited projects for users with a label of **level=admin**.

```
admissionConfig:
  pluginConfig:
    ProjectRequestLimit:
      configuration:
        apiVersion: v1
        kind: ProjectRequestLimitConfig
        limits:
          - selector:
              level: admin ❶
          - selector:
              level: advanced ❷
            maxProjects: 10
          - maxProjects: 2 ❸
```

- ❶ For selector **level=admin**, no **maxProjects** is specified. This means that users with this label will not have a maximum of project requests.
- ❷ For selector **level=advanced**, a maximum number of 10 projects will be allowed.
- ❸ For the third entry, no selector is specified. This means that it will be applied to any user that doesn't satisfy the previous two rules. Because rules are evaluated in order, this rule should be specified last.



NOTE

[Managing User and Group Labels](#) provides further guidance on how to add, remove, or show labels for users and groups.

Once your changes are made, restart OpenShift Container Platform for the changes to take effect.

```
# systemctl restart atomic-openshift-master
```

CHAPTER 5. MANAGING PODS

5.1. OVERVIEW

This topic describes the management of [pods](#), including managing their networks, limiting their run-once duration, and limiting what they can access, and how much bandwidth they can use.

5.2. MANAGING POD NETWORKS

When your cluster is configured to use [the ovs-multitenant SDN plug-in](#), you can manage the separate pod overlay networks for projects using the administrator CLI. See the [Configuring the SDN](#) section for plug-in configuration steps, if necessary.

5.2.1. Joining Project Networks

To join projects to an existing project network:

```
$ oadm pod-network join-projects --to=<project1> <project2> <project3>
```

In the above example, all the pods and services in **<project2>** and **<project3>** can now access any pods and services in **<project1>** and vice versa.

Alternatively, instead of specifying specific project names, you can use the **--selector=<project_selector>** option.

5.3. ISOLATING PROJECT NETWORKS

To isolate the project network in the cluster and vice versa, run:

```
$ oadm pod-network isolate-projects <project1> <project2>
```

In the above example, all of the pods and services in **<project1>** and **<project2>** can *not* access any pods and services from other non-global projects in the cluster and vice versa.

Alternatively, instead of specifying specific project names, you can use the **--selector=<project_selector>** option.

5.3.1. Making Project Networks Global

To allow projects to access all pods and services in the cluster and vice versa:

```
$ oadm pod-network make-projects-global <project1> <project2>
```

In the above example, all the pods and services in **<project1>** and **<project2>** can now access any pods and services in the cluster and vice versa.

Alternatively, instead of specifying specific project names, you can use the **--selector=<project_selector>** option.

5.4. LIMITING RUN-ONCE POD DURATION

OpenShift Container Platform relies on run-once pods to perform tasks such as deploying a pod or performing a build. Run-once pods are pods that have a **RestartPolicy** of **Never** or **OnFailure**.

The cluster administrator can use the **RunOnceDuration** admission control plug-in to force a limit on the time that those run-once pods can be active. Once the time limit expires, the cluster will try to actively terminate those pods. The main reason to have such a limit is to prevent tasks such as builds to run for an excessive amount of time.

5.4.1. Configuring the RunOnceDuration Plug-in

The plug-in configuration should include the default active deadline for run-once pods. This deadline is enforced globally, but can be superseded on a per-project basis.

```
kubernetesMasterConfig:
  admissionConfig:
    pluginConfig:
      RunOnceDuration:
        configuration:
          apiVersion: v1
          kind: RunOnceDurationConfig
          activeDeadlineSecondsOverride: 3600 1
```

- 1 Specify the global default for run-once pods in seconds.

5.4.2. Specifying a Custom Duration per Project

In addition to specifying a global maximum duration for run-once pods, an administrator can add an annotation (**openshift.io/active-deadline-seconds-override**) to a specific project to override the global default.

```
apiVersion: v1
kind: Project
metadata:
  annotations:
    openshift.io/active-deadline-seconds-override: "1000" 1
```

- 1 Overrides the default active deadline seconds for run-once pods to 1000 seconds. Note that the value of the override must be specified in string form.

5.5. CONTROLLING EGRESS TRAFFIC

As an OpenShift Container Platform cluster administrator, you can control egress traffic in two ways:

Firewall

Using an egress firewall allows you to enforce the acceptable outbound traffic policies, so that specific endpoints or IP ranges (subnets) are the only acceptable targets for the dynamic endpoints (pods within OpenShift Container Platform) to talk to.

Router

Using an egress router allows you to create identifiable services to send traffic to a specific destination, ensuring an external destination treats traffic as though it were coming from a known source. This helps with security, because it allows you to secure an external database so that only

specific pods in a namespace can talk to a service (the egress router), which proxies the traffic to your database.

5.5.1. Using an Egress Firewall to Limit Access to External Resources

As an OpenShift Container Platform cluster administrator, you can use egress firewall policy to limit the external addresses that some or all pods can access from within the cluster, so that:

- A pod can only talk to internal hosts, and cannot initiate connections to the public Internet.
Or,
- A pod can only talk to the public Internet, and cannot initiate connections to internal hosts (outside the cluster).
Or,
- A pod cannot reach specified internal subnets/hosts that it should have no reason to contact.

You can configure projects to have different egress policies. For example, allowing **<project A>** access to a specified IP range, but denying the same access to **<project B>**. Or restrict application developers from updating from (Python) pip mirrors, and forcing updates to only come from desired sources.

CAUTION

You must have the [ovs-multitenant plug-in](#) enabled in order to limit pod access via egress policy.

Project administrators can neither create **EgressNetworkPolicy** objects, nor edit the ones you create in their project. There are also several other restrictions on where **EgressNetworkPolicy** can be created:

- The **default** project (and any other project that has been made global via **oadm pod-network make-projects-global**) cannot have egress policy.
- If you merge two projects together (via **oadm pod-network join-projects**), then you cannot use egress policy in *any* of the joined projects.
- No project may have more than one egress policy object.

Violating any of these restrictions results in broken egress policy for the project, and may cause all external network traffic to be dropped.

Use the **oc** command or the REST API to configure egress policy. You can use **oc [create|replace|delete]** to manipulate **EgressNetworkPolicy** objects. The **api/swagger-spec/oapi-v1.json** file has API-level details on how the objects actually work.

To configure egress policy:

1. Navigate to the project you want to affect.
2. Create a JSON file with the desired policy details. For example:

```
{
  "kind": "EgressNetworkPolicy",
  "apiVersion": "v1",
  "metadata": {
```

```

        "name": "default"
      },
      "spec": {
        "egress": [
          {
            "type": "Allow",
            "to": {
              "cidrSelector": "1.2.3.0/24"
            }
          },
          {
            "type": "Deny",
            "to": {
              "cidrSelector": "0.0.0.0/0" ❶
            }
          }
        ]
      }
    }
  }
}

```

- ❶ In earlier versions of {product-name}, a bug required you to specify "**0.0.0.0/32**" rather than "**0.0.0.0/0**" for a "match all" rule. This is fixed as of 3.3.1.25.

When the example above is added in a project, it allows traffic to **1.2.3.0/24**, but denies access to all other external IP addresses. (Traffic to other pods is not affected because the policy only applies to *external* traffic.)

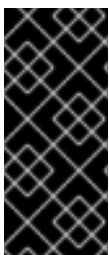
The rules in an **EgressNetworkPolicy** are checked in order, and the first one that matches takes effect. If the two rules in the above example were swapped, then traffic would not be allowed to **1.2.3.0/24** because the **0.0.0.0/0** rule would be checked first, and it would match and deny all traffic.

- Use the JSON file to create an EgressNetworkPolicy object:

```
# oc create -f <policy>.json
```

5.5.2. Using an Egress Router to Allow External Resources to Recognize Pod Traffic

The OpenShift Container Platform egress router runs a service that redirects traffic to a specified remote server, using a private source IP address that is not used for anything else. The service allows pods to talk to servers that are set up to only allow access from whitelisted IP addresses.



IMPORTANT

The egress router is not intended for every outgoing connection. Creating large numbers of egress routers can push the limits of your network hardware. For example, creating an egress router for every project or application could exceed the number of local MAC addresses that the network interface can handle before falling back to filtering MAC addresses in software.

5.5.2.1. Important Deployment Considerations

The Egress router adds a second IP address and MAC address to the node's primary network interface. If you are not running OpenShift Container Platform on bare metal, you may need to configure your hypervisor or cloud provider to allow the additional address.

Red Hat OpenStack Platform

If you are deploying OpenShift Container Platform on Red Hat OpenStack Platform, you need to whitelist the IP and MAC addresses on your Openstack environment, otherwise [communication will fail](#):

```
neutron port-update $neutron_port_uuid \
  --allowed_address_pairs list=true \
  type=dict mac_address=<mac_address>,ip_address=<ip_address>
```

Red Hat Enterprise Virtualization

If you are using [Red Hat Enterprise Virtualization](#), you should set `EnableMACAntiSpoofingFilterRules` to `false`.

VMware vSphere

If you are using VMware vSphere, follow VMware's [Securing Virtual Switch Ports](#) and [Forged Transmissions](#) guidance.

5.5.2.2. Deploying an Egress Router Pod

1. Create a pod configuration using the following:

Example 5.1. Example Pod Definition for an Egress Router

```
apiVersion: v1
kind: Pod
metadata:
  name: egress-1
  labels:
    name: egress-1
  annotations:
    pod.network.openshift.io/assign-macvlan: "true" 1
spec:
  containers:
  - name: egress-router
    image: registry.access.redhat.com/openshift3/ose-egress-router
    securityContext:
      privileged: true
    env:
      - name: EGRESS_SOURCE 2
        value: 192.168.12.99
      - name: EGRESS_GATEWAY 3
        value: 192.168.12.1
      - name: EGRESS_DESTINATION 4
        value: 203.0.113.25
  nodeSelector:
    site: springfield-1 5
```


- 1 The `pod.network.openshift.io/assign-macvlan` annotation creates a Macvlan network interface on the primary network interface, and then moves it into the pod's network name space before starting the **egress-router** container. Preserve the the quotation marks around `"true"`. Omitting them will result in errors.
- 2 An IP address from the physical network that the node itself is on and is reserved by the cluster administrator for use by this pod.
- 3 Same value as the default gateway used by the node itself.
- 4 The external server that to direct traffic to. Using this example, connections to the pod are redirected to 203.0.113.25, with a source IP address of 192.168.12.99.
- 5 The pod will only be deployed to nodes with the label `site=springfield-1`.

2. Create the pod using the above definition:

```
$ oc create -f <pod_name>.json
```

To check to see if the pod has been created:

```
oc get pod <pod_name>
```

3. Ensure other pods can find the pod's IP address by creating a service to point to the egress router:

```
apiVersion: v1
kind: Service
metadata:
  name: egress-1
spec:
  ports:
    - name: http
      port: 80
    - name: https
      port: 443
  type: ClusterIP
  selector:
    name: egress-1
```

Your pods can now connect to this service. Their connections are redirected to the corresponding ports on the external server, using the reserved egress IP address.

The pod contains a single container, using the **openshift3/ose-egress-router** image, and that container is run privileged so that it can configure the Macvlan interface and set up **iptables** rules.

The environment variables tell the **egress-router** image what addresses to use; it will configure the Macvlan interface to use **EGRESS_SOURCE** as its IP address, with **EGRESS_GATEWAY** as its gateway.

NAT rules are set up so that connections to any TCP or UDP port on the pod's cluster IP address are redirected to the same port on **EGRESS_DESTINATION**.

If only some of the nodes in your cluster are capable of claiming the specified source IP address and using the specified gateway, you can specify a **nodeName** or **nodeSelector** indicating which nodes are acceptable.

5.5.2.3. Enabling Failover for Egress Router Pods

Using a replication controller, you can ensure that there is always one copy of the egress router pod in order to prevent downtime.

1. Create a replication controller configuration file using the following:

```
apiVersion: v1
kind: ReplicationController
metadata:
  name: egress-demo-controller
spec:
  replicas: 1 1
  selector:
    name: egress-demo
  template:
    metadata:
      name: egress-demo
      labels:
        name: egress-demo
      annotations:
        pod.network.openshift.io/assign-macvlan: "true"
    spec:
      containers:
      - name: egress-demo-container
        image: openshift/origin-egress-router
        env:
        - name: EGRESS_SOURCE
          value: 192.168.12.99
        - name: EGRESS_GATEWAY
          value: 192.168.12.1
        - name: EGRESS_DESTINATION
          value: 203.0.113.25
        securityContext:
          privileged: true
      nodeSelector:
        site: springfield-1
```

- 1** Ensure **replicas** is set to **1**, because only one pod can be using a given **EGRESS_SOURCE** value at any time. This means that only a single copy of the router will be running, on a node with the label **site=springfield-1**.

2. Create the pod using the definition:

```
$ oc create -f <replication_controller>.json
```

3. To verify, check to see if the replication controller pod has been created:

```
oc describe rc <replication_controller>
```

5.6. 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.

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:

Example 5.2. Limited Pod Object Definition

```
{
  "kind": "Pod",
  "spec": {
    "containers": [
      {
        "image": "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>
```

CHAPTER 6. CONFIGURING SERVICE ACCOUNTS

6.1. OVERVIEW

When a person uses the OpenShift Container Platform CLI or web console, their API token authenticates them to the OpenShift Container Platform API. However, when a regular user's credentials are not available, it is common for components to make API calls independently. For example:

- Replication controllers make API calls to create or delete pods.
- Applications inside containers can make API calls for discovery purposes.
- External applications can make API calls for monitoring or integration purposes.

Service accounts provide a flexible way to control API access without sharing a regular user's credentials.

6.2. USER NAMES AND GROUPS

Every service account has an associated user name that can be granted roles, just like a regular user. The user name is derived from its project and name:

```
system:serviceaccount:<project>:<name>
```

For example, to add the **view** role to the **robot** service account in the **top-secret** project:

```
$ oc policy add-role-to-user view system:serviceaccount:top-secret:robot
```

IMPORTANT

If you want to grant access to a specific service account in a project, you can use the **-z** flag. From the project to which the service account belongs, use the **-z** flag and specify the **<serviceaccount_name>**. This is highly recommended, as it helps prevent typos and ensures that access is granted only to the specified service account. For example:

```
$ oc policy add-role-to-user <role_name> -z
<serviceaccount_name>
```

If not in the project, use the **-n** option to indicate the project namespace it applies to, as shown in the examples below.

Every service account is also a member of two groups:

system:serviceaccounts

Includes all service accounts in the system.

system:serviceaccounts:<project>

Includes all service accounts in the specified project.

For example, to allow all service accounts in all projects to view resources in the **top-secret** project:

```
$ oc policy add-role-to-group view system:serviceaccounts -n top-secret
```

To allow all service accounts in the **managers** project to edit resources in the **top-secret** project:

```
$ oc policy add-role-to-group edit system:serviceaccounts:managers -n top-secret
```

6.3. MANAGING SERVICE ACCOUNTS

Service accounts are API objects that exist within each project. To manage service accounts, you can use the **oc** command with the **sa** or **serviceaccount** object type or use the web console.

To get a list of existing service accounts in the current project:

```
$ oc get sa
NAME          SECRETS  AGE
builder       2         2d
default       2         2d
deployer      2         2d
```

To create a new service account:

```
$ oc create sa robot
serviceaccount "robot" created
```

As soon as a service account is created, two secrets are automatically added to it:

- an API token
- credentials for the OpenShift Container Registry

These can be seen by describing the service account:

```
$ oc describe sa robot
Name: robot
Namespace: project1
Labels: <none>
Annotations: <none>

Image pull secrets: robot-dockercfg-qzbhb

Mountable secrets:  robot-token-f4khf
                   robot-dockercfg-qzbhb

Tokens:             robot-token-f4khf
                   robot-token-z8h44
```

The system ensures that service accounts always have an API token and registry credentials.

The generated API token and registry credentials do not expire, but they can be revoked by deleting the secret. When the secret is deleted, a new one is automatically generated to take its place.

6.4. ENABLING SERVICE ACCOUNT AUTHENTICATION

Service accounts authenticate to the API using tokens signed by a private RSA key. The authentication layer verifies the signature using a matching public RSA key.

To enable service account token generation, update the **serviceAccountConfig** stanza in the */etc/origin/master/master-config.yml* file on the master to specify a **privateKeyFile** (for signing), and a matching public key file in the **publicKeyFiles** list:

```
serviceAccountConfig:
  ...
  masterCA: ca.crt 1
  privateKeyFile: serviceaccounts.private.key 2
  publicKeyFiles:
  - serviceaccounts.public.key 3
  - ...
```

- 1 CA file used to validate the API server's serving certificate.
- 2 Private RSA key file (for token signing).
- 3 Public RSA key files (for token verification). If private key files are provided, then the public key component is used. Multiple public key files can be specified, and a token will be accepted if it can be validated by one of the public keys. This allows rotation of the signing key, while still accepting tokens generated by the previous signer.

6.5. MANAGED SERVICE ACCOUNTS

Service accounts are required in each project to run builds, deployments, and other pods. The **managedNames** setting in the */etc/origin/master/master-config.yml* file on the master controls which service accounts are automatically created in every project:

```
serviceAccountConfig:
  ...
  managedNames: 1
  - builder 2
  - deployer 3
  - default 4
  - ...
```

- 1 List of service accounts to automatically create in every project.
- 2 A **builder** service account in each project is required by build pods, and is given the **system:image-builder** role, which allows pushing images to any image stream in the project using the internal container registry.
- 3 A **deployer** service account in each project is required by deployment pods, and is given the **system:deployer** role, which allows viewing and modifying replication controllers and pods in the project.
- 4 A **default** service account is used by all other pods unless they specify a different service account.

All service accounts in a project are given the **system:image-puller** role, which allows pulling images from any image stream in the project using the internal container registry.

6.6. INFRASTRUCTURE SERVICE ACCOUNTS

Several infrastructure controllers run using service account credentials. The following service accounts are created in the OpenShift Container Platform infrastructure project (**openshift-infra**) at server start, and given the following roles cluster-wide:

Service Account	Description
replication-controller	Assigned the system:replication-controller role
deployment-controller	Assigned the system:deployment-controller role
build-controller	Assigned the system:build-controller role. Additionally, the build-controller service account is included in the privileged security context constraint in order to create privileged build pods.

To configure the project where those service accounts are created, set the **openshiftInfrastructureNamespace** field in in the `/etc/origin/master/master-config.yml` file on the master:

```
policyConfig:
  ...
  openshiftInfrastructureNamespace: openshift-infra
```

6.7. SERVICE ACCOUNTS AND SECRETS

Set the **limitSecretReferences** field in the `/etc/origin/master/master-config.yml` file on the master to **true** to require pod secret references to be whitelisted by their service accounts. Set its value to **false** to allow pods to reference any secret in the project.

```
serviceAccountConfig:
  ...
  limitSecretReferences: false
```

CHAPTER 7. MANAGING AUTHORIZATION POLICIES

7.1. OVERVIEW

You can use [the CLI](#) to view [authorization policies](#) and the administrator CLI to manage the [roles and bindings](#) within a policy.

7.2. VIEWING ROLES AND BINDINGS

[Roles](#) grant various levels of access in the system-wide [cluster policy](#) as well as project-scoped [local policies](#). [Users and groups](#) can be associated with, or *bound* to, multiple roles at the same time. You can view details about the roles and their bindings using the `oc describe` command.

Users with the [cluster-admin default role](#) in the cluster policy can view cluster policy and all local policies. Users with the [admin default role](#) in a given local policy can view that project-scoped policy.



NOTE

Review a full list of verbs in the [Evaluating Authorization](#) section.

7.2.1. Viewing Cluster Policy

To view the cluster roles and their associated rule sets in the cluster policy:

```
$ oc describe clusterPolicy default
```

Example 7.1. Viewing Cluster Roles

```
$ oc describe clusterPolicy default
Name:          default
Created:       5 days ago
Labels:        <none>
Annotations:   <none>
Last Modified: 2016-03-17 13:25:27 -0400 EDT
admin         Verbs          Non-Resource URLs  Extension  Resource Names
API Groups    Resources
  [create delete deletecollection get list patch update watch] []
[] [] [configmaps endpoints persistentvolumeclaims pods pods/attach
pods/exec pods/log pods/portforward pods/proxy replicationcontrollers
replicationcontrollers/scale secrets serviceaccounts services
services/proxy]
  [create delete deletecollection get list patch update watch] []
[] [] [buildconfigs buildconfigs/instantiate
buildconfigs/instantiatebinary buildconfigs/webhooks buildlogs builds
builds/clone builds/custom builds/docker builds/log builds/source
deploymentconfigrollbacks deploymentconfigs deploymentconfigs/log
deploymentconfigs/scale deployments generatedeploymentconfigs
imagestreamimages imagestreamimports imagestreammappings imagestreams
imagestreams/secrets imagestreamtags localresourceaccessreviews
localsubjectaccessreviews processedtemplates projects
resourceaccessreviews rolebindings roles routes subjectaccessreviews
templateconfigs templates]
  [create delete deletecollection get list patch update watch] []
```



```

[] [autoscaling] [horizontalpodautoscalers]
[create delete deletecollection get list patch update watch] []
[] [batch] [jobs]
[create delete deletecollection get list patch update watch] []
[] [extensions] [daemonsets horizontalpodautoscalers jobs
replicationcontrollers/scale]
[get list watch] [] [] [] [bindings configmaps
endpoints events imagestreams/status limitranges minions namespaces
namespaces/status nodes persistentvolumeclaims persistentvolumes pods
pods/log pods/status policies policybindings replicationcontrollers
replicationcontrollers/status resourcequotas resourcequotas/status
resourcequotausages routes/status securitycontextconstraints
serviceaccounts services]
[get update] [] [] [] [imagestreams/layers]
[update] [] [] [] [routes/status]
basic-user Verbs Non-Resource URLs Extension Resource
Names API Groups Resources
[get] [] [~] [] [users]
[list] [] [] [] [projectrequests]
[get list] [] [] [] [clusterroles]
[list] [] [] [] [projects]
[create] [] IsPersonalSubjectAccessReview [] []
[localsubjectaccessreviews subjectaccessreviews]
cluster-admin Verbs Non-Resource URLs Extension Resource
Names API Groups Resources
[*] [] [] [*] [*]
[*] [*] [] [] []
cluster-reader Verbs Non-Resource URLs Extension Resource
Names API Groups Resources
[get list watch] [] [] [] [bindings buildconfigs
buildconfigs/instantiate buildconfigs/instantiatebinary
buildconfigs/webhooks buildlogs builds builds/clone builds/details
builds/log clusternetworks clusterpolicies clusterpolicybindings
clusterrolebindings clusterroles configmaps deploymentconfigrollbacks
deploymentconfigs deploymentconfigs/log deploymentconfigs/scale
deployments endpoints events generateddeploymentconfigs groups
hostsubnets identities images imagestreamimages imagestreamimports
imagestreammappings imagestreams imagestreams/status imagestreamtags
limitranges localresourceaccessreviews localsubjectaccessreviews minions
namespaces netnamespaces nodes oauthclientauthorizations oauthclients
persistentvolumeclaims persistentvolumes pods pods/log policies
policybindings processedtemplates projectrequests projects
replicationcontrollers resourceaccessreviews resourcequotas
resourcequotausages rolebindings roles routes routes/status
securitycontextconstraints serviceaccounts services subjectaccessreviews
templateconfigs templates useridentitymappings users]
[get list watch] [] [] [autoscaling]
[horizontalpodautoscalers]
[get list watch] [] [] [batch] [jobs]
[get list watch] [] [] [extensions] [daemonsets
horizontalpodautoscalers jobs replicationcontrollers/scale]
[create] [] [] [] [resourceaccessreviews
subjectaccessreviews]
[get] [] [] [] [nodes/metrics]
[create get] [] [] [] [nodes/stats]
[get] [*] [] [] []

```

```

cluster-status Verbs Non-Resource URLs Extension Resource
Names API Groups Resources
[get] [/api /api/* /apis /apis/* /healthz /healthz/* /oapi
/oapi/* /osapi /osapi/ /version] [] [] []
edit Verbs Non-Resource URLs Extension Resource Names
API Groups Resources
[create delete deletecollection get list patch update watch] []
[] [] [configmaps endpoints persistentvolumeclaims pods pods/attach
pods/exec pods/log pods/portforward pods/proxy replicationcontrollers
replicationcontrollers/scale secrets serviceaccounts services
services/proxy]
[create delete deletecollection get list patch update watch] []
[] [] [buildconfigs buildconfigs/instantiate
buildconfigs/instantiatebinary buildconfigs/webhooks buildlogs builds
builds/clone builds/custom builds/docker builds/log builds/source
deploymentconfigrollbacks deploymentconfigs deploymentconfigs/log
deploymentconfigs/scale deployments generateddeploymentconfigs
imagestreamimages imagestreamimports imagestreammappings imagestreams
imagestreams/secrets imagestreamtags processedtemplates routes
templateconfigs templates]
[create delete deletecollection get list patch update watch] []
[] [autoscaling] [horizontalpodautoscalers]
[create delete deletecollection get list patch update watch] []
[] [batch] [jobs]
[create delete deletecollection get list patch update watch] []
[] [extensions] [daemonsets horizontalpodautoscalers jobs
replicationcontrollers/scale]
[get list watch] [] [] [] [bindings configmaps
endpoints events imagestreams/status limitranges minions namespaces
namespaces/status nodes persistentvolumeclaims persistentvolumes pods
pods/log pods/status projects replicationcontrollers
replicationcontrollers/status resourcequotas resourcequotas/status
resourcequotausages routes/status securitycontextconstraints
serviceaccounts services]
[get update] [] [] [] [imagestreams/layers]
registry-admin Verbs Non-Resource URLs Extension Resource
Names API Groups Resources
[create delete deletecollection get list patch update watch] []
[] [] [imagestreamimages imagestreamimports imagestreammappings
imagestreams imagestreams/secrets imagestreamtags]
[create delete deletecollection get list patch update watch] []
[] [] [localresourceaccessreviews localsubjectaccessreviews
resourceaccessreviews rolebindings roles subjectaccessreviews]
[get update] [] [] [] [imagestreams/layers]
[get list watch] [] [] [] [policies policybindings]
[get] [] [] [] [namespaces projects]
registry-editor Verbs Non-Resource URLs Extension Resource
Names API Groups Resources
[get] [] [] [] [namespaces projects]
[create delete deletecollection get list patch update watch] []
[] [] [imagestreamimages imagestreamimports imagestreammappings
imagestreams imagestreams/secrets imagestreamtags]
[get update] [] [] [] [imagestreams/layers]
registry-viewer Verbs Non-Resource URLs Extension Resource
Names API Groups Resources
[get list watch] [] [] [] [imagestreamimages

```

```

imagestreamimports imagestreammappings imagestreams imagestreamtags]
  [get]      []  []  []  [imagestreams/layers namespaces
projects]
self-provisioner  Verbs      Non-Resource URLs  Extension  Resource
Names  API Groups  Resources
  [create]      []  []  []  [projectrequests]
system:build-controller  Verbs      Non-Resource URLs  Extension
Resource Names  API Groups  Resources
  [get list watch]      []  []  []  [builds]
  [update]              []  []  []  [builds]
  [create]              []  []  []  [builds/custom builds/docker
builds/source]
  [get]      []  []  []  [imagestreams]
  [create delete get list]      []  []  []  [pods]
  [create patch update]      []  []  []  [events]
system:daemonset-controller  Verbs      Non-Resource URLs  Extension
Resource Names  API Groups  Resources
  [list watch]      []  []  [extensions]  [daemonsets]
  [list watch]      []  []  []  [pods]
  [list watch]      []  []  []  [nodes]
  [update]          []  []  [extensions]  [daemonsets/status]
  [create delete]  []  []  []  [pods]
  [create]          []  []  []  [pods/binding]
  [create patch update]      []  []  []  [events]
system:deployer  Verbs      Non-Resource URLs  Extension  Resource
Names  API Groups  Resources
  [get list]      []  []  []  [replicationcontrollers]
  [get update]    []  []  []  [replicationcontrollers]
  [create get list watch]      []  []  []  [pods]
  [get]           []  []  []  [pods/log]
  [update]        []  []  []  [imagestreamtags]
system:deployment-controller  Verbs      Non-Resource URLs  Extension
Resource Names  API Groups  Resources
  [list watch]      []  []  []  [replicationcontrollers]
  [get update]      []  []  []  [replicationcontrollers]
  [create delete get list update]      []  []  []  [pods]
  [create patch update]      []  []  []  [events]
system:discovery  Verbs      Non-Resource URLs  Extension  Resource
Names  API Groups  Resources
  [get]      [/api /api/* /apis /apis/* /oapi /oapi/* /osapi
/osapi/ /version]  []  []  []
system:hpa-controller  Verbs      Non-Resource URLs  Extension
Resource Names  API Groups  Resources
  [get list watch]      []  []  [extensions autoscaling]
[horizontalpodautoscalers]
  [update]          []  []  [extensions autoscaling]
[horizontalpodautoscalers/status]
  [get update]      []  []  [extensions ]
[replicationcontrollers/scale]
  [get update]      []  []  []  [deploymentconfigs/scale]
  [create patch update]      []  []  []  [events]
  [list]            []  []  []  [pods]
  [proxy]           []  [https:heapster:]  []  [services]
system:image-builder  Verbs      Non-Resource URLs  Extension
Resource Names  API Groups  Resources
  [get update]      []  []  []  [imagestreams/layers]

```

```

    [update]          [] [] [] [builds/details]
system:image-pruner Verbs          Non-Resource URLs Extension
Resource Names API Groups Resources
    [delete]         [] [] [] [images]
    [get list]       [] [] [] [buildconfigs builds
deploymentconfigs images imagestreams pods replicationcontrollers]
    [update]         [] [] [] [imagestreams/status]
system:image-puller Verbs          Non-Resource URLs Extension
Resource Names API Groups Resources
    [get]            [] [] [] [imagestreams/layers]
system:image-pusher Verbs          Non-Resource URLs Extension
Resource Names API Groups Resources
    [get update]     [] [] [] [imagestreams/layers]
system:job-controller Verbs          Non-Resource URLs Extension
Resource Names API Groups Resources
    [list watch]    [] [] [extensions batch] [jobs]
    [update]         [] [] [extensions batch] [jobs/status]
    [list watch]    [] [] [] [pods]
    [create delete] [] [] [] [pods]
    [create patch update] [] [] [] [events]
system:master Verbs          Non-Resource URLs Extension Resource
Names API Groups Resources
    [*]             [] [] [*] [*]
system:namespace-controller Verbs          Non-Resource URLs Extension
Resource Names API Groups Resources
    [delete get list watch] [] [] [] [namespaces]
    [update]         [] [] [] [namespaces/finalize
namespaces/status]
    [delete deletecollection get list] [] [] [*] [*]
system:node Verbs          Non-Resource URLs Extension Resource
Names API Groups Resources
    [create]         [] [] [] [localsubjectaccessreviews
subjectaccessreviews]
    [get list watch] [] [] [] [services]
    [create get list watch] [] [] [] [nodes]
    [update]         [] [] [] [nodes/status]
    [create patch update] [] [] [] [events]
    [get list watch] [] [] [] [pods]
    [create delete get] [] [] [] [pods]
    [update]         [] [] [] [pods/status]
    [get]            [] [] [] [configmaps secrets]
    [get]            [] [] [] [persistentvolumeclaims
persistentvolumes]
    [get]            [] [] [] [endpoints]
system:node-admin Verbs          Non-Resource URLs Extension
Resource Names API Groups Resources
    [get list watch] [] [] [] [nodes]
    [proxy]          [] [] [] [nodes]
    [*]              [] [] [] [nodes/log nodes/metrics nodes/proxy
nodes/stats]
system:node-proxier Verbs          Non-Resource URLs Extension
Resource Names API Groups Resources
    [list watch]    [] [] [] [endpoints services]
system:node-reader Verbs          Non-Resource URLs Extension
Resource Names API Groups Resources
    [get list watch] [] [] [] [nodes]

```

```

    [get]          [] [] [] [nodes/metrics]
    [create get]   [] [] [] [nodes/stats]
system:oauth-token-deleter Verbs          Non-Resource URLs  Extension
Resource Names  API Groups  Resources
    [delete]     [] [] [] [oauthaccesstokens
oauthauthorizetokens]
system:pv-binder-controller Verbs          Non-Resource URLs  Extension
Resource Names  API Groups  Resources
    [list watch]      [] [] [] [persistentvolumes]
    [create delete get update] [] [] []
[persistentvolumes]
    [update]          [] [] [] [persistentvolumes/status]
    [list watch]      [] [] [] [persistentvolumeclaims]
    [get update]      [] [] [] [persistentvolumeclaims]
    [update]          [] [] [] [persistentvolumeclaims/status]
system:pv-provisioner-controller Verbs          Non-Resource URLs
Extension      Resource Names  API Groups  Resources
    [list watch]      [] [] [] [persistentvolumes]
    [create delete get update] [] [] []
[persistentvolumes]
    [update]          [] [] [] [persistentvolumes/status]
    [list watch]      [] [] [] [persistentvolumeclaims]
    [get update]      [] [] [] [persistentvolumeclaims]
    [update]          [] [] [] [persistentvolumeclaims/status]
system:pv-recycler-controller Verbs          Non-Resource URLs
Extension      Resource Names  API Groups  Resources
    [list watch]      [] [] [] [persistentvolumes]
    [create delete get update] [] [] []
[persistentvolumes]
    [update]          [] [] [] [persistentvolumes/status]
    [list watch]      [] [] [] [persistentvolumeclaims]
    [get update]      [] [] [] [persistentvolumeclaims]
    [update]          [] [] [] [persistentvolumeclaims/status]
    [list watch]      [] [] [] [pods]
    [create delete get] [] [] [] [pods]
    [create patch update] [] [] [] [events]
system:registry Verbs          Non-Resource URLs  Extension  Resource
Names  API Groups  Resources
    [delete get]     [] [] [] [images]
    [get]            [] [] [] [imagestreamimages imagestreams
imagestreams/secrets imagestreamtags]
    [update]         [] [] [] [imagestreams]
    [create]         [] [] [] [imagestreammappings]
    [list]           [] [] [] [resourcequotas]
system:replication-controller Verbs          Non-Resource URLs
Extension      Resource Names  API Groups  Resources
    [list watch]      [] [] [] [replicationcontrollers]
    [get update]      [] [] [] [replicationcontrollers]
    [update]          [] [] [] [replicationcontrollers/status]
    [list watch]      [] [] [] [pods]
    [create delete]   [] [] [] [pods]
    [create patch update] [] [] [] [events]
system:router Verbs          Non-Resource URLs  Extension  Resource
Names  API Groups  Resources
    [list watch]      [] [] [] [endpoints routes]
    [update]          [] [] [] [routes/status]

```

```

system:sdn-manager Verbs Non-Resource URLs Extension
Resource Names API Groups Resources
[create delete get list watch] [] [] [] [hostsubnets]
[create delete get list watch] [] [] []
[netnamespaces]
[get list watch] [] [] [] [nodes]
[create get] [] [] [] [clusternetworks]
system:sdn-reader Verbs Non-Resource URLs Extension
Resource Names API Groups Resources
[get list watch] [] [] [] [hostsubnets]
[get list watch] [] [] [] [netnamespaces]
[get list watch] [] [] [] [nodes]
[get] [] [] [] [clusternetworks]
[get list watch] [] [] [] [namespaces]
system:webhook Verbs Non-Resource URLs Extension Resource
Names API Groups Resources
[create get] [] [] [] [buildconfigs/webhooks]
view Verbs Non-Resource URLs Extension Resource Names
API Groups Resources
[get list watch] [] [] [] [bindings buildconfigs
buildconfigs/instantiate buildconfigs/instantiatebinary
buildconfigs/webhooks buildlogs builds builds/clone builds/log
configmaps deploymentconfigrollbacks deploymentconfigs
deploymentconfigs/log deploymentconfigs/scale deployments endpoints
events generatedeploymentconfigs imagestreamimages imagestreamimports
imagestreammappings imagestreams imagestreams/status imagestreamtags
limitranges minions namespaces namespaces/status nodes
persistentvolumeclaims persistentvolumes pods pods/log pods/status
processedtemplates projects replicationcontrollers
replicationcontrollers/status resourcequotas resourcequotas/status
resourcequotausages routes routes/status securitycontextconstraints
serviceaccounts services templateconfigs templates]
[get list watch] [] [] [autoscaling]
[horizontalpodautoscalers]
[get list watch] [] [] [batch] [jobs]
[get list watch] [] [] [extensions] [daemonsets]
horizontalpodautoscalers jobs]

```

To view the current set of cluster bindings, which shows the users and groups that are bound to various roles:

```
$ oc describe clusterPolicyBindings :default
```

Example 7.2. Viewing Cluster Bindings

```

$ oc describe clusterPolicyBindings :default
Name:          :default
Created:       4 hours ago
Labels:        <none>
Last Modified: 2015-06-10 17:22:26 +0000 UTC
Policy:        <none>
RoleBinding[basic-users]:
  Role: basic-user
  Users: []

```

```
    Groups: [system:authenticated]
RoleBinding[cluster-admins]:
  Role: cluster-admin
  Users: []
  Groups: [system:cluster-admins]
RoleBinding[cluster-readers]:
  Role: cluster-reader
  Users: []
  Groups: [system:cluster-readers]
RoleBinding[cluster-status-binding]:
  Role: cluster-status
  Users: []
  Groups: [system:authenticated system:unauthenticated]
RoleBinding[self-provisioners]:
  Role: self-provisioner
  Users: []
  Groups: [system:authenticated]
RoleBinding[system:build-controller]:
  Role: system:build-controller
  Users: [system:serviceaccount:openshift-infra:build-controller]
  Groups: []
RoleBinding[system:deployment-controller]:
  Role: system:deployment-controller
  Users: [system:serviceaccount:openshift-infra:deployment-
controller]
  Groups: []
RoleBinding[system:masters]:
  Role: system:master
  Users: []
  Groups: [system:masters]
RoleBinding[system:node-proxiers]:
  Role: system:node-proxier
  Users: []
  Groups: [system:nodes]
RoleBinding[system:nodes]:
  Role: system:node
  Users: []
  Groups: [system:nodes]
RoleBinding[system:oauth-token-deleters]:
  Role: system:oauth-token-deleter
  Users: []
  Groups: [system:authenticated system:unauthenticated]
RoleBinding[system:registries]:
  Role: system:registry
  Users: []
  Groups: [system:registries]
RoleBinding[system:replication-controller]:
  Role: system:replication-controller
  Users: [system:serviceaccount:openshift-infra:replication-
controller]
  Groups: []
RoleBinding[system:routers]:
  Role: system:router
  Users: []
  Groups: [system:routers]
RoleBinding[system:sdn-readers]:
```

```

Role: system:sdn-reader
Users: []
Groups: [system:nodes]
RoleBinding[system:webhooks]:
  Role: system:webhook
  Users: []
  Groups: [system:authenticated system:unauthenticated]

```

7.2.2. Viewing Local Policy

While the list of local roles and their associated rule sets are not viewable within a local policy, all of the [default roles](#) are still applicable and can be added to users or groups, other than the **cluster-admin** default role. The local bindings, however, are viewable.

To view the current set of local bindings, which shows the users and groups that are bound to various roles:

```
$ oc describe policyBindings :default
```

By default, the current project is used when viewing local policy. Alternatively, a project can be specified with the **-n** flag. This is useful for viewing the local policy of another project, if the user already has the [admindefault role](#) in it.

Example 7.3. Viewing Local Bindings

```

$ oc describe policyBindings :default -n joe-project
Name:          :default
Created:       About a minute ago
Labels:       <none>
Last Modified: 2015-06-10 21:55:06 +0000 UTC
Policy:       <none>
RoleBinding[admins]:
  Role: admin
  Users: [joe]
  Groups: []
RoleBinding[system:deployers]:
  Role: system:deployer
  Users: [system:serviceaccount:joe-project:deployer]
  Groups: []
RoleBinding[system:image-builders]:
  Role: system:image-builder
  Users: [system:serviceaccount:joe-project:builder]
  Groups: []
RoleBinding[system:image-pullers]:
  Role: system:image-puller
  Users: []
  Groups: [system:serviceaccounts:joe-project]

```

By default in a local policy, only the binding for the **admin** role is immediately listed. However, if other [default roles](#) are added to users and groups within a local policy, they become listed as well.

7.3. MANAGING ROLE BINDINGS

Adding, or *binding*, a *role* to *users* or *groups* gives the user or group the relevant access granted by the role. You can add and remove roles to and from users and groups using **oadm policy** commands.

When managing a user or group's associated roles for a local policy using the following operations, a project may be specified with the **-n** flag. If it is not specified, then the current project is used.

Table 7.1. Local Policy Operations

Command	Description
\$ oadm policy who-can <verb> <resource>	Indicates which users can perform an action on a resource.
\$ oadm policy add-role-to-user <role> <username>	Binds a given role to specified users in the current project.
\$ oadm policy remove-role-from-user <role> <username>	Removes a given role from specified users in the current project.
\$ oadm policy remove-user <username>	Removes specified users and all of their roles in the current project.
\$ oadm policy add-role-to-group <role> <groupname>	Binds a given role to specified groups in the current project.
\$ oadm policy remove-role-from-group <role> <groupname>	Removes a given role from specified groups in the current project.
\$ oadm policy remove-group <groupname>	Removes specified groups and all of their roles in the current project.

You can also manage role bindings for the cluster policy using the following operations. The **-n** flag is not used for these operations because the cluster policy uses non-namespaced resources.

Table 7.2. Cluster Policy Operations

Command	Description
\$ oadm policy add-cluster-role-to-user <role> <username>	Binds a given role to specified users for all projects in the cluster.
\$ oadm policy remove-cluster-role-from-user <role> <username>	Removes a given role from specified users for all projects in the cluster.
\$ oadm policy add-cluster-role-to-group <role> <groupname>	Binds a given role to specified groups for all projects in the cluster.

Command	Description
<code>\$ oadm policy remove-cluster-role-from-group <role> <groupname></code>	Removes a given role from specified groups for all projects in the cluster.

For example, you can add the **admin** role to the **alice** user in **joe-project** by running:

```
$ oadm policy add-role-to-user admin alice -n joe-project
```

You can then view the local bindings and verify the addition in the output:

```
$ oc describe policyBindings :default -n joe-project
Name:          :default
Created:       5 minutes ago
Labels:        <none>
Last Modified: 2015-06-10 22:00:44 +0000 UTC
Policy:        <none>
RoleBinding[admins]:
  Role: admin
  Users: [alice joe] 1
  Groups: []
RoleBinding[system:deployers]:
  Role: system:deployer
  Users: [system:serviceaccount:joe-project:deployer]
  Groups: []
RoleBinding[system:image-builders]:
  Role: system:image-builder
  Users: [system:serviceaccount:joe-project:builder]
  Groups: []
RoleBinding[system:image-pullers]:
  Role: system:image-puller
  Users: []
  Groups: [system:serviceaccounts:joe-project]
```

1 The **alice** user has been added to the **admins RoleBinding**.

7.4. GRANTING USERS DAEMONSET PERMISSIONS

By default, project developers do not have the permission to create [daemonsets](#). As a cluster administrator, you can grant them the abilities.

1. Define a **ClusterRole** file:

```
apiVersion: v1
kind: ClusterRole
metadata:
  name: daemonset-admin
rules:
  - resources:
    - daemonsets
  apiGroups:
    - extensions
```

```

verbs:
- create
- get
- list
- watch
- delete
- update

```

2. Create the role:

```
$ oadm policy add-role-to-user daemonset-admin <user>
```

7.5. CREATING A LOCAL ROLE

To create a local role for a project, you can either copy and modify an existing role or build a new role from scratch. It is recommended that you build it from scratch so that you understand each of the permissions assigned.

To copy the cluster role **view** to use as a local role, run:

```

$ oc get clusterrole view -o yaml > clusterrole_view.yaml
$ cp clusterrole_view.yaml localrole_exampleview.yaml
$ vim localrole_exampleview.yaml
# 1. Update kind: ClusterRole to kind: Role
# 2. Update name: view to name: exampleview
# 3. Remove resourceVersion, selfLink, uid, and creationTimestamp
$ oc create -f path/to/localrole_exampleview.yaml -n
<project_you_want_to_add_the_local_role_exampleview_to>

```

To create a new role from scratch, save this snippet into the file **role_exampleview.yaml**:

Example Role Named exampleview

```

apiVersion: v1
kind: Role
metadata:
  name: exampleview
rules:
- apiGroups: null
  attributeRestrictions: null
  resources:
  - pods
  - builds
  verbs:
  - get
  - list
  - watch

```

Then, to use the current project, run:

```
$ oc project <project_you_want_to_add_the_local_role_exampleview_to>
```

Optionally, annotate it with a description.

To use the new role, run:

```
$ oadm policy add-role-to-user exampleview user2
```



NOTE

A **clusterrolebinding** is a role binding that exists at the cluster level. A **rolebinding** exists at the project level. This can be confusing. The **clusterrolebinding** *view* must be assigned to a user within a project for that user to view the project. Local roles are only created if a cluster role does not provide the set of permissions needed for a particular situation, which is unlikely.

Some cluster role names are initially confusing. The **clusterroleclusteradmin** can be assigned to a user within a project, making it appear that this user has the privileges of a cluster administrator. This is not the case. The **clusteradmin** cluster role bound to a certain project is more like a super administrator for that project, granting the permissions of the cluster role **admin**, plus a few additional permissions like the ability to edit rate limits. This can appear especially confusing via the web console UI, which does not list cluster policy (where cluster administrators exist). However, it does list local policy (where a locally bound **clusteradmin** may exist).

Within a project, project administrators should be able to see **rolebindings**, not **clusterrolebindings**.

CHAPTER 8. IMAGE POLICY

8.1. OVERVIEW

You can control which images are allowed to run on your cluster using the ImagePolicy admission plug-in (currently considered beta). It allows you to control:

- **The source of images:** which registries can be used to pull images
- **Image resolution:** force pods to run with immutable digests to ensure the image does not change due to a re-tag
- **Container image label restrictions:** force an image to have or not have particular labels
- **Image annotation restrictions:** force an image in the integrated container registry to have or not have particular annotations

8.2. CONFIGURING THE IMAGEPOLICY ADMISSION PLUG-IN

To enable this feature, configure the plug-in in *master-config.yaml*:

Example 8.1. Annotated Example File

```
admissionConfig:
  pluginConfig:
    openshift.io/ImagePolicy:
      configuration:
        kind: ImagePolicyConfig
        apiVersion: v1
        resolveImages: AttemptRewrite 1
        executionRules: 2
        - name: execution-denied
          # Reject all images that have the annotation
          # images.openshift.io/deny-execution set to true.
          # This annotation may be set by infrastructure that wishes to
          # flag particular images as dangerous
          onResources: 3
          - resource: pods
          - resource: builds
          reject: true 4
          matchImageAnnotations: 5
          - key: images.openshift.io/deny-execution
            value: "true"
          skipOnResolutionFailure: true 6
        - name: allow-images-from-internal-registry
          # allows images from the internal registry and tries to
          # resolve them
          onResources:
            - resource: pods
            - resource: builds
          matchIntegratedRegistry: true
        - name: allow-images-from-dockerhub
          onResources:
            - resource: pods
```

```

- resource: builds
matchRegistries:
- docker.io

```

- 1 Try to resolve images to an immutable image digest and update the image pull specification in the pod.
- 2 Array of rules to evaluate against incoming resources. If you only have `reject==true` rules, the default is **allow all**. If you have any accept rule, the default is **deny all**.
- 3 Indicates which resources to enforce rules upon. If nothing is specified, the default is **pods**.
- 4 Indicates that if this rule matches, the pod should be rejected.
- 5 List of annotations to match on the image object's metadata.
- 6 If you are not able to resolve the image, do not fail the pod.

8.3. TESTING THE IMAGEPOLICY ADMISSION PLUG-IN

1. Use the `openshift/image-policy-check` to test your configuration. For example, use the information above, then test like this:

```
oc import-image openshift/image-policy-check:latest --confirm
```

2. Create a pod using this YAML. The pod should be created.

```

apiVersion: v1
kind: Pod
metadata:
  generateName: test-pod
spec:
  containers:
  - image: docker.io/openshift/image-policy-check:latest
    name: first

```

3. Create another pod pointing to a different registry. The pod should be rejected.

```

apiVersion: v1
kind: Pod
metadata:
  generateName: test-pod
spec:
  containers:
  - image: different-registry/openshift/image-policy-check:latest
    name: first

```

4. Create a pod pointing to the internal registry using the imported image. The pod should be created and if you look at the image specification, you should see a digest in place of the tag.

```

apiVersion: v1
kind: Pod

```

```

metadata:
  generateName: test-pod
spec:
  containers:
  - image: <internal registry IP>:5000/<namespace>/image-policy-
    check:latest
    name: first

```

5. Create a pod pointing to the internal registry using the imported image. The pod should be created and if you look at the image specification, you should see the tag unmodified.

```

apiVersion: v1
kind: Pod
metadata:
  generateName: test-pod
spec:
  containers:
  - image: <internal registry IP>:5000/<namespace>/image-policy-
    check:v1
    name: first

```

6. Get the digest from **oc get istag/image-policy-check:latest** and use it for **oc annotate images/<digest> images.openshift.io/deny-execution=true**. For example:

```

$ oc annotate
images/sha256:09ce3d8b5b63595ffca6636c7daefb1a615a7c0e3f8ea68e5db044
a9340d6ba8 images.openshift.io/deny-execution=true

```

7. Create this pod again, and you should see the pod rejected:

```

apiVersion: v1
kind: Pod
metadata:
  generateName: test-pod
spec:
  containers:
  - image: <internal registry IP>:5000/<namespace>/image-policy-
    check:latest
    name: first

```

CHAPTER 9. SCOPED TOKENS

9.1. OVERVIEW

A user may want to give another entity the power to act as they have, but only in a limited way. For example, a project administrator may want to delegate the power to create pods. One way to do this is to create a scoped token.

A scoped token is a token that identifies as a given user, but is limited to certain actions by its scope. Right now, only a **cluster-admin** can create scoped tokens.

9.2. EVALUATION

Scopes are evaluated by converting the set of scopes for a token into a set of **PolicyRules**. Then, the request is matched against those rules. The request attributes must match at least one of the scope rules to be passed to the "normal" authorizer for further authorization checks.

9.3. USER SCOPES

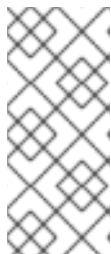
User scopes are focused on getting information about a given user. They are intent-based, so the rules are automatically created for you:

- **user:full** - Allows full read/write access to the API with all of the user's permissions.
- **user:info** - Allows read-only access to information about the user: name, groups, and so on.
- **user:check-access** - Allows access to **self-localsubjectaccessreviews** and **self-subjectaccessreviews**. These are the variables where you pass an empty user and groups in your request object.
- **user:list-projects** - Allows read-only access to list the projects the user has access to.

9.4. ROLE SCOPE

The role scope allows you to have the same level of access as a given role filtered by namespace.

- **role:<cluster-role name>:<namespace or * for all>** - Limits the scope to the rules specified by the cluster-role, but only in the specified namespace .



NOTE

Caveat: This prevents escalating access. Even if the role allows access to resources like secrets, rolebindings, and roles, this scope will deny access to those resources. This helps prevent unexpected escalations. Many people do not think of a role like **edit** as being an escalating role, but with access to a secret it is.

- **role:<cluster-role name>:<namespace or * for all>:!** - This is similar to the example above, except that including the bang causes this scope to allow escalating access.

CHAPTER 10. MONITORING IMAGES

10.1. OVERVIEW

You can monitor [images](#) in your instance using the [CLI](#).

10.2. VIEWING IMAGES STATISTICS

OpenShift Container Platform can display several usage statistics about all the images it manages. In other words, all the images pushed to the internal registry either [directly](#) or through a [build](#).

To view the usage statistics:

```
$ oadm top images
NAME                                IMAGESTREAMTAG          PARENTS
USAGE                               METADATA              STORAGE
sha256:80c985739a78b openshift/python (3.5)
yes                                303.12MiB
sha256:64461b5111fc7 openshift/ruby (2.2)
yes                                234.33MiB
sha256:0e19a0290ddc1 test/ruby-ex (latest)  sha256:64461b5111fc71ec
Deployment: ruby-ex-1/test  yes                    150.65MiB
sha256:a968c61adad58 test/django-ex (latest) sha256:80c985739a78b760
Deployment: django-ex-1/test yes                    186.07MiB
```

The command displays the following information:

- image ID
- project, name, and tag of the accompanying **ImageStreamTag**
- potential parents of the image, using their ID
- information about where the image is being used
- flag informing whether the image contains proper Docker metadata information
- size of the image

10.3. VIEWING IMAGESTREAMS STATISTICS

OpenShift Container Platform can display several usage statistics about all the **ImageStreams**.

To view the usage statistics:

```
$ oadm top imagestreams
NAME                STORAGE    IMAGES  LAYERS
openshift/python   1.21GiB   4       36
openshift/ruby     717.76MiB 3       27
test/ruby-ex       150.65MiB 1       10
test/django-ex     186.07MiB 1       10
```

The command displays the following information:

- project and name of the **ImageStream**
- size of the entire **ImageStream** stored in the internal [Red Hat Container Registry](#)
- number of images this particular **ImageStream** is pointing to
- number of layers **ImageStream** consists of

10.4. PRUNING IMAGES

The information returned from the above commands is helpful when performing [image pruning](#).

CHAPTER 11. MANAGING SECURITY CONTEXT CONSTRAINTS

CONSTRAINTS

11.1. OVERVIEW

Security context constraints allow administrators to control permissions for pods. To learn more about this API type, see the [security context constraints \(SCCs\)](#) architecture documentation. You can manage SCCs in your instance as normal API [objects](#) using [the CLI](#).



NOTE

You must have [cluster-admin privileges](#) to manage SCCs.



IMPORTANT

Do not modify the default SCCs. Customizing the default SCCs can lead to issues when upgrading. Instead, [create new SCCs](#).

11.2. LISTING SECURITY CONTEXT CONSTRAINTS

To get a current list of SCCs:

```
$ oc get scc

NAME                PRIV          CAPS          SELINUX        RUNASUSER
FSGROUP             SUPGROUP     PRIORITY     READONLYROOTFS VOLUMES
anyuid              false        []           MustRunAs     RunAsAny
RunAsAny            RunAsAny     10           false         [configMap
downwardAPI emptyDir persistentVolumeClaim secret]
hostaccess          false        []           MustRunAs     MustRunAsRange
MustRunAs           RunAsAny     <none>       false         [configMap
downwardAPI emptyDir hostPath persistentVolumeClaim secret]
hostmount-anyuid   false        []           MustRunAs     RunAsAny
RunAsAny            RunAsAny     <none>       false         [configMap
downwardAPI emptyDir hostPath persistentVolumeClaim secret]
hostnetwork         false        []           MustRunAs     MustRunAsRange
MustRunAs           MustRunAs     <none>       false         [configMap
downwardAPI emptyDir persistentVolumeClaim secret]
nonroot             false        []           MustRunAs     MustRunAsNonRoot
RunAsAny            RunAsAny     <none>       false         [configMap
downwardAPI emptyDir persistentVolumeClaim secret]
privileged          true         []           RunAsAny      RunAsAny
RunAsAny            RunAsAny     <none>       false         [*]
restricted          false        []           MustRunAs     MustRunAsRange
MustRunAs           RunAsAny     <none>       false         [configMap
downwardAPI emptyDir persistentVolumeClaim secret]
```

11.3. EXAMINING A SECURITY CONTEXT CONSTRAINTS OBJECT

To examine a particular SCC, use `oc get`, `oc describe`, `oc export`, or `oc edit`. For example, to examine the `restricted` SCC:

```
$ oc describe scc restricted
```

```
Name:          restricted
Priority:       <none>
Access:
  Users:       <none>
  Groups:      system:authenticated
Settings:
  Allow Privileged:  false
  Default Add Capabilities:  <none>
  Required Drop Capabilities:  <none>
  Allowed Capabilities:  <none>
  Allowed Volume Types:
awsElasticBlockStore,azureFile,cephFS,cinder,configMap,downwardAPI,emptyDir,fc,flexVolume,flocker,gcePersistentDisk,gitRepo,glusterfs,iscsi,nfs,persistentVolumeClaim,rbd,secret
  Allow Host Network:  false
  Allow Host Ports:    false
  Allow Host PID:      false
  Allow Host IPC:      false
  Read Only Root Filesystem:  false
  Run As User Strategy: MustRunAsRange
    UID:               <none>
    UID Range Min:     <none>
    UID Range Max:     <none>
  SELinux Context Strategy: MustRunAs
    User:              <none>
    Role:              <none>
    Type:              <none>
    Level:             <none>
  FSGroup Strategy: RunAsAny
    Ranges:            <none>
  Supplemental Groups Strategy: RunAsAny
    Ranges:            <none>
```



NOTE

In order to preserve customized SCCs during upgrades, do not edit settings on the default SCCs other than priority, users, groups, labels, and annotations.

11.4. CREATING NEW SECURITY CONTEXT CONSTRAINTS

To create a new SCC:

1. Define the SCC in a JSON or YAML file:

Example 11.1. Security Context Constraint Object Definition

```
kind: SecurityContextConstraints
apiVersion: v1
metadata:
  name: scc-admin
allowPrivilegedContainer: true
runAsUser:
  type: RunAsAny
```

```

seLinuxContext:
  type: RunAsAny
fsGroup:
  type: RunAsAny
supplementalGroups:
  type: RunAsAny
users:
- my-admin-user
groups:
- my-admin-group

```

Optionally, you can add drop capabilities to an SCC by setting the **requiredDropCapabilities** field with the desired values. Any specified capabilities will be dropped from the container. For example, to create an SCC with the **KILL**, **MKNOD**, and **SYS_CHROOT** required drop capabilities, add the following to the SCC object:

```

requiredDropCapabilities:
- KILL
- MKNOD
- SYS_CHROOT

```

You can see the list of possible values in the [Docker documentation](#).

2. Then, run **oc create** passing the file to create it:

```

$ oc create -f scc_admin.yaml
securitycontextconstraints/scc-admin

```

3. Verify that the SCC was created:

```

$ oc get scc
NAME          PRIV    CAPS    HOSTDIR    SELINUX    RUNASUSER
privileged    true    []      true      RunAsAny   RunAsAny
restricted    false   []      false     MustRunAs
MustRunAsRange
scc-admin     true    []      false     RunAsAny   RunAsAny

```

11.5. DELETING SECURITY CONTEXT CONSTRAINTS

To delete an SCC:

```

$ oc delete scc <scc_name>

```



NOTE

If you delete a default SCC, it will be regenerated upon restart.

11.6. UPDATING SECURITY CONTEXT CONSTRAINTS

To update an existing SCC:



```
$ oc edit scc <scc_name>
```

**NOTE**

In order to preserve customized SCCs during upgrades, do not edit settings on the default SCCs other than priority, users, and groups.

11.7. UPDATING THE DEFAULT SECURITY CONTEXT CONSTRAINTS

Default SCCs will be created when the master is started if they are missing. To reset SCCs to defaults, or update existing SCCs to new default definitions after an upgrade you may:

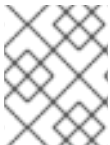
1. Delete any SCC you would like to be reset and let it be recreated by restarting the master
2. Use the `oadm policy reconcile-sccs` command

The `oadm policy reconcile-sccs` command will set all SCC policies to the default values but retain any additional users, groups, labels, and annotations as well as priorities you may have already set. To view which SCCs will be changed you may run the command with no options or by specifying your preferred output with the `-o <format>` option.

After reviewing it is recommended that you back up your existing SCCs and then use the `--confirm` option to persist the data.

**NOTE**

If you would like to reset priorities and grants, use the `--additive-only=false` option.

**NOTE**

If you have customized settings other than priority, users, groups, labels, or annotations in an SCC, you will lose those settings when you reconcile.

11.8. HOW DO I?

The following describe common scenarios and procedures using SCCs.

11.8.1. Grant Access to the Privileged SCC

In some cases, an administrator might want to allow users or groups outside the administrator group access to create more *privileged pods*. To do so, you can:

1. Determine the user or group you would like to have access to the SCC.
2. Run:

```
$ oadm policy add-scc-to-user <scc_name> <user_name>
$ oadm policy add-scc-to-group <scc_name> <group_name>
```

For example, to allow the `e2e-user` access to the `privileged` SCC, run:

```
$ oadm policy add-scc-to-user privileged e2e-user
```

**WARNING**

Granting access to a user only works when the user directly creates a pod. For pods created on behalf of a user, in most cases by the system itself, access should be given to a service account under which related controller is operated upon. Examples of resources that create pods on behalf of a user are Deployments, StatefulSets, DaemonSets, etc.

11.8.2. Grant a Service Account Access to the Privileged SCC

First, create a [service account](#). For example, to create service account `mysvcacct` in project `myproject`:

```
$ oc create serviceaccount mysvcacct -n myproject
```

Then, add the service account to the **privileged** SCC.

```
$ oadm policy add-scc-to-user privileged
system:serviceaccount:myproject:mysvcacct
```

Then, ensure that the resource is being created on behalf of the service account. To do so, set the **spec.serviceAccountName** field to a service account name. Leaving the service account name blank will result in the **default** service account being used.

11.8.3. Enable Images to Run with USER in the Dockerfile

To relax the security in your cluster so that images are not forced to run as a pre-allocated UID, without granting everyone access to the **privileged** SCC:

1. Grant all authenticated users access to the **anyuid** SCC:

```
$ oadm policy add-scc-to-group anyuid system:authenticated
```

**WARNING**

This allows images to run as the root UID if no **USER** is specified in the *Dockerfile*.

11.8.4. Enable Container Images that Require Root

Some container images (examples: **postgres** and **redis**) require root access and have certain expectations about how volumes are owned. For these images, add the service account to the **anyuid** SCC.

```
$ oadm policy add-scc-to-user anyuid
system:serviceaccount:myproject:mysvcacct
```

11.8.5. Use --mount-host on the Registry

It is recommended that [persistent storage](#) using **PersistentVolume** and **PersistentVolumeClaim** objects be used for [registry deployments](#). If you are testing and would like to instead use the **oadm registry** command with the **--mount-host** option, you must first create a new [service account](#) for the registry and add it to the **privileged** SCC. See the [Administrator Guide](#) for full instructions.

11.8.6. Provide Additional Capabilities

In some cases, an image may require capabilities that Docker does not provide out of the box. You can provide the ability to request additional capabilities in the pod specification which will be validated against an SCC.



IMPORTANT

This allows images to run with elevated capabilities and should be used only if necessary. You should not edit the default **restricted** SCC to enable additional capabilities.

When used in conjunction with a non-root user, you must also ensure that the file that requires the additional capability is granted the capabilities using the **setcap** command. For example, in the **Dockerfile** of the image:

```
setcap cap_net_raw,cap_net_admin+p /usr/bin/ping
```

Further, if a capability is provided by default in Docker, you do not need to modify the pod specification to request it. For example, **NET_RAW** is provided by default and capabilities should already be set on **ping**, therefore no special steps should be required to run **ping**.

To provide additional capabilities:

1. Create a new SCC
2. Add the allowed capability using the **allowedCapabilities** field.
3. When creating the pod, request the capability in the **securityContext.capabilities.add** field.

11.8.7. Modify Cluster Default Behavior

When you grant access to the **anyuid** SCC for everyone, your cluster:

- Does not pre-allocate UIDs
- Allows containers to run as any user
- Prevents privileged containers

```
$ oc adm policy add-scc-to-group anyuid system:authenticated
```


To modify your cluster so that it does not pre-allocate UIDs and does not allow containers to run as root, grant access to the **nonroot** SCC for everyone:

```
$ oc adm policy add-scc-to-group nonroot system:authenticated
```



WARNING

Be very careful with any modifications that have a cluster-wide impact. When you grant an SCC to all authenticated users, as in the previous example, or modify an SCC that applies to all users, such as the **restricted** SCC, it also affects Kubernetes and OpenShift Container Platform components, including the web console and integrated docker registry. Changes made with these SCCs can cause these components to stop functioning.

Instead, create a custom SCC and target it to only specific users or groups. This way potential issues are confined to the affected users or groups and do not impact critical cluster components.

11.8.8. Use the hostPath Volume Plug-in

To relax the security in your cluster so that pods are allowed to use the **hostPath** volume plug-in without granting everyone access to more privileged SCCs such as **privileged**, **hostaccess**, or **hostmount-anyuid**, perform the following actions:

1. [Create a new SCC](#) named **hostpath**
2. Set the **allowHostDirVolumePlugin** parameter to **true** for the new SCC:

```
$ oc patch scc hostpath -p '{"allowHostDirVolumePlugin": true}'
```

3. Grant access to this SCC to all users:

```
$ oc adm policy add-scc-to-group hostpath system:authenticated
```

Now, all the pods that request **hostPath** volumes are admitted by the **hostpath** SCC.

11.8.9. Ensure That Admission Attempts to Use a Specific SCC First

You may control the sort ordering of SCCs in admission by setting the **Priority** field of the SCCs. Please see the [SCC Prioritization](#) section for more information on sorting.

11.8.10. Add an SCC to a User, Group, or Project

Before adding an SCC to a user or group, you can first use the **scc-review** option to check if the user or group can create a pod.

SCCs are not granted directly to a project. Instead, you add a service account to an SCC and either specify the service account name on your pod or, when unspecified, run as the **default** service account.

To add an SCC to a user:

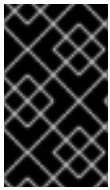
```
$ oadm policy add-scc-to-user <scc_name> <user_name>
```

To add an SCC to a service account:

```
$ oc adm policy add-scc-to-user <scc_name> \  
    system:serviceaccount:<serviceaccount_namespace>:<serviceaccount_name>
```

If you are currently in the project to which the service account belongs, you can use the **-z** flag and just specify the **<serviceaccount_name>**.

```
$ oc adm policy add-scc-to-user <scc_name> -z <serviceaccount_name>
```



IMPORTANT

Usage of the **-z** flag as described above is highly recommended, as it helps prevent typos and ensures that access is granted only to the specified service account. If not in the project, use the **-n** option to indicate the project namespace it applies to.

To add an SCC to a group:

```
$ oadm policy add-scc-to-group <scc_name> <group_name>
```

To add an SCC to all service accounts in a namespace:

```
$ oc adm policy add-scc-to-group <scc_name> \  
    system:serviceaccounts:<serviceaccount_namespace>
```

CHAPTER 12. SETTING QUOTAS

12.1. OVERVIEW

A resource quota, defined by a **ResourceQuota** object, provides constraints that limit aggregate resource consumption per project. It can limit the quantity of objects that can be created in a project by type, as well as the total amount of compute resources that may be consumed by resources in that project.

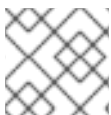


NOTE

See the [Developer Guide](#) for more on compute resources.

12.2. RESOURCES MANAGED BY QUOTA

The following describes the set of compute resources and object types that may be managed by a quota.



NOTE

A pod is in a terminal state if `status.phase in (Failed, Succeeded)` is true.

Table 12.1. Compute Resources Managed by Quota

Resource Name	Description
<code>cpu</code>	The sum of CPU requests across all pods in a non-terminal state cannot exceed this value. <code>cpu</code> and <code>requests.cpu</code> are the same value and can be used interchangeably.
<code>memory</code>	The sum of memory requests across all pods in a non-terminal state cannot exceed this value. <code>memory</code> and <code>requests.memory</code> are the same value and can be used interchangeably.
<code>requests.cpu</code>	The sum of CPU requests across all pods in a non-terminal state cannot exceed this value. <code>cpu</code> and <code>requests.cpu</code> are the same value and can be used interchangeably.
<code>requests.memory</code>	The sum of memory requests across all pods in a non-terminal state cannot exceed this value. <code>memory</code> and <code>requests.memory</code> are the same value and can be used interchangeably.
<code>limits.cpu</code>	The sum of CPU limits across all pods in a non-terminal state cannot exceed this value.
<code>limits.memory</code>	The sum of memory limits across all pods in a non-terminal state cannot exceed this value.

Table 12.2. Object Counts Managed by Quota

Resource Name	Description
pods	The total number of pods in a non-terminal state that can exist in the project.
replicationcontrollers	The total number of replication controllers that can exist in the project.
resourcequotas	The total number of resource quotas that can exist in the project.
services	The total number of services that can exist in the project.
secrets	The total number of secrets that can exist in the project.
configmaps	The total number of ConfigMap objects that can exist in the project.
persistentvolumeclaims	The total number of persistent volume claims that can exist in the project.
openshift.io/imagestreams	The total number of image streams that can exist in the project.

12.3. QUOTA SCOPES

Each quota can have an associated set of *scopes*. A quota will only measure usage for a resource if it matches the intersection of enumerated scopes.

Adding a scope to a quota restricts the set of resources to which that quota can apply. Specifying a resource outside of the allowed set results in a validation error.

Scope	Description
Terminating	Match pods where spec.activeDeadlineSeconds \geq 0.
NotTerminating	Match pods where spec.activeDeadlineSeconds is nil .
BestEffort	Match pods that have best effort quality of service for either cpu or memory .
NotBestEffort	Match pods that do not have best effort quality of service for cpu and memory .

A **BestEffort** scope restricts a quota to limiting the following resources:

- **pods**

A **Terminating**, **NotTerminating**, or **NotBestEffort** scope restricts a quota to tracking the following resources:

- **pods**
- **memory**

- `requests.memory`
- `limits.memory`
- `cpu`
- `requests.cpu`
- `limits.cpu`

12.4. QUOTA ENFORCEMENT

After a resource quota for a project is first created, the project restricts the ability to create any new resources that may violate a quota constraint until it has calculated updated usage statistics.

After a quota is created and usage statistics are updated, the project accepts the creation of new content. When you create or modify resources, your quota usage is incremented immediately upon the request to create or modify the resource.

When you delete a resource, your quota use is decremented during the next full recalculation of quota statistics for the project. A [configurable amount of time](#) determines how long it takes to reduce quota usage statistics to their current observed system value.

If project modifications exceed a quota usage limit, the server denies the action, and an appropriate error message is returned to the user explaining the quota constraint violated, and what their currently observed usage stats are in the system.

12.5. REQUESTS VS LIMITS

When allocating [compute resources](#), each container may specify a request and a limit value each for CPU and memory. Quotas can restrict any of these values.

If the quota has a value specified for `requests.cpu` or `requests.memory`, then it requires that every incoming container make an explicit request for those resources. If the quota has a value specified for `limits.cpu` or `limits.memory`, then it requires that every incoming container specify an explicit limit for those resources.

12.6. SAMPLE RESOURCE QUOTA DEFINITIONS

Example 12.1. *object-counts.yaml*

```

apiVersion: v1
kind: ResourceQuota
metadata:
  name: core-object-counts
spec:
  hard:
    configmaps: "10" 1
    persistentvolumeclaims: "4" 2
    replicationcontrollers: "20" 3
    secrets: "10" 4
    services: "10" 5

```

- 1 The total number of **ConfigMap** objects that can exist in the project.
- 2 The total number of persistent volume claims (PVCs) that can exist in the project.
- 3 The total number of replication controllers that can exist in the project.
- 4 The total number of secrets that can exist in the project.
- 5 The total number of services that can exist in the project.

Example 12.2. *openshift-object-counts.yaml*

```

apiVersion: v1
kind: ResourceQuota
metadata:
  name: openshift-object-counts
spec:
  hard:
    openshift.io/imagestreams: "10" 1

```

- 1 The total number of image streams that can exist in the project.

Example 12.3. *compute-resources.yaml*

```

apiVersion: v1
kind: ResourceQuota
metadata:
  name: compute-resources
spec:
  hard:
    pods: "4" 1
    requests.cpu: "1" 2
    requests.memory: 1Gi 3
    limits.cpu: "2" 4
    limits.memory: 2Gi 5

```

- 1 The total number of pods in a non-terminal state that can exist in the project.
- 2 Across all pods in a non-terminal state, the sum of CPU requests cannot exceed 1 core.
- 3 Across all pods in a non-terminal state, the sum of memory requests cannot exceed 1Gi.
- 4 Across all pods in a non-terminal state, the sum of CPU limits cannot exceed 2 cores.
- 5 Across all pods in a non-terminal state, the sum of memory limits cannot exceed 2Gi.

Example 12.4. *besteffort.yaml*

```

apiVersion: v1
kind: ResourceQuota
metadata:
  name: besteffort
spec:
  hard:
    pods: "1" ①
  scopes:
    - BestEffort ②

```

- ① The total number of pods in a non-terminal state with **BestEffort** quality of service that can exist in the project.
- ② Restricts the quota to only matching pods that have **BestEffort** quality of service for either memory or CPU.

Example 12.5. *compute-resources-long-running.yaml*

```

apiVersion: v1
kind: ResourceQuota
metadata:
  name: compute-resources-long-running
spec:
  hard:
    pods: "4" ①
    limits.cpu: "4" ②
    limits.memory: "2Gi" ③
  scopes:
    - NotTerminating ④

```

- ① The total number of pods in a non-terminal state.
- ② Across all pods in a non-terminal state, the sum of CPU limits cannot exceed this value.
- ③ Across all pods in a non-terminal state, the sum of memory limits cannot exceed this value.
- ④ Restricts the quota to only matching pods where **spec.activeDeadlineSeconds** is **nil**. For example, this quota would not charge for build or deployer pods.

Example 12.6. *compute-resources-time-bound.yaml*

```

apiVersion: v1
kind: ResourceQuota
metadata:
  name: compute-resources-time-bound
spec:
  hard:
    pods: "2" ①
    limits.cpu: "1" ②

```

```

    limits.memory: "1Gi" 3
  scopes:
  - Terminating 4

```

- 1 The total number of pods in a non-terminal state.
- 2 Across all pods in a non-terminal state, the sum of CPU limits cannot exceed this value.
- 3 Across all pods in a non-terminal state, the sum of memory limits cannot exceed this value.
- 4 Restricts the quota to only matching pods where `spec.activeDeadlineSeconds >=0`. For example, this quota would charge for build or deployer pods, but not long running pods like a web server or database.

12.7. CREATING A QUOTA

To create a quota, first define the quota to your specifications in a file, for example as seen in [Sample Resource Quota Definitions](#). Then, create using that file to apply it to a project:

```
$ oc create -f <resource_quota_definition> [-n <project_name>]
```

For example:

```
$ oc create -f resource-quota.json -n demoproject
```

12.8. VIEWING A QUOTA

You can view usage statistics related to any hard limits defined in a project's quota by navigating in the web console to the project's **Quota** page.

You can also use the CLI to view quota details:

1. First, get the list of quotas defined in the project. For example, for a project called **demoproject**:

```

$ oc get quota -n demoproject
NAME                AGE
besteffort          11m
compute-resources   2m
core-object-counts  29m

```

2. Then, describe the quota you are interested in, for example the **core-object-counts** quota:

```

$ oc describe quota core-object-counts -n demoproject
Name:      core-object-counts
Namespace: demoproject
Resource  Used Hard
-----  -
configmaps  3 10
persistentvolumeclaims 0 4

```



```

replicationcontrollers 3 20
secrets      9 10
services     2 10

```

12.9. CONFIGURING QUOTA SYNCHRONIZATION PERIOD

When a set of resources are deleted, the synchronization time frame of resources is determined by the **resource-quota-sync-period** setting in the `/etc/origin/master/master-config.yaml` file.

Before quota usage is restored, a user may encounter problems when attempting to reuse the resources. You can change the **resource-quota-sync-period** setting to have the set of resources regenerate at the desired amount of time (in seconds) and for the resources to be available again:

```

kubernetesMasterConfig:
  apiLevels:
    - v1beta3
    - v1
  apiServerArguments: null
  controllerArguments:
    resource-quota-sync-period:
      - "10s"

```

After making any changes, restart the master service to apply them.

Adjusting the regeneration time can be helpful for creating resources and determining resource usage when automation is used.



NOTE

The **resource-quota-sync-period** setting is designed to balance system performance. Reducing the sync period can result in a heavy load on the master.

12.10. ACCOUNTING FOR QUOTA IN DEPLOYMENT CONFIGURATIONS

If a quota has been defined for your project, see [Deployment Resources](#) for considerations on any deployment configurations.

CHAPTER 13. SETTING MULTI-PROJECT QUOTAS

13.1. OVERVIEW

A multi-project quota, defined by a **ClusterResourceQuota** object, allows [quotas](#) to be shared across multiple projects. Resources used in each selected project will be aggregated and that aggregate will be used to limit resources across all the selected projects.

13.2. SELECTING PROJECTS

Projects can be selected based on either annotation selection, label selection, or both. For example:

```
$ oc create clusterquota for-user \
  --project-annotation-selector openshift.io/requester=<user-name> \
  --hard pods=10 \
  --hard secrets=20
```

creates:

```
apiVersion: v1
kind: ClusterResourceQuota
metadata:
  name: for-user
spec:
  quota: 1
  hard:
    pods: "10"
    secrets: "20"
  selector:
    annotations: 2
      openshift.io/requester: <user-name>
    labels: null 3
status:
  namespaces: 4
  - namespace: ns-one
    status:
      hard:
        pods: "10"
        secrets: "20"
      used:
        pods: "1"
        secrets: "9"
  total: 5
  hard:
    pods: "10"
    secrets: "20"
  used:
    pods: "1"
    secrets: "9"
```

1 The **ResourceQuotaSpec** object that will be enforced over the selected projects.

2 A simple key/value selector for annotations.

- 3 A label selector that can be used to select projects.
- 4 A per-namespace map that describes current quota usage in each selected project.
- 5 The aggregate usage across all selected projects.

This multi-project quota document controls all projects requested by **<user-name>** using the default project request endpoint. You are limited to 10 pods and 20 secrets.

13.3. VIEWING APPLICABLE CLUSTERRESOURCEQUOTAS

A project administrator is not allowed to create or modify the multi-project quota that limits his or her project, but the administrator is allowed to view the multi-project quota documents that are applied to his or her project. The project administrator can do this via the **AppliedClusterResourceQuota** resource.

```
$ oc describe AppliedClusterResourceQuota
```

produces:

```
Name:      for-user
Namespace: <none>
Created:   19 hours ago
Labels:    <none>
Annotations: <none>
Label Selector: <null>
AnnotationSelector: map[openshift.io/requester:<user-name>]
Resource  Used  Hard
-----  ----  ----
pods      1  10
secrets   9  20
```

13.4. SELECTION GRANULARITY

Due to the locking consideration when claiming quota allocations, the number of active projects selected by a multi-project quota is an important consideration. Selecting more than 100 projects under a single multi-project quota may have detrimental effects on API server responsiveness in those projects.

CHAPTER 14. SETTING LIMIT RANGES

14.1. OVERVIEW

A limit range, defined by a **LimitRange** object, enumerates [compute resource constraints](#) in a [project](#) at the pod, container, image and image stream level, and specifies the amount of resources that a pod, container, image or image stream can consume.

All resource create and modification requests are evaluated against each **LimitRange** object in the project. If the resource violates any of the enumerated constraints, then the resource is rejected. If the resource does not set an explicit value, and if the constraint supports a default value, then the default value is applied to the resource.

Example 14.1. Limit Range Object Definition

```

apiVersion: "v1"
kind: "LimitRange"
metadata:
  name: "core-resource-limits" 1
spec:
  limits:
    - type: "Pod"
      max:
        cpu: "2" 2
        memory: "1Gi" 3
      min:
        cpu: "200m" 4
        memory: "6Mi" 5
    - type: "Container"
      max:
        cpu: "2" 6
        memory: "1Gi" 7
      min:
        cpu: "100m" 8
        memory: "4Mi" 9
      default:
        cpu: "300m" 10
        memory: "200Mi" 11
      defaultRequest:
        cpu: "200m" 12
        memory: "100Mi" 13
      maxLimitRequestRatio:
        cpu: "10" 14

```

- 1 The name of the limit range object.
- 2 The maximum amount of CPU that a pod can request on a node across all containers.
- 3 The maximum amount of memory that a pod can request on a node across all containers.
- 4 The minimum amount of CPU that a pod can request on a node across all containers.
- 5 The minimum amount of memory that a pod can request on a node across all containers.

- 6 The maximum amount of CPU that a single container in a pod can request.
- 7 The maximum amount of memory that a single container in a pod can request.
- 8 The minimum amount of CPU that a single container in a pod can request.
- 9 The minimum amount of memory that a single container in a pod can request.
- 10 The default amount of CPU that a container will be limited to use if not specified.
- 11 The default amount of memory that a container will be limited to use if not specified.
- 12 The default amount of CPU that a container will request to use if not specified.
- 13 The default amount of memory that a container will request to use if not specified.
- 14 The maximum amount of CPU burst that a container can make as a ratio of its limit over request.

Example 14.2. OpenShift Container Platform Limit Range Object Definition

```

apiVersion: "v1"
kind: "LimitRange"
metadata:
  name: "openshift-resource-limits"
spec:
  limits:
    - type: openshift.io/Image
      max:
        storage: 1Gi 1
    - type: openshift.io/ImageStream
      max:
        openshift.io/image-tags: 20 2
        openshift.io/images: 30 3

```

- 1 The maximum size of an image that can be pushed to an internal registry.
- 2 The maximum number of unique image tags per image stream's spec.
- 3 The maximum number of unique image references per image stream's status.

Both core and OpenShift Container Platform resources can be specified in just one limit range object. They are separated here into two examples for clarity.

14.1.1. Container Limits

Supported Resources:

- CPU
- Memory

Supported Constraints:

Per container, the following must hold true if specified:

Table 14.1. Container

Constraint	Behavior
Min	<p>Min[resource] less than or equal to container.resources.requests[resource] (required) less than or equal to container/resources.limits[resource] (optional)</p> <p>If the configuration defines a min CPU, then the request value must be greater than the CPU value. A limit value does not need to be specified.</p>
Max	<p>container.resources.limits[resource] (required) less than or equal to Max[resource]</p> <p>If the configuration defines a max CPU, then you do not need to define a request value, but a limit value does need to be set that satisfies the maximum CPU constraint.</p>
MaxLimitRequestRatio	<p>MaxLimitRequestRatio[resource] less than or equal to (container.resources.limits[resource] / container.resources.requests[resource])</p> <p>If a configuration defines a maxLimitRequestRatio value, then any new containers must have both a request and limit value. Additionally, OpenShift Container Platform calculates a limit to request ratio by dividing the limit by the request. This value should be a non-negative integer greater than 1.</p> <p>For example, if a container has cpu: 500 in the limit value, and cpu: 100 in the request value, then its limit to request ratio for cpu is 5. This ratio must be less than or equal to the maxLimitRequestRatio.</p>

Supported Defaults:**Default[resource]**

Defaults **container.resources.limit[resource]** to specified value if none.

Default Requests[resource]

Defaults **container.resources.requests[resource]** to specified value if none.

14.1.2. Pod Limits**Supported Resources:**

- CPU
- Memory

Supported Constraints:

Across all containers in a pod, the following must hold true:

Table 14.2. Pod

Constraint	Enforced Behavior
Min	Min[resource] less than or equal to container.resources.requests[resource] (required) less than or equal to container.resources.limits[resource] (optional)
Max	container.resources.limits[resource] (required) less than or equal to Max[resource]
MaxLimitRequestRatio	MaxLimitRequestRatio[resource] less than or equal to (container.resources.limits[resource] / container.resources.requests[resource])

14.1.3. Image Limits

Supported Resources:

- Storage

Resource type name:

- `openshift.io/Image`

Per image, the following must hold true if specified:

Table 14.3. Image

Constraint	Behavior
Max	image.dockerimagemetadata.size less than or equal to Max[resource]



NOTE

To prevent blobs exceeding the limit from being uploaded to the registry, the registry must be configured to enforce quota. An environment variable **REGISTRY_MIDDLEWARE_REPOSITORY_OPENSHIFT_ENFORCEQUOTA** must be set to **true** which is done by default for new deployments. To update older deployment configuration, refer to [Enforcing quota in the 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 will be converted by the registry to **schema 1** lacking all the size information. No storage limit set on images will prevent it from being uploaded.

[The issue](#) is being addressed.

14.1.4. Image Stream Limits

Supported Resources:

- `openshift.io/image-tags`
- `openshift.io/images`

Resource type name:

- `openshift.io/ImageStream`

Per image stream, the following must hold true if specified:

Table 14.4. ImageStream

Constraint	Behavior
<code>Max[openshift.io/image-tags]</code>	<p><code>length(uniqueimagetags(imagestream.spec.tags))</code> less than or equal to <code>Max[openshift.io/image-tags]</code></p> <p><code>uniqueimagetags</code> returns unique references to images of given spec tags.</p>
<code>Max[openshift.io/images]</code>	<p><code>length(uniqueimages(imagestream.status.tags))</code> less than or equal to <code>Max[openshift.io/images]</code></p> <p><code>uniqueimages</code> returns unique image names found in status tags. The name equals image's digest.</p>

14.1.4.1. Counting of Image References

Resource `openshift.io/image-tags` represents unique [image references](#). Possible references are an `ImageStreamTag`, an `ImageStreamImage` and a `DockerImage`. They may be created using commands `oc tag` and `oc import-image` or by using [tag tracking](#). No distinction is made between internal and external references. However, each unique reference tagged in the image stream's specification is counted just once. It does not restrict pushes to an internal container registry in any way, but is useful for tag restriction.

Resource `openshift.io/images` represents unique image names recorded in image stream status. It allows for restriction of a number of images that can be pushed to the internal registry. Internal and external references are not distinguished.

14.2. CREATING A LIMIT RANGE

To apply a limit range to a project, create a [limit range object definition](#) on your file system to your desired specifications, then run:

```
$ oc create -f <limit_range_file> -n <project>
```

14.3. VIEWING LIMITS

You can view any limit ranges 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. First, get the list of limit ranges defined in the project. For example, for a project called **demoproject**:

```
$ oc get limits -n demoproject
NAME          AGE
resource-limits 6d
```

2. Then, describe the limit range 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
Max           Default Request Default Limit   Max Limit/Request Ratio
----           -
Pod           -
Pod           1Gi -
Container     200m 300m 10
Container     1Gi 100Mi 200Mi
openshift.io/Image      storage
1Gi -
openshift.io/ImageStream openshift.io/image - 12
-
openshift.io/ImageStream openshift.io/image-tags - 10
-
```

14.4. DELETING LIMITS

Remove any active limit range to no longer enforce the limits of a project:

```
$ oc delete limits <limit_name>
```

CHAPTER 15. PRUNING OBJECTS

15.1. OVERVIEW

Over time, [API objects](#) created in OpenShift Container Platform can accumulate in the [etcd data store](#) through normal user operations, such as when building and deploying applications.

As an administrator, you can periodically prune older versions of objects from your OpenShift Container Platform instance that are no longer needed. For example, by pruning images you can delete older images and layers that are no longer in use, but are still taking up disk space.

15.2. BASIC PRUNE OPERATIONS

The CLI groups prune operations under a common parent command.

```
$ oadm prune <object_type> <options>
```

This specifies:

- The **<object_type>** to perform the action on, such as **builds**, **deployments**, or **images**.
- The **<options>** supported to prune that object type.

15.3. PRUNING DEPLOYMENTS

In order to prune deployments that are no longer required by the system due to age and status, administrators may run the following command:

```
$ oadm prune deployments [<options>]
```

Table 15.1. Prune Deployments CLI Configuration Options

Option	Description
--confirm	Indicate that pruning should occur, instead of performing a dry-run.
--orphans	Prune all deployments whose deployment config no longer exists, status is complete or failed, and replica count is zero.
--keep-complete=<N>	Per deployment config, keep the last N deployments whose status is complete and replica count is zero. (default 5)
--keep-failed=<N>	Per deployment config, keep the last N deployments whose status is failed and replica count is zero. (default 1)
--keep-younger-than=<duration>	Do not prune any object that is younger than <duration> relative to the current time. (default 60m)

To see what a pruning operation would delete:

```
$ oadm prune deployments --orphans --keep-complete=5 --keep-failed=1 \
  --keep-younger-than=60m
```

To actually perform the prune operation:

```
$ oadm prune deployments --orphans --keep-complete=5 --keep-failed=1 \
  --keep-younger-than=60m --confirm
```

15.4. PRUNING BUILDS

In order to prune builds that are no longer required by the system due to age and status, administrators may run the following command:

```
$ oadm prune builds [<options>]
```

Table 15.2. Prune Builds CLI Configuration Options

Option	Description
--confirm	Indicate that pruning should occur, instead of performing a dry-run.
--orphans	Prune all builds whose build config no longer exists, status is complete, failed, error, or canceled.
--keep-complete=<N>	Per build config, keep the last N builds whose status is complete. (default 5)
--keep-failed=<N>	Per build config, keep the last N builds whose status is failed, error, or canceled (default 1)
--keep-younger-than=<duration>	Do not prune any object that is younger than <duration> relative to the current time. (default 60m)

To see what a pruning operation would delete:

```
$ oadm prune builds --orphans --keep-complete=5 --keep-failed=1 \
  --keep-younger-than=60m
```

To actually perform the prune operation:

```
$ oadm prune builds --orphans --keep-complete=5 --keep-failed=1 \
  --keep-younger-than=60m --confirm
```

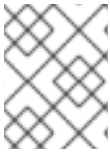
15.5. PRUNING IMAGES

In order to prune images that are no longer required by the system due to age, status, or exceed limits, administrators may run the following command:

```
$ oadm prune images [<options>]
```

**NOTE**

Currently, to prune images you must first [log in to the CLI](#) as a user with an [access token](#). The user must also have the `cluster role:system:image-pruner` or greater (for example, `cluster-admin`).

**NOTE**

Pruning images removes data from the integrated registry. For this operation to work properly, ensure your [registry is configured](#) with `storage:delete:enabled` set to `true`.

Table 15.3. Prune Images CLI Configuration Options

Option	Description
<code>--certificate-authority</code>	The path to a certificate authority file to use when communicating with the OpenShift Container Platform-managed registries. Defaults to the certificate authority data from the current user's config file.
<code>--confirm</code>	Indicate that pruning should occur, instead of performing a dry-run.
<code>--keep-tag-revisions=<N></code>	For each image stream, keep up to at most N image revisions per tag. (default 3)
<code>--keep-younger-than=<duration></code>	Do not prune any image that is younger than <code><duration></code> relative to the current time. Do not prune any image that is referenced by any other object that is younger than <code><duration></code> relative to the current time. (default 60m)
<code>--prune-over-size-limit</code>	Prune each image that exceeds the smallest limit defined in the same project. This flag cannot be combined with <code>--keep-tag-revisions</code> nor <code>--keep-younger-than</code> .

OpenShift Container Platform uses the following logic to determine which images and layers to prune:

- Remove any image "managed by OpenShift Container Platform" (images with the annotation `openshift.io/image.managed`) that was created at least `--keep-younger-than` minutes ago and is not currently referenced by:
 - any pod created less than `--keep-younger-than` minutes ago.
 - any image stream created less than `--keep-younger-than` minutes ago.
 - any running pods.
 - any pending pods.
 - any replication controllers.
 - any deployment configurations.
 - any build configurations.

- any builds.
- the `--keep-tag-revisions` most recent items in `stream.status.tags[].items`.
- Remove any image "managed by OpenShift Container Platform" (images with the annotation `openshift.io/image.managed`) that is exceeding the smallest `limit` defined in the same project and is not currently referenced by:
 - any running pods.
 - any pending pods.
 - any replication controllers.
 - any deployment configurations.
 - any build configurations.
 - any builds.
- There is no support for pruning from external registries.
- When an image is pruned, all references to the image are removed from all image streams that have a reference to the image in `status.tags`.
- Image layers that are no longer referenced by any images are removed as well.



NOTE

`--prune-over-size-limit` cannot be combined with `--keep-tag-revisions` nor `--keep-younger-than` flags. Doing so will return an information that this operation is not allowed.

To see what a pruning operation would delete:

1. Keeping up to three tag revisions, and keeping resources (images, image streams and pods) younger than sixty minutes:

```
$ oadm prune images --keep-tag-revisions=3 --keep-younger-than=60m
```

2. Pruning every image that exceeds defined limits:

```
$ oadm prune images --prune-over-size-limit
```

To actually perform the prune operation for the previously mentioned options accordingly:

```
$ oadm prune images --keep-tag-revisions=3 --keep-younger-than=60m --confirm
```

```
$ oadm prune images --prune-over-size-limit --confirm
```

CHAPTER 16. GARBAGE COLLECTION

16.1. OVERVIEW

The OpenShift Container Platform node performs two types of garbage collection:

- [Container garbage collection](#): Removes terminated containers.
- [Image garbage collection](#): Removes images not referenced by any running pods.

16.2. CONTAINER GARBAGE COLLECTION

Container garbage collection is enabled by default and happens automatically in response to eviction thresholds being reached. The node tries to keep any container for any pod accessible from the API. If the pod has been deleted, the containers will be as well. Containers are preserved as long the pod is not deleted and the eviction threshold is not reached. If the node is under disk pressure, it will remove containers and their logs will no longer be accessible via `oc logs`.

The policy for container garbage collection is based on three node settings:

Setting	Description
<code>minimum-container-ttl-duration</code>	The minimum age that a container is eligible for garbage collection. The default is <code>0</code> . Use <code>0</code> for no limit. Values for this setting can be specified using unit suffixes such as <code>h</code> for hour, <code>m</code> for minutes, <code>s</code> for seconds.
<code>maximum-dead-containers-per-container</code>	The number of instances to retain per pod container. The default is <code>1</code> .
<code>maximum-dead-containers</code>	The maximum number of total dead containers in the node. The default is <code>-1</code> , which means unlimited.

The `maximum-dead-containers` setting takes precedence over the `maximum-dead-containers-per-container` setting when there is a conflict. For example, if retaining the number of `maximum-dead-containers-per-container` would result in a total number of containers that is greater than `maximum-dead-containers`, the oldest containers will be removed to satisfy the `maximum-dead-containers` limit.

When the node removes the dead containers, all files inside those containers are removed as well. Only containers created by the node will be garbage collected.

You can specify values for these settings in the `kubeletArguments` section of the `/etc/origin/node/node-config.yaml` file on node hosts. Add the section if it does not already exist:

Container Garbage Collection Settings

```
kubeletArguments:
  minimum-container-ttl-duration:
    - "10s"
  maximum-dead-containers-per-container:
    - "2"
```

```
maximum-dead-containers:
  - "100"
```

16.2.1. Detecting Containers for Deletion

Each spin of the garbage collector loop goes through the following steps:

1. Retrieve a list of available containers.
2. Filter out all containers that are running or are not alive longer than the **minimum-container-ttl-duration** parameter.
3. Classify all remaining containers into equivalence classes based on pod and image name membership.
4. Remove all unidentified containers (containers that are managed by kubelet but their name is malformed).
5. For each class that contains more containers than the **maximum-dead-containers-per-container** parameter, sort containers in the class by creation time.
6. Start removing containers from the oldest first until the **maximum-dead-containers-per-container** parameter is met.
7. If there are still more containers in the list than the **maximum-dead-containers** parameter, the collector starts removing containers from each class so the number of containers in each one is not greater than the average number of containers per class, or **<all_remaining_containers>/<number_of_classes>**.
8. If this is still not enough, sort all containers in the list and start removing containers from the oldest first until the **maximum-dead-containers** criterion is met.



IMPORTANT

Update the default settings to meet your needs.

Garbage collection only removes the containers that do not have a pod associated with it.

16.3. IMAGE GARBAGE COLLECTION

Image garbage collection relies on disk usage as reported by **cAdvisor** on the node to decide which images to remove from the node. It takes the following settings into consideration:

Setting	Description
image-gc-high-threshold	The percent of disk usage (expressed as an integer) which triggers image garbage collection. The default is 90 .
image-gc-low-threshold	The percent of disk usage (expressed as an integer) to which image garbage collection attempts to free. Default is 80 .

You can specify values for these settings in the `kubeletArguments` section of the `/etc/origin/node/node-config.yaml` file on node hosts. Add the section if it does not already exist:

Image Garbage Collection Settings

```
kubeletArguments:  
  image-gc-high-threshold:  
    - "90"  
  image-gc-low-threshold:  
    - "80"
```

16.3.1. Detecting Images for Deletion

Two lists of images are retrieved in each garbage collector run:

1. A list of images currently running in at least one pod
2. A list of images available on a host

As new containers are run, new images appear. All images are marked with a time stamp. If the image is running (the first list above) or is newly detected (the second list above), it is marked with the current time. The remaining images are already marked from the previous spins. All images are then sorted by the time stamp.

Once the collection starts, the oldest images get deleted first until the stopping criterion is met.

CHAPTER 17. SCHEDULER

17.1. OVERVIEW

The Kubernetes pod scheduler is responsible for determining placement of new pods onto nodes within the cluster. It reads data from the pod and tries to find a node that is a good fit based on configured policies. It is completely independent and exists as a standalone/pluggable solution. It does not modify the pod and just creates a binding for the pod that ties the pod to the particular node.

17.2. GENERIC SCHEDULER

The existing generic scheduler is the default platform-provided scheduler "engine" that selects a node to host the pod in a 3-step operation:

1. Filter the nodes
2. Prioritize the filtered list of nodes
3. Select the best fit node

17.2.1. Filter the Nodes

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

17.2.2. Prioritize the Filtered List of Nodes

This is achieved by passing each node through a series of 'priority' 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 priority function. The node score provided by each priority function is multiplied by the "weight" (default weight is 1) and then combined by just adding the scores for each node provided by all the priority functions. This weight attribute can be used by administrators to give higher importance to some priority functions.

17.2.3. Select 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.

17.3. AVAILABLE PREDICATES

There are several predicates provided out of the box in Kubernetes. Some of these predicates can be customized by providing certain parameters. Multiple predicates can be combined to provide additional filtering of nodes.

17.3.1. Static Predicates

These predicates do not take any configuration parameters or inputs from the user. These are specified in the scheduler configuration using their exact name.

PodFitsPorts deems a node to be fit for hosting a pod based on the absence of port conflicts.

```
┌ {"name" : "PodFitsPorts"}
```

■

PodFitsResources determines a fit based on resource availability. The nodes can declare their resource capacities and then pods can specify what resources they require. Fit is based on requested, rather than used resources.

```
{"name" : "PodFitsResources"}
```

NoDiskConflict determines fit based on non-conflicting disk volumes. It evaluates if a pod can fit due to the volumes it requests, and those that are already mounted. It is GCE PD, Amazon EBS, and Ceph RBD specific. Only Persistent Volume Claims for those supported types are checked. Persistent Volumes added directly to pods are not evaluated and are not constrained by this policy.

```
{"name" : "NoDiskConflict"}
```

MatchNodeSelector determines fit based on node selector query that is defined in the pod.

```
{"name" : "MatchNodeSelector"}
```

HostName determines fit based on the presence of the Host parameter and a string match with the name of the host.

```
{"name" : "HostName"}
```

17.3.2. Configurable Predicates

These predicates can be configured by the user to tweak their functioning. They can be given any user-defined name. The type of the predicate is identified by the argument that they take. Since these are configurable, multiple predicates of the same type (but different configuration parameters) can be combined as long as their user-defined names are different.

ServiceAffinity filters out nodes that do not belong to the specified topological level defined by the provided labels. This predicate takes in a list of labels and ensures affinity within the nodes (that have the same label values) for pods belonging to the same service. If the pod specifies a value for the labels in its NodeSelector, then the nodes matching those labels are the ones where the pod is scheduled. If the pod does not specify the labels in its NodeSelector, then the first pod can be placed on any node based on availability and all subsequent pods of the service will be scheduled on nodes that have the same label values.

```
{"name" : "Zone", "argument" : {"serviceAffinity" : {"labels" : ["zone"]}}}
```

LabelsPresence checks whether a particular node has a certain label defined or not, regardless of its value. Matching by label can be useful, for example, where nodes have their physical location or status defined by labels.

```
{"name" : "RequireRegion", "argument" : {"labelsPresence" : {"labels" : ["region"], "presence" : true}}}
```

- If "presence" is false, and any of the requested labels match any of the nodes's labels, it returns false. Otherwise, it returns true.
- If "presence" is true, and any of the requested labels do not match any of the node's labels, it returns false. Otherwise, it returns true.

17.4. AVAILABLE PRIORITY FUNCTIONS

A custom set of priority functions can be specified to configure the scheduler. There are several priority functions provided out-of-the-box in Kubernetes. Some of these priority functions can be customized by providing certain parameters. Multiple priority functions can be combined and different weights can be given to each in order to impact the prioritization. A weight is required to be specified and cannot be 0 or negative.

17.4.1. Static Priority Functions

These priority functions do not take any configuration parameters or inputs from the user. These are specified in the scheduler configuration using their exact name as well as the weight.

LeastRequestedPriority favors nodes with fewer requested resources. It calculates the percentage of memory and CPU requested by pods scheduled on the node, and prioritizes nodes that have the highest available/remaining capacity.

```
{"name" : "LeastRequestedPriority", "weight" : 1}
```

BalancedResourceAllocation favors nodes with balanced resource usage rate. It calculates the difference between the consumed CPU and memory as a fraction of capacity, and prioritizes the nodes based on how close the two metrics are to each other. This should always be used together with *LeastRequestedPriority*.

```
{"name" : "BalancedResourceAllocation", "weight" : 1}
```

ServiceSpreadingPriority spreads pods by minimizing the number of pods belonging to the same service onto the same machine.

```
{"name" : "ServiceSpreadingPriority", "weight" : 1}
```

EqualPriority gives an equal weight of one to all nodes, if no priority configs are provided. It is not required/recommended outside of testing.

```
{"name" : "EqualPriority", "weight" : 1}
```

17.4.2. Configurable Priority Functions

These priority functions can be configured by the user by providing certain parameters. They can be given any user-defined name. The type of the priority function is identified by the argument that they take. Since these are configurable, multiple priority functions of the same type (but different configuration parameters) can be combined as long as their user-defined names are different.

ServiceAntiAffinity takes a label and ensures a good spread of the pods belonging to the same service across the group of nodes based on the label values. It gives the same score to all nodes that have the same value for the specified label. It gives a higher score to nodes within a group with the least concentration of pods.

```
{"name" : "RackSpread", "weight" : 1, "argument" : {"serviceAntiAffinity" : {"label" : "rack"}}}
```

LabelPreference prefers nodes that have a particular label defined or not, regardless of its value.

```
{ "name" : "RackPreferred", "weight" : 1, "argument" : { "labelPreference" :
  { "label" : "rack" } } }
```

17.5. SCHEDULER POLICY

The selection of the predicate and priority functions defines the policy for the scheduler. Administrators can provide a JSON file that specifies the predicates and priority functions to configure the scheduler. The path to the scheduler policy file can be specified in the master configuration file. In the absence of the scheduler policy file, the default configuration gets applied.

It is important to note that the predicates and priority functions defined in the scheduler configuration file will completely override the default scheduler policy. If any of the default predicates and priority functions are required, they have to be explicitly specified in the scheduler configuration file.

17.5.1. Default Scheduler Policy

The default scheduler policy includes the following predicates:

1. PodFitsPorts
2. PodFitsResources
3. NoDiskConflict
4. MatchNodeSelector
5. HostName

The default scheduler policy includes the following priority functions. Each of the priority function has a weight of '1' applied to it:

1. LeastRequestedPriority
2. BalancedResourceAllocation
3. ServiceSpreadingPriority

17.5.2. Modifying Scheduler Policy

The scheduler policy is defined in a file on the master, named */etc/origin/master/scheduler.json* by default, unless overridden by the `kubernetesMasterConfig.schedulerConfigFile` field in the [master configuration file](#).

To modify the scheduler policy:

1. Edit the scheduler configuration file to set the desired [predicates and priority functions](#). You can create a custom configuration, or modify one of the [sample policy configurations](#).
2. Restart the OpenShift Container Platform [master services](#) for the changes to take effect.

17.6. USE CASES

One of the important use cases for scheduling within OpenShift Container Platform is to support flexible affinity and anti-affinity policies.

17.6.1. Infrastructure Topological Levels

Administrators can define multiple topological levels for their infrastructure (nodes). This is done by specifying [labels on nodes](#) (e.g., `region=r1`, `zone=z1`, `rack=s1`). These label names have no particular meaning and administrators are free to name their infrastructure levels anything (eg, city/building/room). Also, administrators can define any number of levels for their infrastructure topology, with three levels usually being adequate (eg. regions → zones → racks). Lastly, administrators can specify affinity and anti-affinity rules at each of these levels in any combination.

17.6.2. 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 will be 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 will not get scheduled.

17.6.3. 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 will be spread across nodes that belong to that level. This ensures that the application is well spread for high availability purposes. The scheduler will try to balance the service pods across all applicable nodes as evenly as possible.

17.7. SAMPLE POLICY CONFIGURATIONS

The configuration below specifies the default scheduler configuration, if it were to be specified via the scheduler policy file.

```
kind: "Policy"
version: "v1"
predicates:
  - name: "PodFitsPorts"
  - name: "PodFitsResources"
  - name: "NoDiskConflict"
  - name: "MatchNodeSelector"
  - name: "HostName"
priorities:
  - name: "LeastRequestedPriority"
    weight: 1
  - name: "BalancedResourceAllocation"
    weight: 1
  - name: "ServiceSpreadingPriority"
    weight: 1
```



IMPORTANT

In all of the sample configurations below, the list of predicates and priority functions is truncated to include only the ones that pertain to the use case specified. In practice, a complete/meaningful scheduler policy should include most, if not all, of the default predicates and priority functions listed above.

Three topological levels defined as region (affinity) -> zone (affinity) -> rack (anti-affinity)

```
kind: "Policy"
version: "v1"
predicates:
...
- name: "RegionZoneAffinity"
  argument:
    serviceAffinity:
      labels:
        - "region"
        - "zone"
priorities:
...
- name: "RackSpread"
  weight: 1
  argument:
    serviceAntiAffinity:
      label: "rack"
```

Three topological levels defined as city (affinity) -> building (anti-affinity) -> room (anti-affinity):

```
kind: "Policy"
version: "v1"
predicates:
...
- name: "CityAffinity"
  argument:
    serviceAffinity:
      labels:
        - "city"
priorities:
...
- name: "BuildingSpread"
  weight: 1
  argument:
    serviceAntiAffinity:
      label: "building"
- name: "RoomSpread"
  weight: 1
  argument:
    serviceAntiAffinity:
      label: "room"
```

Only use nodes with the 'region' label defined and prefer nodes with the 'zone' label defined:

```
kind: "Policy"
version: "v1"
predicates:
...
- name: "RequireRegion"
  argument:
    labelsPresence:
      labels:
        - "region"
```

```

        presence: true
priorities:
...
  - name: "ZonePreferred"
    weight: 1
    argument:
      labelPreference:
        label: "zone"
        presence: true

```

Configuration example combining static and configurable predicates and priority functions:

```

kind: "Policy"
version: "v1"
predicates:
...
  - name: "RegionAffinity"
    argument:
      serviceAffinity:
        labels:
          - "region"
  - name: "RequireRegion"
    argument:
      labelsPresence:
        labels:
          - "region"
        presence: true
  - name: "BuildingNodesAvoid"
    argument:
      labelsPresence:
        labels:
          - "building"
        presence: false
  - name: "PodFitsPorts"
  - name: "MatchNodeSelector"
priorities:
...
  - name: "ZoneSpread"
    weight: 2
    argument:
      serviceAntiAffinity:
        label: "zone"
  - name: "ZonePreferred"
    weight: 1
    argument:
      labelPreference:
        label: "zone"
        presence: true
  - name: "ServiceSpreadingPriority"
    weight: 1

```

17.8. SCHEDULER EXTENSIBILITY

As is the case with almost everything else in Kubernetes/OpenShift Container Platform, the scheduler is built using a plug-in model and the current implementation itself is a plug-in. There are two ways to extend the scheduler functionality:

- Enhancements
- Replacement

17.8.1. Enhancements

The scheduler functionality can be enhanced by adding new predicates and priority functions. They can either be contributed upstream or maintained separately. These predicates and priority functions would need to be registered with the scheduler factory and then specified in the scheduler policy file.

17.8.2. Replacement

Since the scheduler is a plug-in, it can be replaced in favor of an alternate implementation. 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.

17.9. CONTROLLING POD PLACEMENT

As a cluster administrator, you can set a policy to prevent application developers with certain roles from targeting specific nodes when scheduling pods.

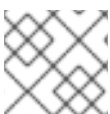


IMPORTANT

This process involves the **pods/binding** permission [role](#), which is needed to target particular nodes. The constraint on the use of the **nodeSelector** field of a pod configuration is based on the **pods/binding** permission and the **nodeSelectorLabelBlacklist** configuration option.

The **nodeSelectorLabelBlacklist** field of a master configuration file gives you control over the labels that certain roles can specify in a pod configuration's **nodeSelector** field. Users, service accounts, and groups that have the **pods/binding** permission can specify any node selector. Those without the **pods/binding** permission are prohibited from setting a **nodeSelector** for any label that appears in **nodeSelectorLabelBlacklist**.

As a hypothetical example, an OpenShift Container Platform cluster might consist of five data centers spread across two regions. In the U.S., **us-east**, **us-central**, and **us-west**; and in the Asia-Pacific region (APAC), **apac-east** and **apac-west**. Each node in each geographical region is labeled accordingly. For example, **region: us-east**.



NOTE

See [Updating Labels on Nodes](#) for details on assigning labels.

As a cluster administrator, you can create an infrastructure where application developers should be deploying pods only onto the nodes closest to their geographical location. You can [create a node selector](#), grouping the U.S. data centers into **superregion: us** and the APAC data centers into **superregion: apac**.

To maintain an even loading of resources per data center, you can add the desired **region** to the **nodeSelectorLabelBlacklist** section of a master configuration. Then, whenever a developer located in the U.S. creates a pod, it is deployed onto a node in one of the regions with the **superregion: us** label. If the developer tries to target a specific region for their pod (for example, **region: us-east**), they will receive an error. If they try again, without the node selector on their pod, it can still be deployed onto the region they tried to target, because **superregion: us** is set as the project-level node selector, and nodes labeled **region: us-east** are also labeled **superregion: us**.

17.9.1. Constraining Pod Placement Using Node Name

Ensure a pod is deployed onto only a specified node host by assigning it a label and specifying this in the **nodeName** setting in a pod configuration.

1. Ensure you have the desired labels and [node selector](#) set up in your environment. For example, make sure that your pod configuration features the **nodeName** value indicating the desired label:

```
apiVersion: v1
kind: Pod
spec:
  nodeName: <key: value>
```

2. Modify the master configuration file, */etc/origin/master/master-config.yaml*, to add **nodeSelectorLabelBlacklist** to the **admissionConfig** section:

```
...
admissionConfig:
  pluginConfig:
    PodNodeConstraints:
      configuration:
        apiversion: v1
        kind: PodNodeConstraintsConfig
...
```

3. Restart OpenShift Container Platform for the changes to take effect.

```
# systemctl restart atomic-openshift-master
```

17.9.2. Constraining Pod Placement Using a Node Selector

Using **nodeSelector** in a pod configuration, you can ensure that pods are only placed onto nodes with specific labels.

1. Ensure you have the desired labels (see [Updating Labels on Nodes](#) for details) and [node selector](#) set up in your environment. For example, make sure that your pod configuration features the **nodeSelector** value indicating the desired label:

```
apiVersion: v1
kind: Pod
spec:
```

```
nodeSelector:  
  <key>: <value>  
  ...
```

2. Modify the master configuration file, `/etc/origin/master/master-config.yaml`, to add **nodeSelectorLabelBlacklist** to the **admissionConfig** section with the labels that are assigned to the node hosts you want to deny pod placement:

```
...  
admissionConfig:  
  pluginConfig:  
    PodNodeConstraints:  
      configuration:  
        apiversion: v1  
        kind: PodNodeConstraintsConfig  
        nodeSelectorLabelBlacklist:  
          - kubernetes.io/hostname  
          - <label>  
  ...
```

3. Restart OpenShift Container Platform for the changes to take effect.

```
# systemctl restart atomic-openshift-master
```

CHAPTER 18. ALLOCATING NODE RESOURCES

18.1. OVERVIEW

To provide more reliable scheduling and minimize node resource overcommitment, each node can reserve a portion of its resources for use by all underlying [node components](#) (e.g., kubelet, kube-proxy, Docker) and the remaining system components (e.g., **sshd**, **NetworkManager**) on the host. Once specified, the scheduler has more information about the resources (e.g., memory, CPU) a node has allocated for pods.

18.2. CONFIGURING NODES FOR ALLOCATED RESOURCES

Resources reserved for node components are based on two node settings:

Setting	Description
kube-reserved	Resources reserved for node components. Default is none.
system-reserved	Resources reserved for the remaining system components. Default is none.

You can set these in the **kubeletArguments** section of the [node configuration file](#) (the `/etc/origin/node/node-config.yaml` file by default) using a set of `<resource_type>=<resource_quantity>` pairs (e.g., `cpu=200m,memory=512Mi`). Add the section if it does not already exist:

Example 18.1. Node Allocatable Resources Settings

```
kubeletArguments:
  kube-reserved:
    - "cpu=200m,memory=512Mi"
  system-reserved:
    - "cpu=200m,memory=512Mi"
```

Currently, the **cpu** and **memory** resource types are supported. For **cpu**, the resource quantity is specified in units of cores (e.g., 200m, 0.5, 1). For **memory**, it is specified in units of bytes (e.g., 200Ki, 50Mi, 5Gi).

See [Compute Resources](#) for more details.

If a flag is not set, it defaults to **0**. If none of the flags are set, the allocated resource is set to the node's capacity as it was before the introduction of allocatable resources.

18.3. COMPUTING ALLOCATED RESOURCES

An allocated amount of a resource is computed based on the following formula:

$$[\text{Allocatable}] = [\text{Node Capacity}] - [\text{kube-reserved}] - [\text{system-reserved}]$$

If `[Allocatable]` is negative, it is set to `0`.

18.4. VIEWING NODE ALLOCATABLE RESOURCES AND CAPACITY

To see a node's current capacity and allocatable resources, you can run:

```
$ oc get node/<node_name> -o yaml
...
status:
...
  allocatable:
    cpu: "4"
    memory: 8010948Ki
    pods: "110"
  capacity:
    cpu: "4"
    memory: 8010948Ki
    pods: "110"
...
```

18.5. SYSTEM RESOURCES REPORTED BY NODE

Starting with OpenShift Container Platform 3.3, each node reports system resources utilized by the container runtime and kubelet. To better aid your ability to configure `--system-reserved` and `--kube-reserved`, you can introspect corresponding node's resource usage using the node summary API, which is accessible at `<master>/api/v1/nodes/<node>/proxy/stats/summary`.

For instance, to access the resources from `cluster.node22` node, you can run:

```
$ curl <certificate details>
https://<master>/api/v1/nodes/cluster.node22/proxy/stats/summary
{
  "node": {
    "nodeName": "cluster.node22",
    "systemContainers": [
      {
        "cpu": {
          "usageCoreNanoSeconds": 929684480915,
          "usageNanoCores": 190998084
        },
        "memory": {
          "rssBytes": 176726016,
          "usageBytes": 1397895168,
          "workingSetBytes": 1050509312
        },
        "name": "kubelet"
      },
      {
        "cpu": {
          "usageCoreNanoSeconds": 128521955903,
          "usageNanoCores": 5928600
        },
        "memory": {
          "rssBytes": 35958784,
```

```

        "usageBytes": 129671168,
        "workingSetBytes": 102416384
      },
      "name": "runtime"
    ]
  }
}

```

See [REST API Overview](#) for more details about certificate details.

18.6. NODE ENFORCEMENT

The node is able to limit the total amount of resources that pods may consume based on the configured allocatable value. This feature significantly improves the reliability of the node by preventing pods from starving system services (for example: container runtime, node agent, etc.) for resources. It is strongly encouraged that administrators reserve resources based on the desired node utilization target in order to improve node reliability.

The node enforces resource constraints using a new cgroup hierarchy that enforces quality of service. All pods are launched in a dedicated cgroup hierarchy separate from system daemons.

To configure this ability, the following kubelet arguments are provided.

Example 18.2. Node Cgroup Settings

```

kubeletArguments:
  cgroups-per-qos:
    - "true" 1
  cgroup-driver:
    - "systemd" 2
  enforce-node-allocatable:
    - "pods" 3

```

- 1 Enable or disable the new cgroup hierarchy managed by the node. Any change of this setting requires a full drain of the node. This flag must be true to allow the node to enforce node allocatable. We do not recommend users change this value.
- 2 The cgroup driver used by the node when managing cgroup hierarchies. This value must match the driver associated with the container runtime. Valid values are **systemd** and **cgroupfs**. The default is **systemd**.
- 3 A comma-delimited list of scopes for where the node should enforce node resource constraints. Valid values are **pods**, **system-reserved**, and **kube-reserved**. The default is **pods**. We do not recommend users change this value.

Optionally, the node can be made to enforce kube-reserved and system-reserved by specifying those tokens in the enforce-node-allocatable flag. If specified, the corresponding **--kube-reserved-cgroup** or **--system-reserved-cgroup** needs to be provided. In future releases, the node and container runtime will be packaged in a common cgroup separate from **system.slice**. Until that time, we do not recommend users change the default value of enforce-node-allocatable flag.

Administrators should treat system daemons similar to Guaranteed pods. System daemons can burst within their bounding control groups and this behavior needs to be managed as part of cluster deployments. Enforcing system-reserved limits can lead to critical system services being CPU starved or OOM killed on the node. The recommendation is to enforce system-reserved only if operators have profiled their nodes exhaustively to determine precise estimates and are confident in their ability to recover if any process in that group is OOM killed.

As a result, we strongly recommended that users only enforce node allocatable for **Pods** by default, and set aside appropriate reservations for system daemons to maintain overall node reliability.

18.7. EVICTION THRESHOLDS

If a node is under memory pressure, it can impact the entire node and all pods running on it. If a system daemon is using more than its reserved amount of memory, an OOM event may occur that can impact the entire node and all pods running on it. To avoid (or reduce the probability of) system OOMs the node provides [Out Of Resource Handling](#).

By reserving some memory via the **--eviction-hard** flag, the node attempts to evict pods whenever memory availability on the node drops below the absolute value or percentage. If system daemons did not exist on a node, pods are limited to the memory **capacity - eviction-hard**. For this reason, resources set aside as a buffer for eviction before reaching out of memory conditions are not available for pods.

Here is an example to illustrate the impact of node allocatable for memory:

- Node capacity is **32Gi**
- **--kube-reserved** is **2Gi**
- **--system-reserved** is **1Gi**
- **--eviction-hard** is set to **<100Mi**.

For this node, the effective node allocatable value is **28.9Gi**. If the node and system components use up all their reservation, the memory available for pods is **28.9Gi**, and kubelet will evict pods when it exceeds this usage.

If we enforce node allocatable (**28.9Gi**) via top level cgroups, then pods can never exceed **28.9Gi**. Evictions would not be performed unless system daemons are consuming more than **3.1Gi** of memory.

If system daemons do not use up all their reservation, with the above example, pods would face memcg OOM kills from their bounding cgroup before node evictions kick in. To better enforce QoS under this situation, the node applies the hard eviction thresholds to the top-level cgroup for all pods to be **Node Allocatable + Eviction Hard Thresholds**.

If system daemons do not use up all their reservation, the node will evict pods whenever they consume more than **28.9Gi** of memory. If eviction does not occur in time, a pod will be OOM killed if pods consume **29Gi** of memory.

18.8. SCHEDULER

The scheduler now uses the value of **node.Status.Allocatable** instead of **node.Status.Capacity** to decide if a node will become a candidate for pod scheduling.

By default, the node will report its machine capacity as fully schedulable by the cluster.

CHAPTER 19. OVERCOMMITTING

19.1. OVERVIEW

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 may 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.

Requests and limits enable administrators to allow and manage the overcommitment of resources on a node, which may be desirable in development environments where a tradeoff of guaranteed performance for capacity is acceptable.

19.2. REQUESTS AND LIMITS

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.

19.3. COMPUTE RESOURCES

The node-enforced behavior for compute resources is specific to the resource type.

19.3.1. CPU

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](#).

19.3.2. Memory

A container is guaranteed the amount of memory it requests. A container may use more memory than requested, but once it exceeds its requested amount, it could be killed in a low memory situation on the node.

If a container uses less memory than requested, it will not be killed 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 killed if it exceeds the limit amount.

19.4. 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.

For each compute resource, a container is divided into one of three QoS classes with decreasing order of priority:

Table 19.1. 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 container 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 container is classified as Burstable .
3 (lowest)	BestEffort	If requests and limits are not set for any of the resources, then the container is classified as BestEffort .

Memory is an incompressible resource, so in low memory situations, containers that have the lowest priority are killed first:

- **Guaranteed** containers are considered top priority, and are guaranteed to only be killed 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 killed 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 killed if the system runs out of memory.

19.5. CONFIGURING MASTERS FOR OVERCOMMITMENT

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.

If OpenShift Container Platform administrators would like to control the level of overcommit and manage

container density on nodes, masters can be configured to override the ratio between request and limit set on developer containers. In conjunction with a [per-project LimitRange](#) specifying limits and defaults, this adjusts the container limit and request to achieve the desired level of overcommit.

This requires configuring the **ClusterResourceOverride** admission controller in the **master-config.yaml** as in the following example (reuse the existing configuration tree if it exists, or introduce absent elements as needed):

```
admissionConfig:
  pluginConfig:
    ClusterResourceOverride: ❶
      configuration:
        apiVersion: v1
        kind: ClusterResourceOverrideConfig
        memoryRequestToLimitPercent: 25 ❷
        cpuRequestToLimitPercent: 25 ❸
        limitCPUToMemoryPercent: 200 ❹
```

- ❶ This is the plug-in name; case matters and anything but an exact match for a plug-in name is ignored.
- ❷ (optional, 1-100) If a container memory limit has been specified or defaulted, the memory request is overridden to this percentage of the limit.
- ❸ (optional, 1-100) If a container CPU limit has been specified or defaulted, the CPU request is overridden to this percentage of the limit.
- ❹ (optional, positive integer) If a container memory limit has been specified or defaulted, the CPU limit is overridden to a percentage of the memory limit, with a 100 percentage scaling 1Gi of RAM to equal 1 CPU core. This is processed prior to overriding CPU request (if configured).

After changing the master configuration, a master restart is required.

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](#)) in order to ensure that the overrides apply.

Note also that after overrides, the container limits and requests must still be validated by any [LimitRange](#) objects 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 [LimitRanges](#) with caution.

When configured, overrides can be disabled per-project (for example, to allow infrastructure components to be configured independently of overrides) by editing the project and adding the following annotation:

```
quota.openshift.io/cluster-resource-override-enabled: "false"
```

19.6. CONFIGURING NODES FOR OVERCOMMITMENT

In an overcommitted environment, it is important to properly configure your node to provide best system behavior.

19.6.1. Enforcing CPU Limits

Nodes by default enforce specified CPU limits using the CPU CFS quota support in the Linux kernel. If you do not want to enforce CPU limits on the node, you can disable its enforcement by modifying the [node configuration file](#) (the *node-config.yaml* file) to include the following:

```
kubeletArguments:
  cpu-cfs-quota:
    - "false"
```

If CPU limit enforcement is disabled, it is important to understand the impact that will have on your node:

- If a container makes a request for CPU, it will continue to be enforced by CFS shares in the Linux kernel.
- If a container makes no explicit request for CPU, but it does specify a limit, the request will default to the specified limit, and be enforced by CFS shares in the Linux kernel.
- If a container specifies both a request and a limit for CPU, the request will be enforced by CFS shares in the Linux kernel, and the limit will have no impact on the node.

19.6.2. Reserving Resources for System Processes

The [scheduler](#) ensures that there are enough resources for all pods on a node based on the pod requests. It verifies that the sum of requests of containers on the node is no greater than the node capacity. It includes all containers started by the node, but not containers or processes started outside the knowledge of the cluster.

It is recommended that you reserve some portion of the node capacity to allow for the system daemons that are required to run on your node for your cluster to function (**sshd**, **docker**, etc.). In particular, it is recommended that you reserve resources for incompressible resources such as memory.

If you want to explicitly reserve resources for non-pod processes, there are two ways to do so:

- The preferred method is to allocate node resources by specifying resources available for scheduling. See [Allocating Node Resources](#) for more details.
- Alternatively, you can create a **resource-reserver** pod that does nothing but reserve capacity from being scheduled on the node by the cluster. For example:

Example 19.1. resource-reserver Pod Definition

```
apiVersion: v1
kind: Pod
metadata:
  name: resource-reserver
spec:
  containers:
    - name: sleep-forever
      image: gcr.io/google_containers/pause:0.8.0
      resources:
        limits:
          cpu: 100m 1
          memory: 150Mi 2
```

- 1 The amount of CPU to reserve on a node for host-level daemons unknown to the cluster.
- 2 The amount of memory to reserve on a node for host-level daemons unknown to the cluster.

You can save your definition to a file, for example *resource-reserver.yaml*, then place the file in the node configuration directory, for example */etc/origin/node/* or the `--config=<dir>` location if otherwise specified.

Additionally, the node server needs to be configured to read the definition from the node configuration directory, by naming the directory in the `kubeletArguments.config` field of the [node configuration file](#) (usually named *node-config.yaml*):

```
kubeletArguments:
  config:
    - "/etc/origin/node" 1
```

- 1 If `--config=<dir>` is specified, use `<dir>` here.

With the *resource-reserver.yaml* file in place, starting the node server also launches the **sleep-forever** container. The scheduler takes into account the remaining capacity of the node, adjusting where to place cluster pods accordingly.

To remove the **resource-reserver** pod, you can delete or move the *resource-reserver.yaml* file from the node configuration directory.

19.6.3. Kernel Tunable Flags

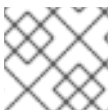
When the node starts, it ensures that the kernel tunable flags for memory management are set properly. The kernel should never fail memory allocations unless it runs out of physical memory.

To ensure this behavior, the node instructs the kernel to always overcommit memory:

```
$ sysctl -w vm.overcommit_memory=1
```

The node also instructs the kernel not to panic when it runs out of memory. Instead, the kernel OOM killer should kill processes based on priority:

```
$ sysctl -w vm.panic_on_oom=0
```



NOTE

The above flags should already be set on nodes, and no further action is required.

19.6.4. Disabling Swap Memory

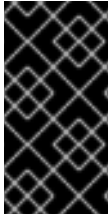
You can disable swap by default on your nodes in order to preserve quality of service guarantees. Otherwise, physical resources on a node can oversubscribe, affecting the resource guarantees the Kubernetes scheduler makes during pod placement.

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.

To disable swap:

```
$ swapoff -a
```

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.

CHAPTER 20. ASSIGNING UNIQUE EXTERNAL IPS FOR INGRESS TRAFFIC

20.1. OVERVIEW



NOTE

This feature is only supported in non-cloud deployments. For cloud (GCE, AWS, and OpenStack) deployments, [load Balancer](#) services can be used to automatically deploy a cloud load balancer to target the service's endpoints.

Cluster administrators can assign a unique external IP address to a service. If routed correctly, external traffic can reach that service's endpoints via any TCP/UDP port the service exposes. This can be simpler than having to manage the port space of a limited number of shared IP addresses when manually assigning external IPs to services.

There is support for both automatic and manual assignment of IP addresses, and each address is guaranteed to be assigned to a maximum of one service. This ensures that each service can simply expose its chosen ports regardless of the ports exposed by other services.

20.2. RESTRICTIONS

To use an `ExternalIP`, you can:

- Select an IP address from the `ExternalIPNetworkCIDRs` range.
- Have an IP address assigned from a pool. In this case, OpenShift Container Platform implements a non-cloud version of the `LoadBalancer` service type and assigns IP addresses to the services.

CAUTION

You must ensure that the IP address pool you assign terminates at one or more nodes in your cluster. You can use the existing `oadm ipfailover` to ensure that the external IPs are highly available.

For manually-configured external IPs, potential port clashes are handled on a first-come, first-served basis. If you request a port, it is only available if it has not yet been assigned for that IP address. For example:

Example 20.1. Port clash example for manually-configured external IPs

Two services have been manually configured with the same external IP address of 172.7.7.7.

MongoDB service A requests port 27017, and then **MongoDB service B** requests the same port; the first request gets the port.

However, port clashes are not an issue for external IPs assigned by the ingress controller, because the controller assigns each service a unique address.

**NOTE**

Ingress IPs can only be assigned if the cluster is not running in the cloud. In cloud environments, LoadBalancer-type services configure cloud-specific load balancers.

20.3. CONFIGURING THE CLUSTER TO USE UNIQUE EXTERNAL IPS

In non-cloud clusters, `ingressIPNetworkCIDR` is set by default to `172.29.0.0/16`. If your cluster environment is not already using this private range, you can use the default. However, if you want to use a different range, then you must set `ingressIPNetworkCIDR` in the `/etc/origin/master/master-config.yaml` file before you assign an ingress IP. Then, restart the master service.

CAUTION

External IPs assigned to services of type `LoadBalancer` will always be in the range of `ingressIPNetworkCIDR`. If `ingressIPNetworkCIDR` is changed such that the assigned external IPs are no longer in range, the affected services will be assigned new external IPs compatible with the new range.

Example 20.2. Sample `/etc/origin/master/master-config.yaml`

```
networkConfig:
  ingressIPNetworkCIDR: 172.29.0.0/16
```

20.4. CONFIGURING AN INGRESS IP FOR A SERVICE

To assign an ingress IP:

1. Create a YAML file for a LoadBalancer service that requests a specific IP via the `loadBalancerIP` setting:

Example 20.3. Sample LoadBalancer Configuration

```
apiVersion: v1
kind: Service
metadata:
  name: egress-1
spec:
  ports:
    - name: db
      port: 3306
  loadBalancerIP: 172.29.0.1
  type: LoadBalancer
  selector:
    name: my-db-selector
```

2. Create a LoadBalancer service on your pod:

```
$ oc create -f loadbalancer.yaml
```

3. Check the service for an external IP. For example, for a service named **myservice**:

```
$ oc get svc myservice
```

When your LoadBalancer-type service has an external IP assigned, the output displays the IP:

```
NAME          CLUSTER-IP      EXTERNAL-IP    PORT(S)    AGE
myservice     172.30.74.106   172.29.0.1     3306/TCP   30s
```

20.5. ROUTING THE INGRESS CIDR FOR DEVELOPMENT OR TESTING

Add a static route directing traffic for the ingress CIDR to a node in the cluster. For example:

```
# route add -net 172.29.0.0/16 gw 10.66.140.17 eth0
```

In the example above, **172.29.0.0/16** is the **ingressIPNetworkCIDR**, and **10.66.140.17** is the node IP.

CHAPTER 21. HANDLING OUT OF RESOURCE ERRORS

21.1. OVERVIEW

The node must preserve node stability when available compute resources are low. This is especially important when dealing with incompressible resources such as memory or disk. If either resource is exhausted, the node becomes unstable.



WARNING

Failure to disable swap memory makes the node not recognize it is under **MemoryPressure**.

To take advantage of memory based evictions, operators must [disable swap](#).

21.2. EVICTION POLICY

Using eviction policies, a node can proactively monitor for and prevent against total starvation of a compute resource.

In cases where a node is running low on available resources, it can proactively fail one or more pods in order to reclaim the starved resource using an eviction policy. When the node fails a pod, it terminates all containers in the pod, and the **PodPhase** is transitioned to **Failed**.

Platform administrators can configure eviction settings within the *node-config.yaml* file.

21.2.1. Eviction Signals

The node can be configured to trigger eviction decisions on the signals described in the table below. The value of each signal is described in the description column based on the node summary API.

To view the signals:

```
curl <certificate details> \
  https://<master>/api/v1/nodes/<node>/proxy/stats/summary
```

Table 21.1. Supported Eviction Signals

Eviction Signal	Description
<code>memory.available</code>	<code>memory.available = node.status.capacity[memory] - node.stats.memory.workingSet</code>

**NOTE**

In future releases, the node will support the ability to trigger eviction decisions based on disk pressure. Until then, use [container and image garbage collection](#).

21.2.2. Eviction Thresholds

You can configure a node to specify eviction thresholds, which trigger the node to reclaim resources.

Eviction thresholds can be soft, for when you allow a grace period before reclaiming resources, and hard, for when the node takes immediate action when a threshold is met.

Thresholds are configured in the following form:

```
<eviction_signal><operator><quantity>
```

- Valid **eviction-signal** tokens as defined by eviction signals.
- Valid **operator** tokens are `<`.
- Valid **quantity** tokens must match the [quantity representation](#) used by Kubernetes.

For example, using the **memory.available** signal, in order to construct a threshold for when the memory available drops below 500Mi, the form would be:

```
memory.available<500Mi
```

21.2.2.1. Soft Eviction Thresholds

A soft eviction threshold pairs an eviction threshold with a required administrator-specified grace period. The node does not reclaim resources associated with the eviction signal until that grace period is exceeded. If no grace period is provided, the node errors on startup.

In addition, if a soft eviction threshold is met, an operator can specify a maximum allowed pod termination grace period to use when evicting pods from the node. If specified, the node uses the lesser value among the **pod.Spec.TerminationGracePeriodSeconds** and the maximum-allowed grace period. If not specified, the node kills pods immediately with no graceful termination.

To configure soft eviction thresholds, the following flags are supported:

- **eviction-soft**: a set of eviction thresholds (for example, **memory.available<1.5Gi**) that, if met over a corresponding grace period, triggers a pod eviction.
- **eviction-soft-grace-period**: a set of eviction grace periods (for example, **memory.available=1m30s**) that correspond to how long a soft eviction threshold must hold before triggering a pod eviction.
- **eviction-max-pod-grace-period**: the maximum-allowed grace period (in seconds) to use when terminating pods in response to a soft eviction threshold being met.

21.2.2.2. Hard Eviction Thresholds

A hard eviction threshold has no grace period and, if observed, the node takes immediate action to reclaim the associated starved resource. If a hard eviction threshold is met, the node kills the pod immediately with no graceful termination.

To configure hard eviction thresholds, the following flag is supported:

- **eviction-hard**: a set of eviction thresholds (for example, **memory.available<1Gi**) that, if met, triggers a pod eviction.

21.2.3. Oscillation of Node Conditions

If a node is oscillating above and below a soft eviction threshold, but not exceeding its associated grace period, the corresponding node condition oscillates between **true** and **false**, which can confuse the scheduler.

To protect this, set the following flag to control how long the node must wait before transitioning out of a pressure condition:

- **eviction-pressure-transition-period**: the duration that the node has to wait before transitioning out of an eviction pressure condition.

Before toggling the condition back to **false**, the node ensures that it has not observed a met eviction threshold for the specified pressure condition for the period specified.

21.2.4. Eviction Monitoring Interval

The node evaluates and monitors eviction thresholds every 10 seconds and the value can not be modified. This is the housekeeping interval.

21.2.5. Mapping Eviction Signals to Node Conditions

The node can map one or more eviction signals to a corresponding node condition.

If an eviction threshold is met, independent of its associated grace period, the node reports a condition indicating that the node is under pressure.

The following node conditions are defined that correspond to the specified eviction signal.

Table 21.2. Node Conditions Related to Low Resources

Node Condition	Eviction Signal	Description
MemoryPressure	memory.available	Available memory on the node has satisfied an eviction threshold.

When the above is set the node continues to report node status updates at the frequency specified by the **node-status-update-frequency** argument, which defaults to **10s**.

21.2.6. Eviction of Pods

If an eviction threshold is met and the grace period is passed, the node initiates the process of evicting pods until it observes the signal going below its defined threshold.

The node ranks pods for eviction by their [quality of service](#), and, among those with the same quality of service, by the consumption of the starved compute resource relative to the pod's scheduling request.

- **BestEffort**: pods that consume the most of the starved resource are failed first.
- **Burstable**: pods that consume the most of the starved resource relative to their request for that resource are failed first. If no pod has exceeded its request, the strategy targets the largest consumer of the starved resource.
- **Guaranteed**: pods that consume the most of the starved resource relative to their request are failed first. If no pod has exceeded its request, the strategy targets the largest consumer of the starved resource.

A **Guaranteed** pod will never be evicted because of another pod's resource consumption unless a system daemon (node, **docker**, **journald**, etc) is consuming more resources than were reserved via **system-reserved**, or **kube-reserved** allocations or if the node has only **Guaranteed** pods remaining.

If the latter, the node evicts a **Guaranteed** pod that least impacts node stability and limits the impact of the unexpected consumption to other **Guaranteed** pods.

21.2.7. Scheduler

The scheduler views node conditions when placing additional pods on the node. For example, if the node has an eviction threshold like the following:

```
eviction-hard is "memory.available<500Mi"
```

and available memory falls below 500Mi, the node reports a value in **Node.Status.Conditions** as **MemoryPressure** as true.

Table 21.3. Node Conditions and Scheduler Behavior

Node Condition	Scheduler Behavior
MemoryPressure	BestEffort pods are not scheduled to the node.

This means that if the scheduler sees the node reporting **MemoryPressure** it will not place **BestEffort** pods on that node.

21.2.8. Example Scenario

Consider the following scenario:

- Node memory capacity of **10Gi**.
- The operator wants to reserve 10% of memory capacity for system daemons (kernel, node, etc.).
- The operator wants to evict pods at 95% memory utilization to reduce thrashing and incidence of system OOM.

A node reports two values:

- **Capacity:** How much resource is on the machine
- **Allocatable:** How much resource is made available for scheduling.

The goal is to allow the scheduler to fully allocate a node and to not have evictions occur.

Evictions should only occur if pods use more than their requested amount of resource.

To facilitate this scenario, the [node configuration file](#) (the *node-config.yaml* file) is modified as follows:

```
kubeletArguments:
  eviction-hard: 1
    - "memory.available<500Mi"
  system-reserved:
    - "memory=1.5Gi"
```

- 1 This threshold can either be **eviction-hard** or **eviction-soft**.



NOTE

Soft eviction usage is more common when you are targeting a certain level of utilization, but can tolerate temporary spikes. It is recommended that the soft eviction threshold is always less than the hard eviction threshold, but the time period is operator specific. The system reservation should also cover the soft eviction threshold.

Implicit in this configuration is the understanding that **system-reserved** should include the amount of memory covered by the eviction threshold.

To reach that capacity, either some pod is using more than its request, or the system is using more than **1Gi**.

If a node has 10 Gi of capacity, and you want to reserve 10% of that capacity for the system daemons, do the following:

```
capacity = 10 Gi
system-reserved = 10 Gi * .1 = 1 Gi
```

The node allocatable value in this setting becomes:

```
allocatable = capacity - system-reserved = 9 Gi
```

This means by default, the scheduler will schedule pods that request 9 Gi of memory to that node.

If you want to turn on eviction so that eviction is triggered when the node observes that available memory falls below 10% of capacity for 30 seconds, or immediately when it falls below 5% of capacity, you need the scheduler to see allocatable as 8Gi. Therefore, ensure your system reservation covers the greater of your eviction thresholds.

```
capacity = 10 Gi
eviction-threshold = 10 Gi * .1 = 1 Gi
system-reserved = (10Gi * .1) + eviction-threshold = 2 Gi
allocatable = capacity - system-reserved = 8 Gi
```

You must set **system-reserved** equal to the amount of resource you want to reserve for system-daemons, plus the amount of resource you want to reserve before triggering evictions.

This configuration ensures that the scheduler does not place pods on a node that immediately induce memory pressure and trigger eviction assuming those pods use less than their configured request.

21.3. OUT OF RESOURCE AND OUT OF MEMORY

If the node experiences a system out of memory (OOM) event before it is able to reclaim memory, the node depends on the OOM killer to respond.

The node sets a **oom_score_adj** value for each container based on the quality of service for the pod.

Table 21.4. Quality of Service OOM Scores

Quality of Service	oom_score_adj Value
Guaranteed	-998
BestEffort	1000
Burstable	$\min(\max(2, 1000 - (1000 * \text{memoryRequestBytes}) / \text{machineMemoryCapacityBytes}), 999)$

If the node is unable to reclaim memory prior to experiencing a system OOM event, the **oom_killer** calculates an **oom_score**:

```
% of node memory a container is using + `oom_score_adj` = `oom_score`
```

The node then kills the container with the highest score.

Containers with the lowest quality of service that are consuming the largest amount of memory relative to the scheduling request are failed first.

Unlike pod eviction, if a pod container is OOM failed, it can be restarted by the node based on its **RestartPolicy**.

21.4. RECOMMENDED PRACTICES

21.4.1. DaemonSets and Out of Resource Handling

If a node evicts a pod that was created by a DaemonSet, the pod will immediately be recreated and rescheduled back to the same node, because the node has no ability to distinguish a pod created from a DaemonSet versus any other object.

In general, DaemonSets should not create **BestEffort** pods to avoid being identified as a candidate pod for eviction. Instead DaemonSets should ideally launch **Guaranteed** pods.

CHAPTER 22. MONITORING ROUTERS

22.1. OVERVIEW

Depending on the underlying implementation, you can monitor a running [router](#) in multiple ways. This topic discusses the HAProxy template router and the components to check to ensure its health.

22.2. VIEWING STATISTICS

The HAProxy router exposes a web listener for the HAProxy statistics. Enter the router's public IP address and the correctly configured port (**1936** by default) to view the statistics page, and enter the administrator password when prompted. This password and port are configured during the router installation, but they can be found by viewing the *haproxy.config* file on the container.

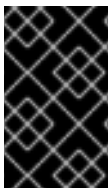
22.3. DISABLING STATISTICS VIEW

By default the HAProxy statistics are exposed on port **1936** (with a password protected account). To disable exposing the HAProxy statistics, specify **0** as the stats port number.

```
$ oadm router hap --service-account=router --stats-port=0
```

Note: HAProxy will still collect and store statistics, it would just *not* expose them via a web listener. You can still get access to the statistics by sending a request to the HAProxy AF_UNIX socket inside the HAProxy Router container.

```
$ cmd="echo 'show stat' | socat - UNIX-
CONNECT:/var/lib/haproxy/run/haproxy.sock"
$ routerPod=$(oc get pods --selector="router=router" \
--template="{{with index .items 0}}{{.metadata.name}}{{end}}")
$ oc exec $routerPod -- bash -c "$cmd"
```



IMPORTANT

For security purposes, the `oc exec` command does not work when accessing privileged containers. Instead, you can SSH into a node host, then use the `docker exec` command on the desired container.

22.4. VIEWING LOGS

To view a router log, run the `oc logs` command on the pod. Since the router is running as a plug-in process that manages the underlying implementation, the log is for the plug-in, not the actual HAProxy log.

To view the logs generated by HAProxy, start a syslog server and pass the location to a router pod using the following environment variables.

Table 22.1. Router Syslog Variables

Environment Variable	Description
ROUTER_SYSLOG_ADDRESS	The IP address of the syslog server. Port 514 is the default if no port is specified.
ROUTER_LOG_LEVEL	Optional. Set to change the HAProxy log level. If not set, the default log level is warning . This can be changed to any log level that HAProxy supports.

To set a running router pod to send messages to a syslog server:

```
$ oc set env dc/router ROUTER_SYSLOG_ADDRESS=<dest_ip:dest_port>
ROUTER_LOG_LEVEL=<level>
```

For example, the following sets HAProxy to send logs to 127.0.0.1 with the default port **514** and changes the log level to **debug**.

```
$ oc set env dc/router ROUTER_SYSLOG_ADDRESS=127.0.0.1
ROUTER_LOG_LEVEL=debug
```

22.5. VIEWING THE ROUTER INTERNALS

routes.json

Routes are processed by the HAProxy router, and are stored both in memory, on disk, and in the HAProxy configuration file. The internal route representation, which is passed to the template to generate the HAProxy configuration file, is found in the `/var/lib/haproxy/router/routes.json` file. When troubleshooting a routing issue, view this file to see the data being used to drive configuration.

HAProxy configuration

You can find the HAProxy configuration and the backends that have been created for specific routes in the `/var/lib/haproxy/conf/haproxy.config` file. The mapping files are found in the same directory. The helper frontend and backends use mapping files when mapping incoming requests to a backend.

Certificates

Certificates are stored in two places:

- Certificates for edge terminated and re-encrypt terminated routes are stored in the `/var/lib/haproxy/router/certs` directory.
- Certificates that are used for connecting to backends for re-encrypt terminated routes are stored in the `/var/lib/haproxy/router/cacerts` directory.

The files are keyed by the namespace and name of the route. The key, certificate, and CA certificate are concatenated into a single file. You can use [OpenSSL](#) to view the contents of these files.

CHAPTER 23. HIGH AVAILABILITY

23.1. OVERVIEW

This topic describes how to set up highly-available services on your OpenShift Container Platform cluster.

The Kubernetes [replication controller](#) ensures that the deployment requirements, in particular the number of replicas, are satisfied when the appropriate resources are available. When run with two or more replicas, the [router](#) can be resilient to failures, providing a highly-available service. Depending on how the router instances are discovered (via a service, DNS entry, or IP addresses), this could impose operational requirements to handle failure cases when one or more router instances are "unreachable".

For some IP-based traffic services, virtual IP addresses (VIPs) should always be serviced for as long as a single instance is available. This simplifies the operational overhead and handles failure cases gracefully.



IMPORTANT

Setting up a nodePort is a privileged operation.



IMPORTANT

Even though a service VIP is highly available, performance can still be affected. **keepalived** makes sure that each of the VIPs is serviced by some node in the configuration, and several VIPs may end up on the same node even when other nodes have none. Strategies that externally load balance across a set of VIPs may be thwarted when ipfailover puts multiple VIPs on the same node.

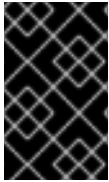
Use cases for high-availability include:

- I want my cluster to be assigned a resource set and I want the cluster to automatically manage those resources.
- I want my cluster to be assigned a set of VIPs that the cluster manages and migrates (with zero or minimal downtime) on failure conditions, and I should not be required to perform any manual interactions to update the upstream "discovery" sources (e.g., DNS). The cluster should service all the assigned VIPs when at least a single node is available, despite the current available resources not being sufficient to reach the desired state.

You can configure a highly-available router or network setup by running multiple instances of the pod and fronting them with a balancing tier. This can be something as simple as DNS round robin, or as complex as multiple load-balancing layers.

23.2. CONFIGURING IP FAILOVER

Using IP failover involves switching IP addresses to a redundant or stand-by set of nodes on failure conditions.

**IMPORTANT**

At this time of writing, ipfailover is not compatible with cloud infrastructures. In the case of AWS, an Elastic Load Balancer (ELB) can be used to make OpenShift Container Platform highly available, [using the AWS console](#).

The `oadm ipfailover` command helps set up the VIP failover configuration. As an administrator, you can configure IP failover on an entire cluster, or on a subset of nodes, as defined by the labeled selector. If you are running in production, match the labeled selector with at least two nodes to ensure you have failover protection and provide a `--replicas=<n>` value that matches the number of nodes for the given labeled selector:

```
$ oadm ipfailover [<Ip_failover_config_name>] <options> --replicas=<n>
```

The `oadm ipfailover` command ensures that a failover pod runs on each of the nodes matching the constraints or label used. This pod uses VRRP (Virtual Router Redundancy Protocol) with [Keepalived](#) to ensure that the service on the watched port is available, and, if needed, Keepalived will automatically float the VIPs if the service is not available.

23.2.1. Virtual IP Addresses

Keepalived manages a set of virtual IP addresses. The administrator must make sure that all these addresses:

- Are accessible on the configured hosts from outside the cluster.
- Are not used for any other purpose within the cluster.

Keepalived on each node determines whether the needed service is running. If it is, VIPs are supported and **Keepalived** participates in the negotiation to determine which node will serve the VIP. For a node to participate, the service must be listening on the watch port on a VIP or the check must be disabled.

**NOTE**

Each VIP in the set may end up being served by a different node.

Option	Variable Name	Notes
<code>--virtual-ips</code>	<code>OPENSIFT_HA_VIRTUAL_IPS</code>	The list of IP address ranges to replicate. This must be provided. (For example, 1.2.3.4-6,1.2.3.9.)

23.2.2. Configuring a Highly-available Routing Service

The following steps describe how to set up a highly-available router environment with IP failover:

1. Label the nodes for the service. This step can be optional if you run the service on any of the nodes in your Kubernetes cluster and use VIPs that can float within those nodes. This process may already exist within a complex cluster, in that nodes may be filtered by any constraints or requirements specified (e.g., nodes with SSD drives, or higher CPU, memory, or disk requirements, etc.).

The following example defines a label as router instances that are servicing traffic in the US west geography **ha-router=geo-us-west**

```
$ oc label nodes openshift-node-{5,6,7,8,9} "ha-router=geo-us-west"
```

- OpenShift Container Platform's **ipfailover** internally uses **keepalived**, so ensure that multicast is enabled on the nodes labeled above and that the nodes can accept network traffic for 224.0.0.18 (the VRRP multicast IP address). Depending on your environment's multicast configuration, you may need to add an **iptables** rule to each of the above labeled nodes. If you do need to add the **iptables** rules, please also ensure that the rules persist after a system restart:

```
$ for node in openshift-node-{5,6,7,8,9}; do ssh $node <<EOF

export interface=${interface:-"eth0"}
echo "Check multicast enabled ... ";
ip addr show $interface | grep -i MULTICAST

echo "Check multicast groups ... "
ip maddr show $interface | grep 224.0.0 | grep $interface

echo "Optionally, add accept rule and persist it ... "
sudo /sbin/iptables -I INPUT -i $interface -d 224.0.0.18/32 -j
ACCEPT

echo "Please ensure the above rule is added on system restarts."

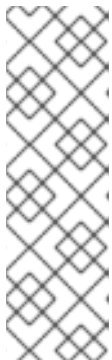
EOF
done;
```

- Add the **ipfailover** service account in the **default** namespace to the **privileged** SCC:

```
$ oadm policy add-scc-to-user privileged
system:serviceaccount:default:ipfailover
```

- Start the router with at least two replicas on nodes matching the labels used in the first step. The following example runs three instances using the **ipfailover** service account:

```
$ oadm router ha-router-us-west --replicas=3 \
  --selector="ha-router=geo-us-west" \
  --labels="ha-router=geo-us-west" \
  --service-account=ipfailover
```



NOTE

The above command runs fewer router replicas than available nodes, so that, in the chance of node failures, Kubernetes can still ensure three available instances until the number of available nodes labeled **ha-router=geo-us-west** is below three. Additionally, the router uses the host network as well as ports 80 and 443, so fewer number of replicas are running to ensure a higher Service Level Availability (SLA). If there are no constraints on the service being setup for failover, it is possible to target the service to run on one or more, or even all, of the labeled nodes.

- Finally, configure the VIPs and failover for the nodes labeled with **ha-router=geo-us-west** in the first step. Ensure the number of replicas match the number of nodes and that they satisfy the label setup in the first step. The name of the **ipfailover** configuration (**ipf-ha-router-us-west** in the example below) should be different from the name of the router configuration (**ha-router-us-west**) as both the router and **ipfailover** create deployment configuration with those names. Specify the VIPs addresses and the port number that **ipfailover** should monitor on the desired instances:

```
$ oadm ipfailover ipf-ha-router-us-west \
  --replicas=5 --watch-port=80 \
  --selector="ha-router=geo-us-west" \
  --virtual-ips="10.245.2.101-105" \
  --service-account=ipfailover --create
```

For details on how to dynamically update the virtual IP addresses for high availability, see [Dynamically Updating Virtual IPs for a Highly-available Service](#).

23.2.3. Configuring a Highly-available Network Service

The following steps describe how to set up a highly-available IP-based network service with IP failover:

- Label the nodes for the service. This step can be optional if you run the service on any of the nodes in your Kubernetes cluster and use VIPs that can float within those nodes. This process may already exist within a complex cluster, in that the nodes may be filtered by any constraints or requirements specified (e.g., nodes with SSD drives, or higher CPU, memory, or disk requirements, etc.).

The following example labels a highly-available cache service that is listening on port 9736 as **ha-cache=geo**:

```
$ oc label nodes openshift-node-{6,3,7,9} "ha-cache=geo"
```

- OpenShift Container Platform's **ipfailover** internally uses **keepalived**, so ensure that multicast is enabled on the nodes labeled above and that the nodes can accept network traffic for 224.0.0.18 (the VRRP multicast IP address). Depending on your environment's multicast configuration, you may need to add an **iptables** rule to each of the above labeled nodes. If you do need to add the **iptables** rules, please also ensure that the rules persist after a system restart:

```
$ for node in openshift-node-{6,3,7,9}; do ssh $node <<EOF
export interface=${interface:-"eth0"}
echo "Check multicast enabled ... ";
ip addr show $interface | grep -i MULTICAST

echo "Check multicast groups ... "
ip maddr show $interface | grep 224.0.0 | grep $interface

echo "Optionally, add accept rule and persist it ... "
sudo /sbin/iptables -I INPUT -i $interface -d 224.0.0.18/32 -j
ACCEPT

echo "Please ensure the above rule is added on system restarts."

EOF
done;
```

3. Create a new **ipfailover** service account in the **default** namespace:

```
$ oc create serviceaccount ipfailover -n default
```

4. Add the **ipfailover** service account in the **default** namespace to the **privileged** SCC:

```
$ oadm policy add-scc-to-user privileged
system:serviceaccount:default:ipfailover
```

5. Run a **geo-cache** service with two or more replicas. An example configuration for running a **geo-cache** service [is provided here](#).



IMPORTANT

Be sure to replace the **myimages/geo-cache** container image referenced in the file with your intended image. Also, change the number of replicas to the desired amount and ensure the label matches the one used in the first step.

```
$ oc create -n <namespace> -f ./examples/geo-cache.json
```

6. Finally, configure the VIPs and failover for the nodes labeled with **ha-cache=geo** in the first step. Ensure the number of replicas match the number of nodes and that they satisfy the label setup in first step. Specify the VIP addresses and the port number that **ipfailover** should monitor for the desired instances:

```
$ oadm ipfailover ipf-ha-geo-cache \
  --replicas=4 --selector="ha-cache=geo" \
  --virtual-ips=10.245.2.101-104 --watch-port=9736 \
  --service-account=ipfailover --create
```

Using the above example, you can now use the VIPs 10.245.2.101 through 10.245.2.104 to send traffic to the geo-cache service. If a particular geo-cache instance is "unreachable", perhaps due to a node failure, Keepalived ensures that the VIPs automatically float amongst the group of nodes labeled "ha-cache=geo" and the service is still reachable via the virtual IP addresses.

23.2.4. Dynamically Updating Virtual IPs for a Highly-available Service

The default deployment strategy for the IP failover service is to recreate the deployment. In order to dynamically update the virtual IPs for a highly available routing service with minimal or no downtime, you must:

- update the IP failover service deployment configuration to use a rolling update strategy, and
- update the **OPENSIFT_HA_VIRTUAL_IPS** environment variable with the updated list or sets of virtual IP addresses.

The following example shows how to dynamically update the deployment strategy and the virtual IP addresses:

1. Consider an IP failover configuration that was created using the following:

```
$ oadm ipfailover ipf-ha-router-us-west \
  --replicas=5 --watch-port=80 \
```

```
--selector="ha-router=geo-us-west" \
--virtual-ips="10.245.2.101-105" \
--service-account=ipfailover --create
```

2. Edit the deployment configuration:

```
$ oc edit dc/ipf-ha-router-us-west
```

3. Update the `spec.strategy.type` field from **Recreate** to **Rolling**:

```
spec:
  replicas: 5
  selector:
    ha-router: geo-us-west
  strategy:
    recreateParams:
      timeoutSeconds: 600
    resources: {}
    type: Rolling ❶
```

- ❶ Set to **Rolling**.

4. Update the `OPENSIFT_HA_VIRTUAL_IPS` environment variable to contain the additional virtual IP addresses:

```
- name: OPENSIFT_HA_VIRTUAL_IPS
  value: 10.245.2.101-105,10.245.2.110,10.245.2.201-205 ❶
```

- ❶ `10.245.2.110,10.245.2.201-205` have been added to the list.

23.2.5. Multiple Highly Available Services In a Network

The IPFailover service uses VRRP (Virtual Router Redundancy Protocol) to communicate with its peers. By default, the generated Keepalived configuration uses a VRRP ID offset starting from 0 (and sequentially increasing) to denote the peers in a network. If you wish to run multiple highly available services in the same network (have multiple IP Failover deployments), you need to ensure that there is no overlap of the VRRP IDs by using a different starting offset for your IPFailover deployment using the `-vrrp-id-offset=<n>` parameter.

```
$ oadm ipfailover ipf-ha-router-us-west \
  --replicas=5 --watch-port=80 \
  --selector="ha-router=geo-us-west" \
  --virtual-ips="10.245.2.101-105" \
  --service-account=ipfailover --create

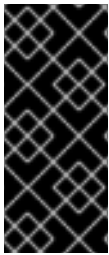
$ # Second IPFailover service with VRRP ids starting at 10.
$ oadm ipfailover ipf-service-redux \
  --replicas=2 --watch-port=6379 --vrrp-id-offset=10 \
  --selector="ha-service=redux" \
  --virtual-ips="10.245.2.199" \
  --service-account=ipfailover --create
```

CHAPTER 24. IPTABLES

24.1. OVERVIEW

There are many system components including OpenShift Container Platform, containers, and software that manage local firewall policies that rely on the kernel iptables configuration for proper network operation. In addition, the iptables configuration of all nodes in the cluster must be correct for networking to work.

All components independently work with iptables without knowledge of how other components are using them. This makes it very easy for one component to break another component's configuration. Further, OpenShift Container Platform and the Docker service assume that iptables remains set up exactly as they have set it up. They may not detect changes introduced by other components and if they do there may be some lag in implementing the fix. In particular, OpenShift Container Platform does monitor and fix problems. However, the Docker service does not.



IMPORTANT

You must ensure that changes you make to the iptables configuration on a node do not impact the operation of OpenShift Container Platform and the Docker service. Also, changes will often need to be made on all nodes in the cluster. Use caution, as iptables is not designed to have multiple concurrent users and it is very easy to break OpenShift Container Platform and Docker networking.

The chains, order of the chains, and rules in the kernel iptables must be properly set up on each node in the cluster for OpenShift Container Platform and Docker networking to work properly. There are several tools and services that are commonly used in the system that interact with the kernel iptables and can accidentally impact OpenShift Container Platform and the Docker service.

24.2. IPTABLES

The iptables tool can be used to set up, maintain, and inspect the tables of IPv4 packet filter rules in the Linux kernel.

Independent of other use, such as a firewall, OpenShift Container Platform and the the Docker service manage chains in some of the tables. The chains are inserted in specific order and the rules are specific to their needs.

CAUTION

`iptables --flush [chain]` can remove key required configuration. Do not execute this command.

24.3. IPTABLES.SERVICE

The iptables service supports a local network firewall. It assumes total control of the iptables configuration. When it starts, it flushes and restores the complete iptables configuration. The restored rules are from its configuration file, `/etc/sysconfig/iptables`. The configuration file is not kept up to date during operation, so the dynamically added rules are lost during every restart.

**WARNING**

Stopping and starting **iptables.service** will destroy configuration that is required by OpenShift Container Platform and Docker. OpenShift Container Platform and Docker are not notified of the change.

```
# systemctl disable iptables.service
# systemctl mask iptables.service
```

If you need to run **iptables.service**, keep a limited configuration in the configuration file and rely on OpenShift Container Platform and Docker to install their needed rules.

The **iptables.service** configuration is loaded from:

```
/etc/sysconfig/iptables
```

To make permanent rules changes, edit the changes into this file. Do not include Docker or OpenShift Container Platform rules.

After **iptables.service** is started or restarted on a node, the Docker service and **atomic-openshift-node.service** must be restarted to reconstruct the needed iptables configuration.

**IMPORTANT**

Restarting the Docker service will cause all containers running on the node to be stopped and restarted.

```
# systemctl restart iptables.service
# systemctl restart docker
# systemctl restart atomic-openshift-node.service
```


CHAPTER 25. SECURING BUILDS BY STRATEGY

25.1. OVERVIEW

Builds in OpenShift Container Platform are run in [privileged containers](#) that have access to the Docker daemon socket. As a security measure, it is recommended to limit who can run builds and the strategy that is used for those builds. [Custom builds](#) are inherently less safe than [Source builds](#), given that they can execute any code in the build with potentially full access to the node's Docker socket, and as such are disabled by default. [Docker build](#) permission should also be granted with caution as a vulnerability in the Docker build logic could result in a privileges being granted on the host node.

By default, all users that can create builds are granted permission to use the Docker and Source-to-Image build strategies. Users with [cluster-admin](#) privileges can enable the Custom build strategy, as referenced in the [Restricting Build Strategies to a User Globally](#) section of this page.

You can control who can build with what build strategy using an [authorization policy](#). Each build strategy has a corresponding build subresource. A user must have permission to create a build *and* permission to create on the build strategy subresource in order to create builds using that strategy. Default roles are provided which grant the **create** permission on the build strategy subresource.

Table 25.1. Build Strategy Subresources and Roles

Strategy	Subresource	Role
Docker	builds/docker	system:build-strategy-docker
Source-to-Image	builds/source	system:build-strategy-source
Custom	builds/custom	system:build-strategy-custom
JenkinsPipeline	builds/jenkinspipeline	system:build-strategy-jenkinspipeline

25.2. DISABLING A BUILD STRATEGY GLOBALLY

To prevent access to a particular build strategy globally, log in as a user with [cluster-admin](#) privileges and remove the corresponding role from the **system:authenticated** group:

```
$ oadm policy remove-cluster-role-from-group system:build-strategy-custom
system:authenticated
$ oadm policy remove-cluster-role-from-group system:build-strategy-docker
system:authenticated
$ oadm policy remove-cluster-role-from-group system:build-strategy-source
system:authenticated
$ oadm policy remove-cluster-role-from-group system:build-strategy-
jenkinspipeline system:authenticated
```

In versions prior to 3.2, the build strategy subresources were included in the **admin** and **edit** roles. Ensure the build strategy subresources are also removed from these roles:

```
$ oc edit clusterrole admin
$ oc edit clusterrole edit
```

For each role, remove the line that corresponds to the resource of the strategy to disable.

Example 25.1. Disable the Docker Build Strategy for admin

```
kind: ClusterRole
metadata:
  name: admin
...
rules:
- resources:
  - builds/custom
  - builds/docker 1
  - builds/source
...
...
```

1 Delete this line to disable Docker builds globally for users with the **admin** role.

25.3. RESTRICTING BUILD STRATEGIES TO A USER GLOBALLY

To allow only a set of specific users to create builds with a particular strategy:

1. [Disable global access to the build strategy.](#)
2. Assign the role corresponding to the build strategy to a specific user. For example, to add the **system:build-strategy-docker** cluster role to the user **devuser**:

```
$ oadm policy add-cluster-role-to-user system:build-strategy-docker
devuser
```



WARNING

Granting a user access at the cluster level to the **builds/docker** subresource means that the user will be able to create builds with the Docker strategy in any project in which they can create builds.

25.4. RESTRICTING BUILD STRATEGIES TO A USER WITHIN A PROJECT

Similar to granting the build strategy role to a user globally, to allow only a set of specific users within a project to create builds with a particular strategy:

1. [Disable global access to the build strategy.](#)

2. Assign the role corresponding to the build strategy to a specific user within a project. For example, to add the **system:build-strategy-docker** role within the project **devproject** to the user **devuser**:

```
$ oadm policy add-role-to-user system:build-strategy-docker devuser  
-n devproject
```

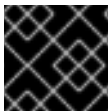
CHAPTER 26. RESTRICTING APPLICATION CAPABILITIES USING SECCOMP

26.1. OVERVIEW

Seccomp (secure computing mode) is used to restrict the set of system calls applications can make, allowing cluster administrators greater control over the security of workloads running in OpenShift Container Platform.

Seccomp support is achieved via two annotations in the pod configuration:

- **seccomp.security.alpha.kubernetes.io/pod**: profile applies to all containers in the pod that do not override
- **container.seccomp.security.alpha.kubernetes.io/<container_name>**: container-specific profile override



IMPORTANT

Containers are run with **unconfined** seccomp settings by default.

For detailed design information, refer to the [seccomp design document](#).

26.2. ENABLING SECCOMP

Seccomp is a feature of the Linux kernel. To ensure seccomp is enabled on your system, run:

```
$ cat /boot/config-`uname -r` | grep CONFIG_SECCOMP=
CONFIG_SECCOMP=y
```

26.3. CONFIGURING OPENSIFT CONTAINER PLATFORM FOR SECCOMP

A seccomp profile is a json file providing syscalls and the appropriate action to take when a syscall is invoked.

1. Create the seccomp profile.
The [default profile](#) is sufficient in many cases, but the cluster administrator must define the security constraints of an individual system.

To create your own custom profile, create a file on every node in the **seccomp-profile-root** directory.

If you are using the default **docker/default** profile, you do not need to create one.

2. Configure your nodes to use the **seccomp-profile-root** where your profiles will be stored. In the **node-config.yaml** via the **kubeletArguments**:

```
kubeletArguments:
  seccomp-profile-root:
    - "/your/path"
```

- Restart the node service to apply the changes:

```
# systemctl restart atomic-openshift-node
```

- In order to control which profiles may be used, and to set the default profile, [configure your SCC](#) via the **seccompProfiles** field. The first profile will be used as a default. The allowable formats of the **seccompProfiles** field include:

- **docker/default**: the default profile for the container runtime (no profile required)
- **unconfined**: unconfined profile, and disables seccomp
- **localhost/<profile-name>**: the profile installed to the node's local seccomp profile root
For example, if you are using the default **docker/default** profile, configure your SCC with:

```
seccompProfiles:
- docker/default
```

26.4. CONFIGURING OPENSIFT CONTAINER PLATFORM FOR A CUSTOM SECCOMP PROFILE

To ensure pods in your cluster run with a custom profile:

- Create the seccomp profile in **seccomp-profile-root**.
- Configure **seccomp-profile-root**:

```
kubeletArguments:
  seccomp-profile-root:
    - "/your/path"
```

- Restart the node service to apply the changes:

```
# systemctl restart atomic-openshift-node
```

- Configure your SCC:

```
seccompProfiles:
- localhost/<profile-name>
```

CHAPTER 27. SYSCTLS

27.1. OVERVIEW

Sysctl settings are exposed via Kubernetes, allowing users to modify certain kernel parameters at runtime for namespaces within a container. Only sysctls that are namespaced can be set independently on pods; if a sysctl is not namespaced (called *node-level*), it cannot be set within OpenShift Container Platform. Moreover, only those sysctls considered *safe* are whitelisted by default; other *unsafe* sysctls can be manually enabled on the node to be available to the user.



NOTE

As of OpenShift Container Platform 3.3.1, sysctl support is a feature in [Technology Preview](#).

27.2. UNDERSTANDING SYSCTLS

In Linux, the sysctl interface allows an administrator to modify kernel parameters at runtime. Parameters are available via the */proc/sys/* virtual process file system. The parameters cover various subsystems such as:

- kernel (common prefix: *kernel.*)
- networking (common prefix: *net.*)
- virtual memory (common prefix: *vm.*)
- MDADM (common prefix: *dev.*)

More subsystems are described in [Kernel documentation](#). To get a list of all parameters, you can run:

```
$ sudo sysctl -a
```

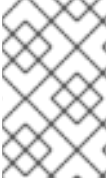
27.3. NAMESPACED VS NODE-LEVEL SYSCTLS

A number of sysctls are *namespaced* in today's Linux kernels. This means that they can be set independently for each pod on a node. Being namespaced is a requirement for sysctls to be accessible in a pod context within Kubernetes.

The following sysctls are known to be namespaced:

- *kernel.shm**
- *kernel.msg**
- *kernel.sem*
- *fs.mqueue.**
- *net.**

Sysctls that are not namespaced are called *node-level* and must be set manually by the cluster administrator, either by means of the underlying Linux distribution of the nodes (e.g., via */etc/sysctls.conf*) or using a DaemonSet with privileged containers.

**NOTE**

Consider marking nodes with special sysctls as tainted. Only schedule pods onto them that need those sysctl settings. Use the [Kubernetes taints and toleration feature](#) to implement this.

27.4. SAFE VS UNSAFE SYSCTLS

Sysctls are grouped into *safe* and *unsafe* sysctls. In addition to proper namespacing, a safe sysctl must be properly isolated between pods on the same node. This means that setting a safe sysctl for one pod:

- must not have any influence on any other pod on the node,
- must not allow to harm the node's health, and
- must not allow to gain CPU or memory resources outside of the resource limits of a pod.

By far, most of the namespaced sysctls are not necessarily considered safe.

For OpenShift Container Platform 3.3.1, the following sysctls are supported (whitelisted) in the safe set:

- *kernel.shm_rmid_forced*
- *net.ipv4.ip_local_port_range*

This list will be extended in future versions when the kubelet supports better isolation mechanisms.

All safe sysctls are enabled by default. All unsafe sysctls are disabled by default and must be allowed manually by the cluster administrator on a per-node basis. Pods with disabled unsafe sysctls will be scheduled, but will fail to launch.

**WARNING**

Due to their nature of being unsafe, the use of unsafe sysctls is at-your-own-risk and can lead to severe problems like wrong behavior of containers, resource shortage, or complete breakage of a node.

27.5. ENABLING UNSAFE SYSCTLS

With the warning above in mind, the cluster administrator can allow certain unsafe sysctls for very special situations, e.g., high-performance or real-time application tuning.

If you want to use unsafe sysctls, cluster administrators must enable them individually on nodes. Only namespaced sysctls can be enabled this way.

1. Use the `kubeletArguments` field in the `/etc/origin/node/node-config.yaml` file, as described in [Configuring Node Resources](#), to set the desired unsafe sysctls:

```
kubeletArguments:
  experimental-allowed-unsafe-sysctls:
    - "kernel.msg*,net.ipv4.route.min_pmtu"
```

- Restart the node service to apply the changes:

```
# systemctl restart atomic-openshift-node
```

27.6. SETTING SYSCTLS FOR A POD

Sysctls are set on pods using annotations. They apply to all containers in the same pod.

Here is an example, with different annotations for safe and unsafe sysctls:

```
apiVersion: v1
kind: Pod
metadata:
  name: sysctl-example
  annotations:
    security.alpha.kubernetes.io/sysctls: kernel.shm_rmid_forced=1
    security.alpha.kubernetes.io/unsafe-sysctls:
net.ipv4.route.min_pmtu=1000,kernel.msgmax=1 2 3
spec:
  ...
```



NOTE

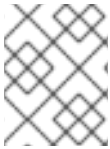
A pod with the unsafe sysctls specified above will fail to launch on any node that has not enabled those two unsafe sysctls explicitly. As with node-level sysctls, use the [taints and toleration feature](#) or [labels on nodes](#) to schedule those pods onto the right nodes.

CHAPTER 28. ENCRYPTING HOSTS WITH IPSEC

28.1. OVERVIEW

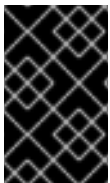
IPsec protects traffic in an OpenShift Container Platform cluster by encrypting the communication between all master and node hosts that communicate using the Internet Protocol (IP).

This topic shows how to secure communication of an entire IP subnet from which the OpenShift Container Platform hosts receive their IP addresses, including all cluster management and pod data traffic.



NOTE

Because OpenShift Container Platform management traffic uses HTTPS, enabling IPsec encrypts management traffic a second time.



IMPORTANT

This procedure should be repeated on each master host, then node host, in your cluster. Hosts that do not have IPsec enabled will not be able to communicate with a host that does.

28.2. ENCRYPTING HOSTS

28.2.1. Step 1: Prerequisites

At this time, **libreswan** version 3.15 is the latest version supported on Red Hat Enterprise Linux 7. Ensure that **libreswan** 3.15 or later is installed on cluster hosts. If [opportunistic group functionality](#) is required, then **libreswan** version 3.19 or later is required.

[Configure the SDN MTU](#) to allow space for the IPsec header. In the configuration described here IPsec requires 62 bytes. If the cluster is operating on an ethernet network with an MTU of 1500 then the SDN MTU should be 1388, to allow for the overhead of IPsec and the SDN encapsulation.

28.2.2. Step 2: Certificates

By default, OpenShift Container Platform secures cluster management communication with mutually authenticated HTTPS communication. This means that both the client (for example, an OpenShift Container Platform node) and the server (for example, an OpenShift Container Platform api-server) send each other their certificates, which are checked against a known certificate authority (CA). These certificates are generated at cluster set up time, and typically live on each host.

These certificates can also be used to secure pod communications with IPsec. You need three files on each host:

- Cluster CA file
- Host client certificate file
- Host private key file

1. Determine what the certificate's nickname will be after it has been imported into the **libreswan** certificate database. The nickname is taken directly from the certificate's subject's Common Name (CN):

```
# openssl x509 \
  -in /path/to/client-certificate -subject -noout | \
  sed -n 's/.*CN=\.*/\1/p'
```

2. Use **openssl** to combine the client certificate, CA certificate, and private key files into a **PKCS#12** file, which is a common file format for multiple certificates and keys:

```
# openssl pkcs12 -export \
  -in /path/to/client-certificate \
  -inkey /path/to/private-key \
  -certfile /path/to/certificate-authority \
  -passout pass: \
  -out certs.p12
```

3. Import the **PKCS#12** file into the **libreswan** certificate database. The **-w** option is left empty, because no password is assigned to the **PKCS#12** file, as it is only temporary.

```
# ipsec initnss
# pk12util -i certs.p12 -d sql:/etc/ipsec.d -w ""
# rm certs.p12
```

28.2.3. Step 3: libreswan IPsec Policy

Now that the necessary certificates are imported into the **libreswan** certificate database, create a policy that uses them to secure communication between hosts in your cluster.

If you are using **libreswan** 3.19 or later, then [opportunistic group configuration](#) is recommended. Otherwise, explicit connections are required.

28.2.3.1. Opportunistic Group Configuration

The following configuration creates two **libreswan** connections. The first encrypts traffic using the OpenShift Container Platform certificates, while the second creates exceptions to the encryption for cluster-external traffic.

1. Place the following into the **/etc/ipsec.d/openshift-cluster.conf** file:

```
conn private
  left=%defaultroute
  leftid=%fromcert
  # our certificate
  leftcert="NSS Certificate DB:<cert_nickname>" 1
  right=%opportunisticgroup
  rightid=%fromcert
  # their certificate transmitted via IKE
  rightca=%same
  ikev2=insist
  authby=rsasig
  failureshunt=drop
  negotiationshunt=hold
```

```

auto=ondemand

conn clear
left=%defaultroute
right=%group
authby=never
type=passthrough
auto=route
priority=100

```

- 1 Replace `<cert_nickname>` with the certificate nickname from step one.
2. Tell **libreswan** which IP subnets and hosts to apply each policy using policy files in `/etc/ipsec.d/policies/`, where each configured connection has a corresponding policy file. So, in the example above, the two connections, **private** and **clear**, each have a file in `/etc/ipsec.d/policies/`. `/etc/ipsec.d/policies/private` should contain the IP subnet of your cluster, which your hosts receive IP addresses from. By default, this causes all communication between hosts in the cluster subnet to be encrypted if the remote host's client certificate authenticates against the local host's Certificate Authority certificate. If the remote host's certificate does not authenticate, all traffic between the two hosts will be blocked.

For example, if all hosts are configured to use addresses in the `172.16.0.0/16` address space, your **private** policy file would contain `172.16.0.0/16`. Any number of additional subnets to encrypt may be added to this file, which results in all traffic to those subnets using IPsec as well.

3. Unencrypt the encryption between all hosts and the subnet gateway to ensure that traffic can enter and exit the cluster. Add the gateway to the `/etc/ipsec.d/policies/clear` file:

```
172.16.0.1/32
```

Additional hosts and subnets may be added to this file, which will result in all traffic to these hosts and subnets being unencrypted.

28.2.3.2. Explicit Connection Configuration

In this configuration, each IPsec node configuration must explicitly list the configuration of every other node in the cluster. Using a configuration management tool such as Ansible to generate this file on each host is recommended.

1. Place the following lines into the `/etc/ipsec.d/openshift-cluster.conf` file on each node for every other node in the cluster:

```

conn <other_node_hostname>
  left=<this_node_ip> 1
  leftid="CN=<this_node_cert_nickname>" 2
  lefttrsasigkey=%cert
  leftcert=<this_node_cert_nickname> 3
  right=<other_node_ip> 4
  rightid="CN=<other_node_cert_nickname>" 5
  righttrsasigkey=%cert
  auto=start
  keyingtries=%forever

```

-

- 1 Replace `<this_node_ip>` with the cluster IP address of this node.
- 2 3 Replace `<this_node_cert_nickname>` with the node certificate nickname from step one.
- 4 Replace `<other_node_ip>` with the cluster IP address of the other node.
- 5 Replace `<other_node_cert_nickname>` with the other node certificate nickname from step one.

2. Place the following in the `/etc/ipsec.d/openshift-cluster.secrets` file on each node:

```
| : RSA "<this_node_cert_nickname>" 1
```

- 1 Replace `<this_node_cert_nickname>` with the node certificate nickname from step one.

28.3. IPSEC FIREWALL CONFIGURATION

All nodes within the cluster need to allow IPsec related network traffic. This includes IP protocol numbers 50 and 51 as well as UDP port 500.

For example, if the cluster nodes communicate over interface `eth0`:

```
| -A OS_FIREWALL_ALLOW -i eth0 -p 50 -j ACCEPT
| -A OS_FIREWALL_ALLOW -i eth0 -p 51 -j ACCEPT
| -A OS_FIREWALL_ALLOW -i eth0 -p udp --dport 500 -j ACCEPT
```



NOTE

IPsec also uses UDP port 4500 for NAT traversal, though this should not apply to normal cluster deployments.

28.4. STARTING AND ENABLING IPSEC

1. Start the `ipsec` service to load the new configuration and policies, and begin encrypting:

```
| # systemctl start ipsec
```

2. Enable the `ipsec` service to start on boot:

```
| # systemctl enable ipsec
```

28.5. TROUBLESHOOTING

When authentication cannot be completed between two hosts, you will not be able to ping between them, because all IP traffic will be rejected. If the `clear` policy is not configured correctly, you will also not be able to SSH to the host from another host in the cluster.

You can use the `ipsec status` command to check that the `clear` and `private` policies have been loaded.

CHAPTER 29. BUILDING DEPENDENCY TREES

29.1. OVERVIEW

OpenShift Container Platform uses [image change triggers](#) in a [build configuration](#) to detect when an [image stream tag](#) has been updated. You can use the `oadm build-chain` command to build a dependency tree that identifies which [images](#) would be affected by updating an image in a specified [image stream](#).

The `build-chain` tool can determine which [builds](#) to trigger; it analyzes the output of those builds to determine if they will in turn update another image stream tag. If they do, the tool continues to follow the dependency tree. Lastly, it outputs a graph specifying the image stream tags that would be impacted by an update to the top-level tag. The default output syntax for this tool is set to a human-readable format; the DOT format is also supported.

29.2. USAGE

The following table describes common `build-chain` usage and general syntax:

Table 29.1. Common build-chain Operations

Description	Syntax
Build the dependency tree for the latest tag in <code><image-stream></code> .	<pre>\$ oadm build-chain <image-stream></pre>
Build the dependency tree for the v2 tag in DOT format, and visualize it using the DOT utility.	<pre>\$ oadm build-chain <image-stream>:v2 \ -o dot \ dot -T svg -o deps.svg</pre>
Build the dependency tree across all projects for the specified image stream tag found the test project.	<pre>\$ oadm build-chain <image-stream>:v1 \ -n test --all</pre>



NOTE

You may need to install the `graphviz` package to use the `dot` command.

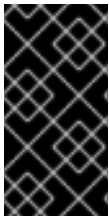
CHAPTER 30. BACKUP AND RESTORE

30.1. OVERVIEW

In OpenShift Container Platform, you can *back up* (saving state to separate storage) and *restore* (recreating state from separate storage) at the cluster level. There is also some preliminary support for [per-project backup](#). The full state of a cluster installation includes:

- etcd data on each master
- API objects
- registry storage
- volume storage

This topic does not cover how to back up and restore [persistent storage](#), as those topics are left to the underlying storage provider. However, an example of how to perform a **generic** backup of [application data](#) is provided.



IMPORTANT

This topic only provides a generic way of backing up applications and the OpenShift Container Platform cluster. It can not take into account custom requirements. Therefore, you should create a full backup and restore procedure. To prevent data loss, necessary precautions should be taken.

30.2. PREREQUISITES

1. Because the restore procedure involves a complete reinstallation, save all the files used in the initial installation. This may include:
 - `~/.config/openshift/installer.cfg.yml` (from the [Quick Installation](#) method)
 - Ansible playbooks and inventory files (from the [Advanced Installation](#) method)
 - `/etc/yum.repos.d/ose.repo` (from the [Disconnected Installation](#) method)
2. Backup the procedures for post-installation steps. Some installations may involve steps that are not included in the installer. This may include changes to the services outside of the control of OpenShift Container Platform or the installation of extra services like monitoring agents. Additional configuration that is not supported yet by the advanced installer might also be affected, for example when using multiple authentication providers.
3. Install packages that provide various utility commands:

```
# yum install etcd
```

4. If using a container-based installation, pull the etcd image instead:

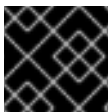
```
# docker pull rhel7/etcd
```

Note the location of the **etcd** data directory (or `$ETCD_DATA_DIR` in the following sections), which depends on how **etcd** is deployed.

Deployment Type	Description	Data Directory
separate etcd	etcd runs as a separate service, either co-located on master nodes or on separate nodes.	<i><code>/var/lib/etcd</code></i>
embedded etcd	etcd runs as part of the master service.	<i><code>/var/lib/origin/openshift.local.etcd</code></i>

30.3. CLUSTER BACKUP

30.3.1. Master Backup



IMPORTANT

You must perform the following step on each master node.

1. Create a backup of the master host configuration files:

```
$ MYBACKUPDIR=/backup/$(hostname)/$(date +%Y%m%d)
$ sudo mkdir -p ${MYBACKUPDIR}/etc/sysconfig
$ sudo cp -aR /etc/origin ${MYBACKUPDIR}/etc
$ sudo cp -aR /etc/sysconfig/atomic-* ${MYBACKUPDIR}/etc/sysconfig/
```

2. If **etcd** is running on more than one host, stop it on each host:

```
# sudo systemctl stop etcd
```

Although this step is not strictly necessary, doing so ensures that the **etcd** data is fully synchronized.

3. Create an **etcd** backup:

```
# etcdctl backup \
  --data-dir $ETCD_DATA_DIR \
  --backup-dir $ETCD_DATA_DIR.bak
```



NOTE

If **etcd** is running on more than one host, the various instances regularly synchronize their data, so creating a backup for one of them is sufficient.



NOTE

For a container-based installation, you must use **docker exec** to run **etcdctl** inside the container.

4. Copy the **db** file over to the backup you created:

```
$ cp "$ETCD_DATA_DIR"/member/snap/db
  "$ETCD_DATA_DIR.bak"/member/snap/db
```

30.4. CLUSTER RESTORE FOR SINGLE-MEMBER ETCD CLUSTERS

To restore the cluster:

1. Reinstall OpenShift Container Platform.
This should be done in the [same way](#) that OpenShift Container Platform was previously installed.
2. Run all necessary post-installation steps.
3. Restore the certificates and keys, on each master:

```
# cd /etc/origin/master
# tar xvf /tmp/certs-and-keys-$(hostname).tar
```

4. Restore from the **etcd** backup:

```
# mv $ETCD_DATA_DIR $ETCD_DATA_DIR.orig
# cp -Rp $ETCD_DATA_DIR.bak $ETCD_DATA_DIR
# chcon -R --reference $ETCD_DATA_DIR.orig $ETCD_DATA_DIR
# chown -R etcd:etcd $ETCD_DATA_DIR
```

5. Create the new single node cluster using etcd's **--force-new-cluster** option. You can do this using the values from */etc/etcd/etcd.conf*, or you can temporarily modify the **systemd** unit file and start the service normally.

To do so, edit the */usr/lib/systemd/system/etcd.service* file, and add **--force-new-cluster**:

```
# sed -i '/ExecStart/s/"$/ --force-new-cluster"/'
/usr/lib/systemd/system/etcd.service
# systemctl show etcd.service --property ExecStart --no-pager

ExecStart=/bin/bash -c "GOMAXPROCS=$(nproc) /usr/bin/etcd --force-
new-cluster"
```

Then, restart the **etcd** service:

```
# systemctl daemon-reload
# systemctl start etcd
```

6. Verify the **etcd** service started correctly, then re-edit the */usr/lib/systemd/system/etcd.service* file and remove the **--force-new-cluster** option:

```
# sed -i '/ExecStart/s/ --force-new-cluster//'
/usr/lib/systemd/system/etcd.service
# systemctl show etcd.service --property ExecStart --no-pager

ExecStart=/bin/bash -c "GOMAXPROCS=$(nproc) /usr/bin/etcd"
```

7. Restart the **etcd** service, then verify the etcd cluster is running correctly and displays OpenShift Container Platform's configuration:


```
# systemctl daemon-reload
# systemctl restart etcd
```

30.5. CLUSTER RESTORE FOR MULTIPLE-MEMBER ETCD CLUSTERS

When using a separate etcd cluster, you must first restore the etcd backup by creating a new, single node etcd cluster. If you run etcd as a stand-alone service on your master nodes, you can create the single node etcd cluster on a master node. If you use separate etcd with multiple members, you must then also add any additional etcd members to the etcd cluster one by one.

However, the details of the restoration process differ between [embedded](#) and [external](#) etcd. See the following section and follow the relevant steps before [Bringing OpenShift Services Back Online](#).

30.5.1. Embedded etcd

Restore your etcd backup and configuration:

1. Run the following on the master with the embedded etcd:

```
# ETCD_DIR=/var/lib/origin/openshift.local.etcd
# mv $ETCD_DIR /var/lib/etcd.orig
# cp -Rp /var/lib/origin/etcd-backup-<timestamp>/ $ETCD_DIR
# chcon -R --reference /var/lib/etcd.orig/ $ETCD_DIR
# chown -R etcd:etcd $ETCD_DIR
```



WARNING

The `$ETCD_DIR` location differs between external and embedded etcd.

2. Create the new, single node etcd cluster:

```
# etcd -data-dir=/var/lib/origin/openshift.local.etcd \
  -force-new-cluster
```

Verify etcd has started successfully by checking the output from the above command, which should look similar to the following near the end:

```
[...]
2016-06-24 12:14:45.644073 I | etcdserver: starting server...
[version: 2.2.5, cluster version: 2.2]
[...]
2016-06-24 12:14:46.834394 I | etcdserver: published {Name:default
ClientURLs:[http://localhost:2379 http://localhost:4001]} to cluster
5580663a6e0002
```

3. Shut down the process by running the following from a separate terminal:

```
# pkill etcd
```

- Continue to [Bringing OpenShift Container Platform Services Back Online](#).

30.5.2. Separate etcd

Choose a system to be the initial etcd member, and restore its etcd backup and configuration:

- Run the following on the etcd host:

```
# ETCD_DIR=/var/lib/etcd/
# mv $ETCD_DIR /var/lib/etcd.orig
# cp -Rp /var/lib/origin/etcd-backup-<timestamp>/ $ETCD_DIR
# chcon -R --reference /var/lib/etcd.orig/ $ETCD_DIR
# chown -R etcd:etcd $ETCD_DIR
```



WARNING

The `$ETCD_DIR` location differs between external and embedded etcd.

- Restore your `/etc/etcd/etcd.conf` file from backup or `.rpmsave`.
- Create the new single node cluster using etcd's `--force-new-cluster` option. You can do this with a long complex command using the values from `/etc/etcd/etcd.conf`, or you can temporarily modify the `systemd` unit file and start the service normally. To do so, edit the `/usr/lib/systemd/system/etcd.service` file, and add `--force-new-cluster`:

```
# sed -i '/ExecStart/s/"$/ --force-new-cluster"/'
/usr/lib/systemd/system/etcd.service
# systemctl show etcd.service --property ExecStart --no-pager

ExecStart=/bin/bash -c "GOMAXPROCS=$(nproc) /usr/bin/etcd --force-
new-cluster"
```

Then restart the `etcd` service:

```
# systemctl daemon-reload
# systemctl start etcd
```

- Verify the `etcd` service started correctly, then re-edit the `/usr/lib/systemd/system/etcd.service` file and remove the `--force-new-cluster` option:

```
# sed -i '/ExecStart/s/ --force-new-cluster//'
/usr/lib/systemd/system/etcd.service
# systemctl show etcd.service --property ExecStart --no-pager

ExecStart=/bin/bash -c "GOMAXPROCS=$(nproc) /usr/bin/etcd"
```

- Restart the **etcd** service, then verify the etcd cluster is running correctly and displays OpenShift Container Platform's configuration:

```
# systemctl daemon-reload
# systemctl restart etcd
# etcdctl --cert-file=/etc/etcd/peer.crt \
  --key-file=/etc/etcd/peer.key \
  --ca-file=/etc/etcd/ca.crt \
  --peers="https://172.16.4.18:2379,https://172.16.4.27:2379" \ 1
ls /
```

- 1 Ensure that you specify the URLs of only active etcd members in the **--peers** parameter value.

- If you have additional etcd members to add to your cluster, continue to [Adding Additional etcd Members](#). Otherwise, if you only want a single node separate etcd cluster, continue to [Bringing OpenShift Container Platform Services Back Online](#).

30.5.2.1. Adding Additional etcd Members

To add additional etcd members to the cluster, you must first adjust the default **localhost** peer in the **peerURLs** value for the first member:

- Get the member ID for the first member using the **member list** command:

```
# etcdctl --cert-file=/etc/etcd/peer.crt \
  --key-file=/etc/etcd/peer.key \
  --ca-file=/etc/etcd/ca.crt \
  --
peers="https://172.18.1.18:2379,https://172.18.9.202:2379,https://17
2.18.0.75:2379" \ 1
member list
```

- 1 Ensure that you specify the URLs of only active etcd members in the **--peers** parameter value.

- Update the value of **peerURLs** using the **etcdctl member update** command by passing the member ID obtained from the previous step:

```
# etcdctl --cert-file=/etc/etcd/peer.crt \
  --key-file=/etc/etcd/peer.key \
  --ca-file=/etc/etcd/ca.crt \
  --
peers="https://172.18.1.18:2379,https://172.18.9.202:2379,https://17
2.18.0.75:2379" \
member update 511b7fb6cc0001 https://172.18.1.18:2380
```

Alternatively, you can use **curl**:

```
# curl --cacert /etc/etcd/ca.crt \
  --cert /etc/etcd/peer.crt \
  --key /etc/etcd/peer.key \
  https://172.18.1.18:2379/v2/members/511b7fb6cc0001 \
```

```
-XPUT -H "Content-Type: application/json" \
-d '{"peerURLs":["https://172.18.1.18:2380"]}'
```

3. Re-run the **member list** command and ensure the peer URLs no longer include **localhost**.
4. Now, add each additional member to the cluster one at a time.



WARNING

Each member must be fully added and brought online one at a time. When adding each additional member to the cluster, the **peerURLs** list must be correct for that point in time, so it will grow by one for each member added. The **etcdctl member add** command will output the values that need to be set in the **etcd.conf** file as you add each member, as described in the following instructions.

- a. For each member, add it to the cluster using the values that can be found in that system's **etcd.conf** file:

```
# etcdctl --cert-file=/etc/etcd/peer.crt \
--key-file=/etc/etcd/peer.key \
--ca-file=/etc/etcd/ca.crt \
--peers="https://172.16.4.18:2379,https://172.16.4.27:2379" \
member add 10.3.9.222 https://172.16.4.27:2380 1
```

Added member named 10.3.9.222 with ID 4e1db163a21d7651 to cluster

```
ETCD_NAME="10.3.9.222"
ETCD_INITIAL_CLUSTER="10.3.9.221=https://172.16.4.18:2380,10.3.9.222=https://172.16.4.27:2380"
ETCD_INITIAL_CLUSTER_STATE="existing"
```

- 1** In this line, **10.3.9.222** is a label for the etcd member. You can specify the host name, IP address, or a simple name.

- b. Using the environment variables provided in the output of the above **etcdctl member add** command, edit the **/etc/etcd/etcd.conf** file on the member system itself and ensure these settings match.

- c. Now start etcd on the new member:

```
# rm -rf /var/lib/etcd/member
# systemctl enable etcd
# systemctl start etcd
```

- d. Ensure the service starts correctly and the etcd cluster is now healthy:

```
# etcdctl --cert-file=/etc/etcd/peer.crt \
--key-file=/etc/etcd/peer.key \
```

```

--ca-file=/etc/etcd/ca.crt \
--peers="https://172.16.4.18:2379,https://172.16.4.27:2379" \
member list

51251b34b80001: name=10.3.9.221 peerURLs=https://172.16.4.18:2380
clientURLs=https://172.16.4.18:2379
d266df286a41a8a4: name=10.3.9.222
peerURLs=https://172.16.4.27:2380
clientURLs=https://172.16.4.27:2379

# etcdctl --cert-file=/etc/etcd/peer.crt \
--key-file=/etc/etcd/peer.key \
--ca-file=/etc/etcd/ca.crt \
--peers="https://172.16.4.18:2379,https://172.16.4.27:2379" \
cluster-health

cluster is healthy
member 51251b34b80001 is healthy
member d266df286a41a8a4 is healthy

```

- e. Now repeat this process for the next member to add to the cluster.
5. After all additional etcd members have been added, continue to [Bringing OpenShift Container Platform Services Back Online](#).

30.6. ADDING NEW ETCD HOSTS

In cases where etcd members have failed and you still have a quorum of etcd cluster members running, you can use the surviving members to add additional etcd members without downtime.

Suggested Cluster Size

Having a cluster with an odd number of etcd hosts can account for fault tolerance. Having an odd number of etcd hosts does not change the number needed for a quorum, but increases the tolerance for failure. For example, a cluster size of three members, quorum is two leaving a failure tolerance of one. This ensures the cluster will continue to operate if two of the members are healthy.

Having an in-production cluster of three etcd hosts is recommended.



NOTE

The following presumes you have a backup of the **/etc/etcd** configuration for the etcd hosts.

1. If the new etcd members will also be OpenShift Container Platform nodes, see [Add the desired number of hosts to the cluster](#). The rest of this procedure presumes you have added just one host, but if adding multiple, perform all steps on each host.
2. Upgrade etcd and iptables on the surviving nodes:

```
# yum update etcd iptables-services
```

Ensure version **etcd-2.3.7-4.e17.x86_64** or greater is installed, and that the same version is installed on each host.

3. Install etcd and iptables on the new host

```
# yum install etcd iptables-services
```

Ensure version **etcd-2.3.7-4.el7.x86_64** or greater is installed, and that the same version is installed on the new host.

4. [Backup the etcd data store](#) on surviving hosts before making any cluster configuration changes.
5. If replacing a failed etcd member, remove the failed member *before* adding the new member.

```
# etcdctl -C https://<surviving host IP>:2379 \
  --ca-file=/etc/etcd/ca.crt \
  --cert-file=/etc/etcd/peer.crt \
  --key-file=/etc/etcd/peer.key cluster-health

# etcdctl -C https://<surviving host IP>:2379 \
  --ca-file=/etc/etcd/ca.crt \
  --cert-file=/etc/etcd/peer.crt \
  --key-file=/etc/etcd/peer.key member remove <failed member
  identifier>
```

Stop the etcd service on the failed etcd member:

```
# systemctl stop etcd
```

6. On the new host, add the appropriate iptables rules:

```
# systemctl enable iptables.service --now
# iptables -N OS_FIREWALL_ALLOW
# iptables -t filter -I INPUT -j OS_FIREWALL_ALLOW
# iptables -A OS_FIREWALL_ALLOW -p tcp -m state \
  --state NEW -m tcp --dport 2379 -j ACCEPT
# iptables -A OS_FIREWALL_ALLOW -p tcp -m state \
  --state NEW -m tcp --dport 2380 -j ACCEPT
# iptables-save > /etc/sysconfig/iptables
```

7. Generate the required certificates for the new host. On a surviving etcd host:

- a. Make a backup of the **/etc/etcd/ca/** directory.
- b. Set the variables and working directory for the certificates, ensuring to create the **PREFIX** directory if one has not been created:

```
# cd /etc/etcd
# export NEW_ETCD="<NEW_HOST_NAME>"

# export CN=$NEW_ETCD
# export SAN="IP:<NEW_HOST_IP>"
# export PREFIX="./generated_certs/etcd-$CN/"
```

- c. Create the \$PREFIX directory:

```
$ mkdir -p $PREFIX
```

- d. Create the **server.csr** and **server.crt** certificates:

```
# openssl req -new -keyout ${PREFIX}server.key \
  -config ca/openssl.cnf \
  -out ${PREFIX}server.csr \
  -reqexts etcd_v3_req -batch -nodes \
  -subj /CN=$CN

# openssl ca -name etcd_ca -config ca/openssl.cnf \
  -out ${PREFIX}server.crt \
  -in ${PREFIX}server.csr \
  -extensions etcd_v3_ca_server -batch
```

- e. Create the **peer.csr** and **peer.crt** certificates:

```
# openssl req -new -keyout ${PREFIX}peer.key \
  -config ca/openssl.cnf \
  -out ${PREFIX}peer.csr \
  -reqexts etcd_v3_req -batch -nodes \
  -subj /CN=$CN

# openssl ca -name etcd_ca -config ca/openssl.cnf \
  -out ${PREFIX}peer.crt \
  -in ${PREFIX}peer.csr \
  -extensions etcd_v3_ca_peer -batch
```

- f. Copy the **etcd.conf** and **ca.crt** files, and archive the contents of the directory:

```
# cp etcd.conf ${PREFIX}
# cp ca.crt ${PREFIX}
# tar -czvf ${PREFIX}${CN}.tgz -C ${PREFIX} .
```

- g. Transfer the files to the new etcd hosts:

```
# scp ${PREFIX}${CN}.tgz $CN:/etc/etcd/
```

8. While still on the surviving etcd host, add the new host to the cluster:

- a. Add the new host to the cluster:

```
# export ETCD_CA_HOST="<SURVIVING_ETCD_HOSTNAME>"
# export NEW_ETCD="<NEW_ETCD_HOSTNAME>"
# export NEW_ETCD_IP="<NEW_HOST_IP>"

# etcdctl -C https://${ETCD_CA_HOST}:2379 \
  --ca-file=/etc/etcd/ca.crt \
  --cert-file=/etc/etcd/peer.crt \
  --key-file=/etc/etcd/peer.key member add ${NEW_ETCD}
https://${NEW_ETCD_IP}:2380

ETCD_NAME="<NEW_ETCD_HOSTNAME>"
ETCD_INITIAL_CLUSTER="
<NEW_ETCD_HOSTNAME>=https://<NEW_HOST_IP>:2380,
<SURVIVING_ETCD_HOST>=https://<SURVIVING_HOST_IP>:2380
ETCD_INITIAL_CLUSTER_STATE="existing"
```

-

Copy the three environment variables in the `etcdctl` member add output. They will be used later.

- b. On the new host, extract the copied configuration data and set the permissions:

```
# tar -xf /etc/etcd/<NEW_ETCD_HOSTNAME>.tgz -C /etc/etcd/ --
  overwrite
# chown -R etcd:etcd /etc/etcd/*
```

- c. On the new host, remove any etcd data:

```
# rm -rf /var/lib/etcd/member
# chown -R etcd:etcd /var/lib/etcd
```

9. On the new etcd host, update the ***etcd.conf*** file:

- a. Replace the following with the values generated in the previous step:

- `ETCD_NAME`
- `ETCD_INITIAL_CLUSTER`
- `ETCD_INITIAL_CLUSTER_STATE`

- b. Replace the IP address with the "NEW_ETCD" value for:

- `ETCD_LISTEN_PEER_URLS`
- `ETCD_LISTEN_CLIENT_URLS`
- `ETCD_INITIAL_ADVERTISE_PEER_URLS`
- `ETCD_ADVERTISE_CLIENT_URLS`

- c. For replacing failed members, replace the failed hosts with the new hosts.

10. To ensure the etcd configuration does not use the failed host when the etcd service is restarted, modify the ***etcd.conf*** file on all remaining etcd hosts and remove the failed host in the value for the **`ETCD_INITIAL_CLUSTER`** variable.

11. On the node that hosts the installation files, update the **`[etcd]`** hosts group in the ***/etc/ansible/hosts*** inventory file. Remove the old etcd hosts and add the new ones.

12. Start etcd on the new host:

```
# systemctl enable etcd --now
```

13. To verify that the new member has been added successfully:

```
etcdctl -C https://${ETCD_CA_HOST}:2379 --ca-file=/etc/etcd/ca.crt \
  --cert-file=/etc/etcd/peer.crt \
  --key-file=/etc/etcd/peer.key cluster-health
```

14. Update the master configuration on all masters to point to the new etcd host

- a. On every master in the cluster, edit ***/etc/origin/master/master-config.yaml***

- a. On every master in the cluster, edit `/etc/origin/master/master-config.yaml`
- b. Find the `etcdClientInfo` section.
- c. Add the new etcd host to the `urls` list.
- d. If a failed etcd host was replaced, remove it from the list.
- e. Restart the master API service.
On a single master cluster installation:

```
# systemctl restart atomic-openshift-master
```

On a multi-master cluster installation, on each master:

```
# systemctl restart atomic-openshift-master-api
```

The procedure to add an etcd member is complete.

30.7. BRINGING OPENSIFT CONTAINER PLATFORM SERVICES BACK ONLINE

On each OpenShift Container Platform master, restore your master and node configuration from backup and enable and restart all relevant services.

On the master in a single master cluster:

```
# cp ${MYBACKUPDIR}/etc/sysconfig/atomic-openshift-master
/etc/sysconfig/atomic-openshift-master
# cp ${MYBACKUPDIR}/etc/origin/master/master-config.yaml.<timestamp>
/etc/origin/master/master-config.yaml
# cp ${MYBACKUPDIR}/etc/origin/node/node-config.yaml.<timestamp>
/etc/origin/node/node-config.yaml
# systemctl enable atomic-openshift-master
# systemctl enable atomic-openshift-node
# systemctl start atomic-openshift-master
# systemctl start atomic-openshift-node
```

On each master in a multi-master cluster:

```
# cp ${MYBACKUPDIR}/etc/sysconfig/atomic-openshift-master-api
/etc/sysconfig/atomic-openshift-master-api
# cp ${MYBACKUPDIR}/etc/sysconfig/atomic-openshift-master-controllers
/etc/sysconfig/atomic-openshift-master-controllers
# cp ${MYBACKUPDIR}/etc/origin/master/master-config.yaml.<timestamp>
/etc/origin/master/master-config.yaml
# cp ${MYBACKUPDIR}/etc/origin/node/node-config.yaml.<timestamp>
/etc/origin/node/node-config.yaml
# systemctl enable atomic-openshift-master-api
# systemctl enable atomic-openshift-master-controllers
# systemctl enable atomic-openshift-node
# systemctl start atomic-openshift-master-api
# systemctl start atomic-openshift-master-controllers
# systemctl start atomic-openshift-node
```

On each OpenShift Container Platform node, restore your **node-config.yaml** file from backup and enable and restart the **atomic-openshift-node** service:

```
# cp /etc/origin/node/node-config.yaml.<timestamp> /etc/origin/node/node-  
config.yaml  
# systemctl enable atomic-openshift-node  
# systemctl start atomic-openshift-node
```

Your OpenShift Container Platform cluster should now be back online.

30.8. PROJECT BACKUP

A future release of OpenShift Container Platform will feature specific support for per-project back up and restore.

For now, to back up API objects at the project level, use **oc export** for each object to be saved. For example, to save the deployment configuration **frontend** in YAML format:

```
$ oc export dc frontend -o yaml > dc-frontend.yaml
```

To back up all of the project (with the exception of cluster objects like namespaces and projects):

```
$ oc export all -o yaml > project.yaml
```

30.8.1. Role Bindings

Sometimes custom policy [role bindings](#) are used in a project. For example, a project administrator can give another user a certain role in the project and grant that user project access.

These role bindings can be exported:

```
$ oc get rolebindings -o yaml --export=true > rolebindings.yaml
```

30.8.2. Service Accounts

If custom service accounts are created in a project, these need to be exported:

```
$ oc get serviceaccount -o yaml --export=true > serviceaccount.yaml
```

30.8.3. Secrets

Custom secrets like source control management secrets (SSH Public Keys, Username/Password) should be exported if they are used:

```
$ oc get secret -o yaml --export=true > secret.yaml
```

30.8.4. Persistent Volume Claims

If the an application within a project uses a persistent volume through a persistent volume claim (PVC), these should be backed up:

-

```
$ oc get pvc -o yaml --export=true > pvc.yaml
```

30.9. PROJECT RESTORE

To restore a project, recreate the project and recreate all of the objects that were exported during the backup:

```
$ oc new-project myproject
$ oc create -f project.yaml
$ oc create -f secret.yaml
$ oc create -f serviceaccount.yaml
$ oc create -f pvc.yaml
$ oc create -f rolebindings.yaml
```



NOTE

Some resources can fail to be created (for example, pods and default service accounts).

30.10. APPLICATION DATA BACKUP

In many cases, application data can be backed up using the `oc rsync` command, assuming `rsync` is installed within the container image. The Red Hat `rhel7` base image does contain `rsync`. Therefore, all images that are based on `rhel7` contain it as well. See [Troubleshooting and Debugging CLI Operations - rsync](#).



WARNING

This is a *generic* backup of application data and does not take into account application-specific backup procedures, for example special export/import procedures for database systems.

Other means of backup may exist depending on the type of the persistent volume (for example, Cinder, NFS, Gluster, or others).

The paths to back up are also *application specific*. You can determine what path to back up by looking at the `mountPath` for volumes in the `deploymentconfig`.

Example of Backing up a Jenkins Deployment's Application Data

1. Get the application data `mountPath` from the `deploymentconfig`:

```
$ oc get dc/jenkins -o jsonpath='{ .spec.template.spec.containers[?
(@.name=="jenkins")].volumeMounts[?(@.name=="jenkins-
data")].mountPath }'
/var/lib/jenkins
```

2. Get the name of the pod that is currently running:

■

```
$ oc get pod --selector=deploymentconfig=jenkins -o jsonpath='{
.metadata.name }'
jenkins-1-37nux
```

3. Use the **oc rsync** command to copy application data:

```
$ oc rsync jenkins-1-37nux:/var/lib/jenkins /tmp/
```



NOTE

This type of application data backup can only be performed while an application pod is currently running.

30.11. APPLICATION DATA RESTORE

The process for restoring application data is similar to the [application backup procedure](#) using the **oc rsync** tool. The same restrictions apply and the process of restoring application data requires a persistent volume.

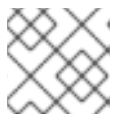
Example of Restoring a Jenkins Deployment's Application Data

1. Verify the backup:

```
$ ls -la /tmp/jenkins-backup/
total 8
drwxrwxr-x.  3 user      user   20 Sep  6 11:14 .
drwxrwxrwt. 17 root      root  4096 Sep  6 11:16 ..
drwxrwsrwx. 12 user      user  4096 Sep  6 11:14 jenkins
```

2. Use the **oc rsync** tool to copy the data into the running pod:

```
$ oc rsync /tmp/jenkins-backup/jenkins jenkins-1-37nux:/var/lib
```



NOTE

Depending on the application, you may be required to restart the application.

3. Restart the application with new data (*optional*):

```
$ oc delete pod jenkins-1-37nux
```

Alternatively, you can scale down the deployment to 0, and then up again:

```
$ oc scale --replicas=0 dc/jenkins
$ oc scale --replicas=1 dc/jenkins
```

CHAPTER 31. TROUBLESHOOTING OPENSIFT SDN

31.1. OVERVIEW

As described in the [SDN documentation](#) there are multiple layers of interfaces that are created to correctly pass the traffic from one container to another. In order to debug connectivity issues, you have to test the different layers of the stack to work out where the problem arises. This guide will help you dig down through the layers to identify the problem and how to fix it.

Part of the problem is that OpenShift Container Platform can be set up many ways, and the networking can be wrong in a few different places. So this document will work through some scenarios that, hopefully, will cover the majority of cases. If your problem is not covered, the tools and concepts that are introduced should help guide debugging efforts.

31.2. NOMENCLATURE

Cluster

The set of machines in the cluster. *i.e.* the Masters and the Nodes.

Master

A controller of the OpenShift Container Platform cluster. Note that the master may not be a node in the cluster, and thus, may not have IP connectivity to the pods.

Node

Host in the cluster running OpenShift Container Platform that can host pods.

Pod

Group of containers running on a node, managed by OpenShift Container Platform.

Service

Abstraction that presents a unified network interface that is backed by one or more pods.

Router

A web proxy that can map various URLs and paths into OpenShift Container Platform services to allow external traffic to travel into the cluster.

Node Address

The IP address of a node. This is assigned and managed by the owner of the network to which the node is attached. Must be reachable from any node in the cluster (master and client).

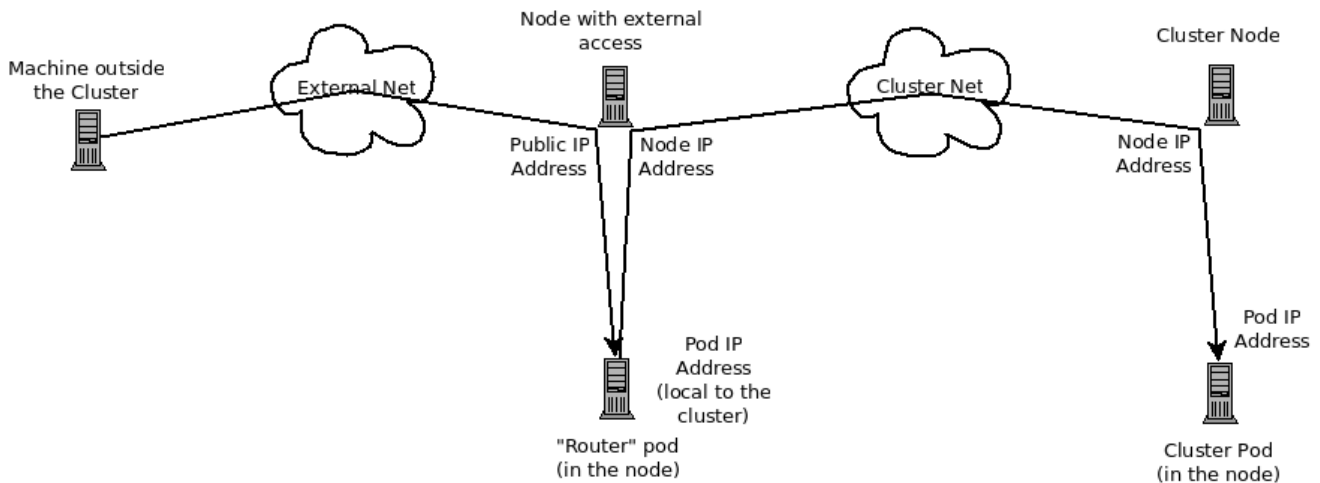
Pod Address

The IP address of a pod. These are assigned and managed by OpenShift Container Platform. By default they are assigned out of the 10.128.0.0/14 network (or, in older versions, 10.1.0.0/16). Only reachable from the client nodes.

Service Address

An IP address that represents the service, and is mapped to a pod address internally. These are assigned and managed by OpenShift Container Platform. By default they are assigned out of the 172.30.0.0/16 network. Only reachable from the client nodes.

The following diagram shows all of the pieces involved with external access.



31.3. DEBUGGING EXTERNAL ACCESS TO AN HTTP SERVICE

If you are on a machine outside the cluster and are trying to access a resource provided by the cluster there needs to be a process running in a pod that listens on a public IP address and "routes" that traffic inside the cluster. The [OpenShift Container Platform router](#) serves that purpose for HTTP, HTTPS (with SNI), WebSockets, or TLS (with SNI).

Assuming you can't access an HTTP service from the outside of the cluster, let's start by reproducing the problem on the command line of the machine where things are failing. Try:

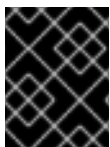
```
curl -kv http://foo.example.com:8000/bar # But replace the argument
with your URL
```

If that works, are you reproducing the bug from the right place? It is also possible that the service has some pods that work, and some that don't. So jump ahead to the [Section 31.4, "Debugging the Router"](#) section.

If that failed, then let's resolve the DNS name to an IP address (assuming it isn't already one):

```
dig +short foo.example.com # But replace the hostname
with yours
```

If that doesn't give back an IP address, it's time to troubleshoot DNS, but that's outside the scope of this guide.



IMPORTANT

Make sure that the IP address that you got back is one that you expect to be running the router. If it's not, fix your DNS.

Next, use `ping -c address` and `tracpath address` to check that you can reach the router host. It is possible that they will not respond to ICMP packets, in which case those tests will fail, but the router machine may be reachable. In which case, try using the telnet command to access the port for the router directly:

```
telnet 1.2.3.4 8000
```

You may get:

■

```
Trying 1.2.3.4...
Connected to 1.2.3.4.
Escape character is '^]'.
```

If so, there's something listening on the port on the IP address. That's good. Hit **ctrl-]** then hit the *enter* key and then type **close** to quit telnet. Move on to the [Section 31.4, "Debugging the Router"](#) section to check other things on the router.

Or you could get:

```
Trying 1.2.3.4...
telnet: connect to address 1.2.3.4: Connection refused
```

Which tells us that the router is not listening on that port. Please see the [Section 31.4, "Debugging the Router"](#) section for more pointers on how to configure the router.

Or if you see:

```
Trying 1.2.3.4...
telnet: connect to address 1.2.3.4: Connection timed out
```

Which tells us that you can't talk to anything on that IP address. Check your routing, firewalls, and that you have a router listening on that IP address. To debug the router, see the [Section 31.4, "Debugging the Router"](#) section. For IP routing and firewall issues, debugging that is beyond the purview of this guide.

31.4. DEBUGGING THE ROUTER

Now that you have an IP address, we need to **ssh** to that machine and check that the router software is running on that machine and configured correctly. So let's **ssh** there and get administrative OpenShift Container Platform credentials.



NOTE

If you have access to administrator credentials but are no longer logged in as the [default system user **system:admin**](#), you can log back in as this user at any time as long as the credentials are still present in your [CLI configuration file](#). The following command logs in and switches to the **default** project:

```
$ oc login -u system:admin -n default
```

Check that the router is running:

```
# oc get endpoints --namespace=default --selector=router
NAMESPACE   NAME           ENDPOINTS
default     router         10.128.0.4:80
```

If that command fails, then your OpenShift Container Platform configuration is broken. Fixing that is outside the scope of this document.

You should see one or more router endpoints listed, but that won't tell you if they are running on the machine with the given external IP address, since the endpoint IP address will be one of the pod addresses that is internal to the cluster. To get the list of router host IP addresses, run:

```
# oc get pods --all-namespaces --selector=router --template='{{range
.items}}HostIP: {{.status.hostIP}} PodIP: {{.status.podIP}}{{end}}
{{"\n"}}'
```

HostIP: 192.168.122.202 PodIP: 10.128.0.4

You should see the host IP that corresponds to your external address. If you do not, please refer to the [router documentation](#) to configure the router pod to run on the right node (by setting the affinity correctly) or update your DNS to match the IP addresses where the routers are running.

At this point in the guide, you should be on a node, running your router pod, but you still cannot get the HTTP request to work. First we need to make sure that the router is mapping the external URL to the correct service, and if that works, we need to dig into that service to make sure that all endpoints are reachable.

Let's list all of the routes that OpenShift Container Platform knows about:

```
# oc get route --all-namespaces
```

NAME	HOST/PORT	PATH	SERVICE	LABELS
TLS TERMINATION				
route-unsecured	www.example.com	/test	service-name	

If the host name and path from your URL don't match anything in the list of returned routes, then you need to add a route. See the [router documentation](#).

If your route is present, then you need to debug access to the endpoints. That's the same as if you were debugging problems with a service, so please continue on with the next [Section 31.5, "Debugging a Service"](#) section.

31.5. DEBUGGING A SERVICE

If you can't communicate with a service from inside the cluster (either because your services can't communicate directly, or because you are using the router and everything works until you get into the cluster) then you need to work out what endpoints are associated with a service and debug them.

First, let's get the services:

```
# oc get services --all-namespaces
```

NAMESPACE	NAME	LABELS	SELECTOR	IP(S)	PORT(S)
default	docker-registry	docker-registry=default	docker-registry=default	172.30.243.225	5000/TCP
default	kubernetes	component=apiserver,provider=kubernetes	<none>	172.30.0.1	443/TCP
default	router	router=router	router=router	172.30.213.8	80/TCP

You should see your service in the list. If not, then you need to define your [service](#).

The IP addresses listed in the service output are the Kubernetes service IP addresses that Kubernetes will map to one of the pods that backs that service. So you should be able to talk to that IP address. But, unfortunately, even if you can, it doesn't mean all pods are reachable; and if you can't, it doesn't mean all pods aren't reachable. It just tells you the status of the *one* that kubeproxy hooked you up to.

Let's test the service anyway. From one of your nodes:

■


```
curl -kv http://172.30.243.225:5000/bar # Replace the
argument with your service IP address and port
```

Then, let's work out what pods are backing our service (replace **docker-registry** with the name of the broken service):

```
# oc get endpoints --selector=docker-registry
NAME                ENDPOINTS
docker-registry     10.128.2.2:5000
```

From this, we can see that there's only one endpoint. So, if your service test succeeded, and the router test succeeded, then something really odd is going on. But if there's more than one endpoint, or the service test failed, try the following *for each* endpoint. Once you identify what endpoints aren't working, then proceed to the next section.

First, test each endpoint (change the URL to have the right endpoint IP, port, and path):

```
curl -kv http://10.128.2.2:5000/bar
```

If that works, great, try the next one. If it failed, make a note of it and we'll work out why, in the next section.

If all of them failed, then it is possible that the local node is not working, jump to the [Section 31.7, "Debugging Local Networking"](#) section.

If all of them worked, then jump to the [Section 31.11, "Debugging Kubernetes"](#) section to work out why the service IP address isn't working.

31.6. DEBUGGING NODE TO NODE NETWORKING

Using our list of non-working endpoints, we need to test connectivity to the node.

1. Make sure that all nodes have the expected IP addresses:

```
# oc get hostsubnet
NAME                HOST                HOST IP
SUBNET
rh71-os1.example.com  rh71-os1.example.com  192.168.122.46
10.1.1.0/24
rh71-os2.example.com  rh71-os2.example.com  192.168.122.18
10.1.2.0/24
rh71-os3.example.com  rh71-os3.example.com  192.168.122.202
10.1.0.0/24
```

If you are using DHCP they could have changed. Ensure the host names, IP addresses, and subnets match what you expect. If any node details have changed, use **oc edit hostsubnet** to correct the entries.

2. After ensuring the node addresses and host names are correct, list the endpoint IPs and node IPs:

```
# oc get pods --selector=docker-registry \
  --template='{{range .items}}HostIP: {{.status.hostIP}} PodIP:
  {{.status.podIP}}{{end}}{\n}'
```

```
HostIP: 192.168.122.202   PodIP: 10.128.0.4
```

3. Find the endpoint IP address you made note of before and look for it in the **PodIP** entry, and find the corresponding **HostIP** address. Then test connectivity at the node host level using the address from **HostIP**:

- **ping -c 3 <IP_address>**: No response could mean that an intermediate router is eating the ICMP traffic.
- **tracpath <IP_address>**: Shows the IP route taken to the target, if ICMP packets are returned by all hops.
If both **tracpath** and **ping** fail, then look for connectivity issues with your local or virtual network.

4. For local networking, check the following:

- Check the route the packet takes out of the box to the target address:

```
# ip route get 192.168.122.202
 192.168.122.202 dev ens3  src 192.168.122.46
  cache
```

In the above example, it will go out the interface named **ens3** with the source address of **192.168.122.46** and go directly to the target. If that is what you expected, use **ip a show dev ens3** to get the interface details and make sure that is the expected interface.

An alternate result may be the following:

```
# ip route get 192.168.122.202
 1.2.3.4 via 192.168.122.1 dev ens3  src 192.168.122.46
```

It will pass through the **via** IP value to route appropriately. Ensure that the traffic is routing correctly. Debugging route traffic is beyond the scope of this guide.

Other debugging options for node to node networking can be solved with the following:

- Do you have ethernet link on both ends? Look for **Link detected: yes** in the output from **ethtool <network_interface>**.
- Are your duplex settings, and ethernet speeds right on both ends? Look through the rest of the **ethtool <network_interface>** information.
- Are the cables plugged in correctly? To the correct ports?
- Are the switches configured correctly?

Once you have ascertained that the node to node connectivity is fine, we need to look at the SDN configuration on both ends.

31.7. DEBUGGING LOCAL NETWORKING

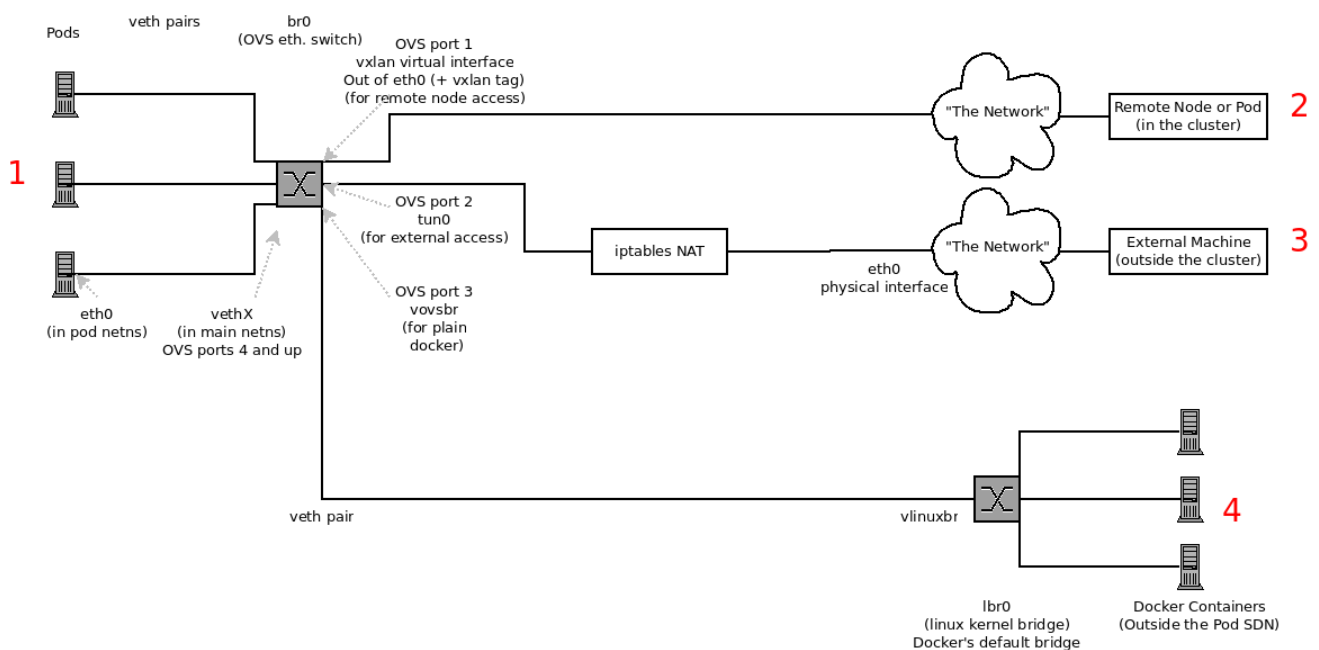
At this point we should have a list of one or more endpoints that you can't communicate with, but that have node to node connectivity. For each one, we need to work out what is wrong, but first you need to understand how the SDN sets up the networking on a node for the different pods.

31.7.1. The Interfaces on a Node

These are the interfaces that the OpenShift Container Platform SDN creates:

- **br0**: The OVS bridge device that containers will be attached to. OpenShift Container Platform SDN also configures a set of non-subnet-specific flow rules on this bridge. (The **multitenant** plug-in does this immediately; the **ovssubnet** plug-in waits until the SDN master announces the creation of the new node subnet.)
- **lbr0**: A Linux bridge device, which is configured as Docker's bridge and given the cluster subnet gateway address (eg, 10.128.x.1/23).
- **tun0**: An OVS internal port (port 2 on **br0**). This **also** gets assigned the cluster subnet gateway address, and is used for external network access. OpenShift Container Platform SDN configures **netfilter** and routing rules to enable access from the cluster subnet to the external network via NAT.
- **vlinuxbr** and **vovsbr**: Two Linux peer virtual Ethernet interfaces. **vlinuxbr** is added to **lbr0**, and **vovsbr** is added to **br0** (port 3), to provide connectivity for containers created directly with Docker outside of OpenShift Container Platform.
- **vxlan0**: The OVS VXLAN device (port 1 on **br0**), which provides access to containers on remote nodes.
- **vethX** (in the main netns): A Linux virtual ethernet peer of **eth0** in the docker netns. It will be attached to the OVS bridge on one of the other ports.

31.7.2. SDN Flows Inside a Node



Depending on what you are trying to access (or be accessed from) the path will vary. There are four different places the SDN connects (inside a node). They are labeled in red on the diagram above.

- **Pod:** Traffic is going from one pod to another on the same machine (1 to a different 1)
- **Remote Node (or Pod):** Traffic is going from a local pod to a remote node or pod in the same cluster (1 to 2)
- **External Machine:** Traffic is going from a local pod outside the cluster (1 to 3)
- **Local Docker:** Traffic is going from a local pod to a local container that is not managed by Kubernetes (1 to 4)

Of course the opposite traffic flows are also possible.

31.7.3. Debugging Steps

31.7.3.1. Is IP Forwarding Enabled?

Check that `sysctl net.ipv4.ip_forward` is set to 1 (and check the host if this is a VM)

31.7.3.2. Are your routes correct?

Check the route tables with `ip route`:

```
# ip route
default via 192.168.122.1 dev ens3
10.128.0.0/14 dev tun0 proto kernel scope link #
This sends all pod traffic into OVS
10.128.2.0/23 dev tun0 proto kernel scope link src 10.128.2.1 #
This is traffic going to local pods, overriding the above
169.254.0.0/16 dev ens3 scope link metric 1002 #
This is for Zeroconf (may not be present)
172.17.0.0/16 dev docker0 proto kernel scope link src 172.17.42.1 #
Docker's private IPs... used only by things directly configured by docker;
not {product-title}
192.168.122.0/24 dev ens3 proto kernel scope link src 192.168.122.46 #
The physical interface on the local subnet
```

You should see the 10.128.x.x lines (assuming you have your pod network set to the default range in your configuration). If you do not, check the OpenShift Container Platform logs (see the [Section 31.10, “Reading the Logs”](#) section)

31.7.4. Is the Open vSwitch configured correctly?

Check the Open vSwitch bridges on both sides:

```
# ovs-vsctl list-br
br0
```

This should just be br0.

You can list all of the ports that ovs knows about:

```
# ovs-ofctl -O OpenFlow13 dump-ports-desc br0
OFPST_PORT_DESC reply (OF1.3) (xid=0x2):
  1(vxlan0): addr:9e:f1:7d:4d:19:4f
```

```

    config:      0
    state:       0
    speed: 0 Mbps now, 0 Mbps max
2(tun0): addr:6a:ef:90:24:a3:11
    config:      0
    state:       0
    speed: 0 Mbps now, 0 Mbps max
8(vethe19c6ea): addr:1e:79:f3:a0:e8:8c
    config:      0
    state:       0
    current:     10GB-FD COPPER
    speed: 10000 Mbps now, 0 Mbps max
9(vovsbr): addr:6e:dc:28:df:63:c3
    config:      0
    state:       0
    current:     10GB-FD COPPER
    speed: 10000 Mbps now, 0 Mbps max
LOCAL(br0): addr:0a:7f:b4:33:c2:43
    config:      PORT_DOWN
    state:       LINK_DOWN
    speed: 0 Mbps now, 0 Mbps max

```

Next list the flows that are configured on that bridge. In output below I have removed the **cookie**, **duration**, **n_packets** and **n_bytes** columns; and I have lined up the various columns to make it easier to understand, and added in-line comments and blank lines:

```

# ovs-ofctl -O OpenFlow13 dump-flows br0
OFPST_FLOW reply (OF1.3) (xid=0x2):

# External access is the default if no higher priority matches
table=0, priority=50                                actions=output:2

# ARP and IP Traffic destined for the local subnet gateway goes out of the
switch to
# IP tables and the main route table
table=0, priority=100, arp, arp_tpa=10.128.2.1      actions=output:2
table=0, priority=100, ip, nw_dst=10.128.2.1      actions=output:2

# All remote nodes should have two entries here, one for IP and one for
ARP.
# Here we see the entries for two remote nodes
table=0, priority=100, arp, arp_tpa=10.128.4.0/23
actions=set_field:192.168.122.18->tun_dst,output:1
table=0, priority=100, ip, nw_dst=10.128.4.0/23
actions=set_field:192.168.122.18->tun_dst,output:1

table=0, priority=100, arp, arp_tpa=10.128.0.0/23
actions=set_field:192.168.122.202->tun_dst,output:1
table=0, priority=100, ip, nw_dst=10.128.0.0/23
actions=set_field:192.168.122.202->tun_dst,output:1

# Other traffic destined for a local pod IP that hasn't been handled by a
higher priority rule
# goes out port 9 to the virtual bridge for docker
table=0, priority=75, ip, nw_dst=10.128.2.0/23  actions=output:9
table=0, priority=75, arp, arp_tpa=10.128.2.0/23  actions=output:9

```

```
# Then ports 3-8 or 10+ are for local pods, here there are two local pods
table=0, priority=100, ip, nw_dst=10.128.2.7      actions=output:8
table=0, priority=100, arp, arp_tpa=10.128.2.7   actions=output:8

table=0, priority=100, ip, nw_dst=10.128.2.10   actions=output:12
table=0, priority=100, arp, arp_tpa=10.128.2.10 actions=output:12
```

The SDN networking plug-in configures two entries (one for arp and one for ip) with **output=1** per peer endpoint (i.e. if there are five nodes, then there should be 4 * 2 rules; In the example above we have 3 nodes total, so there are four entries above). It also sets up the other entries on ports 2 and 9 that are shown above. If there are flows missing, please look in the [Section 31.10, “Reading the Logs”](#) section.

31.7.4.1. Is the iptables configuration correct?

Check the output from **iptables-save** to make sure you are not filtering traffic. However, OpenShift Container Platform sets up iptables rules during normal operation, so do not be surprised to see entries there.

31.7.4.2. Is your external network correct?

Check external firewalls, if any, allow traffic to the target address (this is site-dependent, and beyond the purview of this guide).

31.8. DEBUGGING VIRTUAL NETWORKING

31.8.1. Builds on a Virtual Network are Failing

If you are installing OpenShift Container Platform using a virtual network (for example, OpenStack), and a build is failing, the maximum transmission unit (MTU) of the target node host might not be compatible with the MTU of the primary network interface (for example, **eth0**).

For a build to complete successfully, the MTU of an SDN must be less than the eth0 network MTU in order to pass data to between node hosts.

1. Check the MTU of your network by running the **ip addr** command:

```
# ip addr
---
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
state UP qlen 1000
    link/ether fa:16:3e:56:4c:11 brd ff:ff:ff:ff:ff:ff
    inet 172.16.0.0/24 brd 172.16.0.0 scope global dynamic eth0
        valid_lft 168sec preferred_lft 168sec
    inet6 fe80::f816:3eff:fe56:4c11/64 scope link
        valid_lft forever preferred_lft forever
---
```

The MTU of the above network is 1500.

2. The MTU in your node configuration must be lower than the network value. Check the **mtu** in the node configuration of the targeted node host:

```
# cat /etc/origin/node/node-config.yaml
```

```

...
networkConfig:
  mtu: 1450
  networkPluginName: company/openshift-ovs-subnet
...

```

In the above node configuration file, the `mtu` value is lower than the network MTU, so no configuration is needed. If the `mtu` value was higher, edit the file and lower the value to at least 50 units fewer than the MTU of the primary network interface, then restart the node service. This would allow larger packets of data to pass between nodes.

31.9. DEBUGGING POD EGRESS

If you are trying to access an external service from a pod, e.g.:

```
curl -kv github.com
```

Make sure that the DNS is resolving correctly:

```
dig +search +noall +answer github.com
```

That should return the IP address for the github server, but check that you got back the correct address. If you get back no address, or the address of one of your machines, then you may be matching the wildcard entry in your local DNS server.

To fix that, you either need to make sure that DNS server that has the wildcard entry is not listed as a **nameserver** in your `/etc/resolv.conf` or you need to make sure that the wildcard domain is not listed in the **search** list.

If the correct IP address was returned, then try the debugging advice listed above in [Section 31.7](#), “[Debugging Local Networking](#)”. Your traffic should leave the Open vSwitch on port 2 to pass through the **iptables** rules, then out the route table normally.

31.10. READING THE LOGS

Run: `journalctl -u atomic-openshift-node.service --boot | less`

Look for the **Output of setup script:** line. Everything starting with '+' below that are the script steps. Look through that for obvious errors.

Following the script you should see lines with **Output of adding table=0**. Those are the OVS rules, and there should be no errors.

31.11. DEBUGGING KUBERNETES

Check `iptables -t nat -L` to make sure that the service is being NAT'd to the right port on the local machine for the **kubeproxy**.

**WARNING**

This is all changing soon... Kubeproxy is being eliminated and replaced with an **iptables**-only solution.

31.12. FURTHER HELP

1. Run the script at <https://raw.githubusercontent.com/openshift/openshift-sdn/master/hack/debug.sh> on the master (or from another machine with access to the master) to generate useful debugging information.
2. When debugging IP failover problems, run the script at <https://raw.githubusercontent.com/openshift/openshift-sdn/master/hack/ipf-debug.sh> on the master (or from another machine with access to the master) to generate useful debugging information.

31.13. MISCELLANEOUS NOTES

31.13.1. Other clarifications on ingress

- Kube - declare a service as NodePort and it will claim that port on all machines in the cluster (on what interface?) and then route into kube-proxy and then to a backing pod. See <http://kubernetes.io/v1.0/docs/user-guide/services.html#type-nodeport> (some node must be accessible from outside)
- Kube - declare as a LoadBalancer and something *you* have to write does the rest
- OS/AE - Both use the router

31.13.2. TLS Handshake Timeout

When a pod fails to deploy, check its docker log for a TLS handshake timeout:

```
$ docker log <container_id>
...
[...] couldn't get deployment [...] TLS handshake timeout
...
```

This condition, and generally, errors in establishing a secure connection, may be caused by a large difference in the MTU values between tun0 and the primary interface (e.g., eth0), such as when tun0 MTU is 1500 and eth0 MTU is 9000 (jumbo frames).

31.13.3. Other debugging notes

- Peer interfaces (of a Linux virtual ethernet pair) can be determined with **ethtool -S ifname**
- Driver type: **ethtool -i ifname**

CHAPTER 32. DIAGNOSTICS TOOL

32.1. OVERVIEW

The `oc adm diagnostics` command runs a series of checks for error conditions in the host or cluster. Specifically, it:

- Verifies that the default registry and router are running and correctly configured.
- Checks `ClusterRoleBindings` and `ClusterRoles` for consistency with base policy.
- Checks that all of the client configuration contexts are valid and can be connected to.
- Checks that SkyDNS is working properly and the pods have SDN connectivity.
- Validates master and node configuration on the host.
- Checks that nodes are running and available.
- Analyzes host logs for known errors.
- Checks that systemd units are configured as expected for the host.

32.2. USING THE DIAGNOSTICS TOOL

OpenShift Container Platform can be deployed in many ways: built from source, included in a VM image, in a container image, or as enterprise RPMs. Each method implies a different configuration and environment. To minimize environment assumptions, the diagnostics were added to the `openshift` binary so that wherever there is an OpenShift Container Platform server or client, the diagnostics can run in the exact same environment.

To use the diagnostics tool, preferably on a master host and as cluster administrator, run:

```
$ oc adm diagnostics
```

This runs all available diagnostics, skipping any that do not apply. For example, the `NodeConfigCheck` does not run unless a node configuration is available. You can also run specific diagnostics by name as you work to address issues. For example:

```
$ oc adm diagnostics NodeConfigCheck UnitStatus
```

Diagnostics look for configuration files in standard locations:

- Client:
 - As indicated by the `$KUBECONFIG` environment variable
 - `~/.kube/config` file
- Master:
 - `/etc/origin/master/master-config.yaml`
- Node:
 - `/etc/origin/node/node-config.yaml`

- `/etc/origin/node/node-config.yaml`

Non-standard locations can be specified with flags (respectively, `--config`, `--master-config`, and `--node-config`). If a configuration file is not found or specified, related diagnostics are skipped.

Consult the output with the `--help` flag for all available options.

32.3. RUNNING DIAGNOSTICS IN A SERVER ENVIRONMENT

Master and node diagnostics are most useful in a specific target environment, which is a deployment of RPMs with Ansible deployment logic. This provides some diagnostic benefits:

- Master and node configuration is based on a configuration file in a standard location.
- Systemd units are configured to manage the server(s).
- All components log to journald.

Having configuration files where Ansible places them means that you will generally not need to specify where to find them. Running `oc adm diagnostics` without flags will look for master and node configurations in the standard locations and use them if found; this should make the Ansible-installed use case as simple as possible. Also, it is easy to specify configuration files that are not in the expected locations:

```
$ oc adm diagnostics --master-config=<file_path> --node-config=<file_path>
```

Systemd units and logs entries in journald are necessary for the current log diagnostic logic. For other deployment types, logs may be going into files, to stdout, or may combine node and master. At this time, for these situations, log diagnostics are not able to work properly and will be skipped.

32.4. RUNNING DIAGNOSTICS IN A CLIENT ENVIRONMENT

You may have access as an ordinary user, and/or as a **cluster-admin** user, and/or may be running on a host where OpenShift Container Platform master or node servers are operating. The diagnostics attempt to use as much access as the user has available.

A client with ordinary access should be able to diagnose its connection to the master and run a diagnostic pod. If multiple users or masters are configured, connections will be tested for all, but the diagnostic pod only runs against the current user, server, or project.

A client with **cluster-admin** access available (for any user, but only the current master) should be able to diagnose the status of infrastructure such as nodes, registry, and router. In each case, running `oc adm diagnostics` looks for the client configuration in its standard location and uses it if available.

CHAPTER 33. IDLING APPLICATIONS

33.1. OVERVIEW

As an OpenShift Container Platform administrator, you can idle applications in order to reduce the consumption of resources.

Applications are made of services, as well as other scalable resources, such as deployment configurations. The action of idling an application involves idling all associated resources.

33.2. IDLING APPLICATIONS

Idling an application involves finding the scalable resources (deployment configurations, replication controllers, and others) associated with a service. Idling an application finds the service and marks it as idled, scaling down the resources to zero replicas.

You can use the `oc idle` command to [idle a single service](#), or use the `--resource-names-file` option to [idle multiple services](#).

33.2.1. Idling Single Services

Idle a single service with the following command:

```
$ oc idle <service>
```

33.2.2. Idling Multiple Services

Idle multiple services by creating a list of the desired services, then using the `--resource-names-file` option with the `oc idle` command.

This is helpful if an application spans across a set of services within a project, or when idling multiple services in conjunction with a script in order to idle multiple applications in bulk within the same project.

1. Create a text file containing a list of the services, each on their own line.
2. Idle the services using the `--resource-names-file` option:

```
$ oc idle --resource-names-file <filename>
```



NOTE

The `idle` command is limited to a single project. For idling applications across a cluster, run the `idle` command for each project individually.

33.3. UNIDLING APPLICATIONS

Application services become active again when they receive network traffic and will be scaled back up their previous state. This includes both traffic to the services and traffic passing through routes.

Applications may be manually unidled by scaling up the resources. For example, to scale up a `deploymentconfig`, run the command:



```
$ oc scale --replicas=1 dc <deploymentconfig>
```



NOTE

Automatic unidling by a router is currently only supported by the default HAProxy router.

CHAPTER 34. REVISION HISTORY: CLUSTER ADMINISTRATION

Red Hat OpenShift Documentation Team 3.3 :experimental:

34.1. THU JUL 27 2017

Affected Topic	Description of Change
Setting Quotas	Updated the references to quota and limit ranges, as they are now listed on the Quota page.
Setting Limit Ranges	Updated the references to quota and limit ranges, as they are now listed on the Quota page.
Setting Quotas	Removed unsupported options from the Compute Resources Managed by Quota table.

34.2. TUE JUL 18 2017

Affected Topic	Description of Change
Managing Security Context Constraints	Updated the Add an SCC to a User, Group, or Project section to add notes on granting SCC access and clarify project access.

34.3. THU MAY 25 2017

Affected Topic	Description of Change
Managing Security Context Constraints	Added a warning about pod creation on behalf of a user within the Grant Access to the Privileged SCC section.

34.4. MON MAY 15 2017

Affected Topic	Description of Change
Backup and Restore	Restored and updated steps for adding an etcd member .

34.5. TUE MAY 02 2017

Affected Topic	Description of Change
Securing Builds by Strategy	Added that custom builds are disabled by default.

34.6. WED APR 12 2017

Affected Topic	Description of Change
Managing Security Context Constraints	Added information about preserving labels and annotations, in addition to groups.
Managing Nodes	Fixed markup error in the examples in the Setting Maximum Pods Per Node section.

34.7. MON MAR 27 2017

Affected Topic	Description of Change
Setting Limit Ranges	Added the missing <code>-n demoproject</code> option to the oc describe limits example and updated the command's output.
Backup and Restore	Updated the backup and restore procedure.

34.8. MON MAR 20 2017

Affected Topic	Description of Change
Managing Nodes	Added the Setting Maximum Pods Per Node section.
Managing Authorization Policies	Updated the ClusterRole file in the Granting Users Daemonset Permissions section.

34.9. TUE MAR 14 2017

Affected Topic	Description of Change
Managing Nodes	Renamed instances of <code>openshift_node_set_node_ip</code> to <code>openshift_set_node_ip</code> , the correct <code>openshift-ansible</code> variable name.
Restricting Application Capabilities Using Seccomp	Updated Seccomp references of <code>runtime/default</code> to be <code>docker/default</code> .

34.10. TUE MAR 07 2017

Affected Topic	Description of Change
Encrypting Hosts with IPsec	Re-added the <i>Encrypting Hosts with IPsec</i> topic and made it specific to the current version of libreswan .
Managing Pods	<p>Added information and arranged the Controlling Egress Traffic section.</p> <p>Added clarifying details around EgressNetworkPolicy, including that it only affects external traffic (not pod-to-pod traffic) and that you can only have a single EgressNetworkPolicy in a namespace; added additional details about rule ordering and that breaking the rules can result in all egress traffic from the namespace being dropped.</p>

34.11. THU FEB 16 2017

Affected Topic	Description of Change
Managing Pods	Added more information about disabling MAC filtering for the Egress router.
Aggregating Container Logs	Added a requirement that port 9300 be open for Elasticsearch to the Pre-deployment Configuration section.
High Availability	Added a step for deploying the ipfailover router to monitor postgresql listening to the Configuring a Highly-available Service section

34.12. MON FEB 06 2017

Affected Topic	Description of Change
Handling Out of Resource Errors	Added clarifying details around kubeletArguments in the Example Scenario section.

34.13. WED JAN 25 2017

Affected Topic	Description of Change
Monitoring Routers	Removed references to the deprecated --credentials option.
High Availability	Removed references to the deprecated --credentials option.
Configuring the Cluster to Use Unique External IPs	Added a CAUTION box indicating that external IPs assigned to services of type LoadBalancer will always be in the range of ingressIPNetworkCIDR and updated Ingress CIDR references to the new default.

34.14. MON JAN 09 2017

Affected Topic	Description of Change
Managing Pods	Added important box about Red Hat OpenStack Platform to the Limiting Pod Access with an Egress Router section.
Managing Authorization Policies	Added clarifying details about cluster roles.

34.15. TUE DEC 20 2016

Affected Topic	Description of Change
Backup and Restore	Added to the note with information on host backups over 700 MB.

34.16. TUE DEC 13 2016

Affected Topic	Description of Change
Idling Applications	New topic.
Diagnostics Tool	Added Running Diagnostics in a Server Environment and Running Diagnostics in a Client Environment sections.

34.17. MON DEC 05 2016

Affected Topic	Description of Change
Managing Pods	Fixed the syntax of the Example Pod Definition for an Egress Router .
Backup and Restore	Added the Backup and Restore section.

34.18. MON NOV 21 2016

Affected Topic	Description of Change
Sysctls	New topic on Technology Preview sysctl support.
Managing Security Context Constraints	Updated the output for <code>oc get scc</code> .

34.19. MON NOV 14 2016

Affected Topic	Description of Change
Troubleshooting OpenShift SDN	Removed references to firewalld , as the installer does not currently support it.
iptables	New topic on how OpenShift Container Platform and iptables interact.
Securing Builds by Strategy	Added jenkinspipeline build strategy role information.
Assigning Unique External IPs for Ingress Traffic	Added a NOTE stating that this feature is only supported in non-cloud deployments.
Overcommitting	Added a Warning box about swap in the Disabling Swap Memory section.
Out of Resource Handling	New topic about memory eviction.

34.20. TUE NOV 01 2016

Affected Topic	Description of Change
Backup and Restore	Added a NOTE box to the Cluster Restore section, indicating that the outlined procedure only works for single-member etcd clusters.

34.21. MON OCT 24 2016

Affected Topic	Description of Change
Configuring Service Accounts	Added a Service Accounts and Secrets heading.
Restricting Application Capabilities Using Seccomp	New topic.

34.22. MON OCT 17 2016

Affected Topic	Description of Change
High Availability	Added the Multiple Highly Available Services In a Network section.
Diagnostics Tool	New topic about the oc adm diagnostics command.

34.23. TUE OCT 11 2016

Affected Topic	Description of Change
Setting Quotas	Added that cpu and requests.cpu are the same value and can be used interchangeably, as with memory and requests.memory .

34.24. TUE OCT 04 2016

Affected Topic	Description of Change
High Availability	Fixed deprecated commands in the Configuring a Highly-available Routing Service section.
Backup and Restore	Added Prerequisites details and created new sections for Application Data Backup, Application Data Restore, Project Restore, as well as backing up Role Bindings, Service Accounts, Secrets, and Persistent Volume Claims.
Pruning Objects	Added a Note box about the required storage:delete:enabled flag when pruning images .

34.25. TUE SEP 27 2016

OpenShift Container Platform 3.3 initial release.

Affected Topic	Description of Change
High Availability	Fixed deprecated commands in the Configuring a Highly-available Routing Service section.
Backup and Restore	Added Prerequisites details and created new sections for Application Data Backup, Application Data Restore, Project Restore, as well as backing up Role Bindings, Service Accounts, Secrets, and Persistent Volume Claims.
Pruning Objects	Added a Note box about the required storage:delete:enabled flag when pruning images .
Cluster Administration → Managing Pods → Limiting the Bandwidth Available to Pods	Added details on limiting the bandwidth available to pods via quality-of-service traffic shaping.
Cluster Administration → Limit Pod Access with Egress Firewall	Added new topic covering how to limit the IP addresses and traffic that a pod can access.

Affected Topic	Description of Change
Scoped Tokens	New topic discussing scoped tokens, which are tokens that identify given users, but are limited to certain actions by its scope.
Image Policy	New topic about controlling which images are allowed to run on your cluster using the ImagePolicy admission plug-in.
Setting Multi-Project Quotas	New topic about how to set multi-project quotas.
Monitoring Images	New topic discussing oadm top images and oadm top imagestreams commands.
Managing Nodes	Added a new Rebooting Nodes section.
Pruning Objects	Added --prune-over-size-limit information.
Setting Quotas	Added recent image quota restrictions.
Setting Limit Ranges	Added recent image quota restrictions.