OpenShift Container Platform 3.11

Container Security Guide

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Legal Notice

Abstract

Secure your cluster using these recommendations

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CHAPTER 1. INTRODUCTION

1.1. ABOUT THIS GUIDE

This guide provides a high-level walkthrough of the container security measures available in OpenShift Container Platform, including solutions for the host layer, the container and orchestration layer, and the build and application layer. This guide contains the following information:

- Why container security is important and how it compares with existing security standards.
- Which container security measures are provided by the host (RHEL) layer and which are provided by OpenShift Container Platform.
- How to evaluate your container content and sources for vulnerabilities.
- How to design your build and deployment process to proactively check container content.
- How to control access to containers via authentication and authorization.
- How networking and attached storage are secured in OpenShift Container Platform.
- Containerized solutions for API management and SSO.

1.2. WHAT ARE CONTAINERS?

Containers package an application and all its dependencies into a single image that can be promoted from development, to test, to production, without change.

Containers provide consistency across environments and multiple deployment targets: physical servers, virtual machines (VMs), and private or public cloud.

Some of the benefits of using containers include:

INFRASTRUCTURE	APPLICATIONS
Sandboxed application processes on a shared Linux OS kernel	Package my application and all of its dependencies
Simpler, lighter, and denser than virtual machines	Deploy to any environment in seconds and enable CI/CD
Portable across different environments	Easily access and share containerized components

Further Reading

- *OpenShift Container Platform Architecture*: Core Concepts → Containers and Images
- *Red Hat Enterprise Linux Atomic Host Container Security Guide*

1.3. CONTAINER SECURITY IN OPENSHIFT CONTAINER PLATFORM

This guide describes the key elements of security for each layer of the container solution stack, while also showing how OpenShift Container Platform can be used to to create, deploy, and manage containers at scale, with security in mind at every stage and every layer.

Further Reading

- *Red Hat Enterprise Linux Atomic Host Overview of Containers in Red Hat Systems*
- *Red Hat Enterprise Linux Atomic Host Container Security Guide*

CHAPTER 2. CONTAINER HOSTS AND MULTI-TENANCY

2.1. HOW CONTAINERS ARE SECURED ON RHEL

Containers enable you to simplify multi-tenancy deployments by deploying multiple applications on a single host, using the kernel and the docker runtime to spin up each container.

You must have an operating system (OS) that can secure the host kernel and secure containers from each other. In Linux, containers are just a special type of process, so securing containers is the same as securing any running process. Containers should run as a non-root user. Dropping the privilege level or creating containers with the least amount of privileges possible is recommended.

Because OpenShift Container Platform runs on Red Hat Enterprise Linux (RHEL) and RHEL Atomic Host, the following concepts apply by default to any deployed OpenShift Container Platform cluster and are at the core of what make containers secure on the platform.

- *Linux namespaces* enable creating an abstraction of a particular global system resource to make it appear as a separate instance to processes within a namespace. Consequently, several containers can use the same resource simultaneously without creating a conflict. See Overview of Containers in Red Hat Systems for details on the types of namespaces (e.g., mount, PID, and network).

- *SELinux* provides an additional layer of security to keep containers isolated from each other and from the host. SELinux allows administrators to enforce mandatory access controls (MAC) for every user, application, process, and file.

- *CGroups* (control groups) limit, account for, and isolate the resource usage (CPU, memory, disk I/O, network, etc.) of a collection of processes. CGroups are used to ensure that containers on the same host are not impacted by each other.

- *Secure computing mode (seccomp)* profiles can be associated with a container to restrict available system calls.

- Deploying containers using *RHEL Atomic Host* reduces the attack surface by minimizing the host environment and tuning it for containers.

Further Reading

- Linux man page: *namespaces(7)*

- *Red Hat Enterprise Linux Atomic Host Overview of Containers in Red Hat Systems* : Secure Containers with SELinux

- *Red Hat Enterprise Linux Resource Management Guide* : Introduction to Control Groups (CGroups)

- *Red Hat Enterprise Linux Atomic Host Container Security Guide* : Linux Capabilities and seccomp

- Kernel documentation: *seccomp*

2.2. MULTI-TENANCY: VIRTUALIZATION VERSUS CONTAINERS

Traditional virtualization also enables multi-tenancy, but in a very different way from containers. Virtualization relies on a hypervisor spinning up guest virtual machines (VMs), each of which has its own operating system (OS), as well as the running application and its dependencies.

With VMs, the hypervisor isolates the guests from each other and from the host kernel. Fewer individuals and processes have access to the hypervisor, reducing the attack surface on the physical server. That said, security must still be monitored: one guest VM may be able to use hypervisor bugs to gain access to another VM or the host kernel. And, when the OS needs patching, it must be patched on all guest VMs using that OS.

Containers can be run inside guest VMs, and there may be use cases where this is desirable. For example, you may be deploying a traditional application in a container, perhaps in order to lift-and-shift an application to the cloud. However, container multi-tenancy on a single host provides a more lightweight, flexible, and easier-to-scale deployment solution. This deployment model is particularly appropriate for cloud-native applications.

Further Reading

- *Red Hat Enterprise Linux Atomic Host Overview of Containers in Red Hat Systems* : Linux Containers Compared to KVM Virtualization

CHAPTER 3. CONTAINER CONTENT

3.1. SECURITY INSIDE THE CONTAINER

Applications and infrastructures are composed of readily available components, many of which are open source packages such as, the Linux operating system, JBoss Web Server, PostgreSQL, and Node.js.

Containerized versions of these packages are also available. However, you need to know where the packages originally came from, who built them, and whether there is any malicious code inside them.

Some questions to answer include:

- Will what is inside the containers compromise your infrastructure?
- Are there known vulnerabilities in the application layer?
- Are the runtime and OS layers current?

Further Reading

- *OpenShift Container Platform Using Images*
  - Reference documentation on framework, database, and service container images provided by Red Hat for use on OpenShift Container Platform

3.2. CONTAINER CONTENT SCANNING

Container scanning tools can leverage continuously updated vulnerability databases to ensure that you always have the latest information on known vulnerabilities for your container content. The list of known vulnerabilities constantly evolves; you must check the contents of your container images when you first download them and continue to track vulnerability status over time for all of your approved and deployed images.

RHEL provides a pluggable API to support multiple scanners. You can also use Red Hat CloudForms with OpenSCAP to scan container images for security issues. See the Red Hat Enterprise Linux Security Guide for general information on OpenSCAP in RHEL, and the Red Hat CloudForms Policies and Profiles Guide for specifics on OpenSCAP integration.

OpenShift Container Platform enables you to leverage such scanners with your CI/CD process. For example, you can integrate static code analysis tools that test for security flaws in your source code and software composition analysis tools that identify open source libraries in order to provide metadata on those libraries such as known vulnerabilities. This is covered in more detail in Build Process.

3.3. INTEGRATING EXTERNAL SCANNING TOOLS WITH OPENSHIFT

OpenShift Container Platform makes use of object annotations to extend functionality. External tools, such as vulnerability scanners, may annotate image objects with metadata to summarize results and control pod execution. This section describes the recognized format of this annotation so it may be reliably used in consoles to display useful data to users.

3.3.1. Image Metadata

There are different types of image quality data, including package vulnerabilities and open source software (OSS) license compliance. Additionally, there may be more than one provider of this metadata. To that end, the following annotation format has been reserved:

```
quality.images.openshift.io/<qualityType>.<providerId>: {}
```

Table 3.1. Annotation Key Format

Component	Description	Acceptable Values
qualityType	Metadata type	**vulnerability** **license** **operations** **policy**
providerId	Provider ID string	**openscap** **redhatcatalog** **redhatinsights** **blackduck** **jfrog**

3.3.1.1. Example Annotation Keys

```
quality.images.openshift.io/vulnerability.blackduck: {}
quality.images.openshift.io/vulnerability.jfrog: {}
quality.images.openshift.io/license.blackduck: {}
quality.images.openshift.io/vulnerability.openscap: {}
```

The value of the image quality annotation is structured data that must adhere to the following format:

Table 3.2. Annotation Value Format

Field	Required?	Description	Type
name	Yes	Provider display name	String
timestamp	Yes	Scan timestamp	String
description	No	Short description	String
reference	Yes	URL of information source and/or more details. Required so user may validate the data.	String
scannerVersion	No	Scanner version	String
compliant	No	Compliance pass/fail	Boolean

Field	Required?	Description	Type
summary	No	Summary of issues found	List (see table below)

The **summary** field must adhere to the following format:

Table 3.3. Summary Field Value Format

Field	Description	Type
label	Display label for component (for example, "critical," "important," "moderate," "low," or "health")	String
data	Data for this component (for example, count of vulnerabilities found or score)	String
severityIndex	Component index allowing for ordering and assigning graphical representation. The value is range **0..3** where **0** = low.	Integer
reference	URL of information source and/or more details. Optional.	String

3.3.1.2. Example Annotation Values

This example shows an OpenSCAP annotation for an image with vulnerability summary data and a compliance boolean:

OpenSCAP Annotation

```
{
  "name": "OpenSCAP",
  "description": "OpenSCAP vulnerability score",
  "timestamp": "2016-09-08T05:04:46Z",
  "reference": "https://www.open-scap.org/930492",
  "compliant": true,
  "scannerVersion": "1.2",
  "summary": [
    { "label": "critical", "data": "4", "severityIndex": 3, "reference": null },
    { "label": "important", "data": "12", "severityIndex": 2, "reference": null },
    { "label": "moderate", "data": "8", "severityIndex": 1, "reference": null },
    { "label": "low", "data": "26", "severityIndex": 0, "reference": null }
  ]
}
```

This example shows a Red Hat Container Catalog annotation for an image with health index data with an external URL for additional details:

Red Hat Container Catalog Annotation

```
{
  "name": "Red Hat Container Catalog",
  "description": "Container health index",
  "timestamp": "2016-09-08T05:04:46Z",
  "reference": "https://access.redhat.com/errata/RHBA-2016:1566",
  "compliant": null,
  "scannerVersion": "1.2",
  "summary": [
    { "label": "Health index", "data": "B", "severityIndex": 1, "reference": null }
  ]
}
```

3.3.2. Annotating Image Objects

While image stream objects are what an end-user of OpenShift Container Platform operates against, image objects are annotated with security metadata. Image objects are cluster-scoped, pointing to a single image that may be referenced by many image streams and tags.

3.3.2.1. Example Annotate CLI Command

Replace **<image>** with an image digest, for example **sha256:fec8a395afe3e804b3db5cb277869142d2b5c561ebb517585566e160ff321988**:

```
$ oc annotate image <image> \
    quality.images.openshift.io/vulnerability.redhatcatalog='{ \
    "name": "Red Hat Container Catalog", \
    "description": "Container health index", \
    "timestamp": "2016-09-08T05:04:46Z", \
    "compliant": null, \
    "scannerVersion": "1.2", \
    "reference": "https://access.redhat.com/errata/RHBA-2016:1566", \
    "summary": "[ \
      { "label": "Health index", "data": "B", "severityIndex": 1, "reference": null } ]" }'
```

3.3.3. Controlling Pod Execution

To programmatically control if an image may be run, the **images.openshift.io/deny-execution** image policy may be used. See Image Policy for more information.

3.3.3.1. Example Annotation

```
annotations:
  images.openshift.io/deny-execution: true
```

3.3.4. Integration Reference

In most cases, external tools such as vulnerability scanners will develop a script or plug-in that watches for image updates, performs scanning, and annotates the associated image object with the results. Typically this automation calls the OpenShift Container Platform REST API to write the annotation. See REST API Reference for general information on the REST API and **PATCH** call to update images.

3.3.4.1. Example REST API Call

The following example call using **curl** overrides the value of the annotation. Be sure to replace the values for **<token>**, **<openshift_server>**, **<image_id>**, and **<image_annotation>**.

Patch API Call

```
$ curl -X PATCH \
  -H "Authorization: Bearer <token>" \
  -H "Content-Type: application/merge-patch+json" \
  https://<openshift_server>:8443/oapi/v1/images/<image_id> \
  --data '{ <image_annotation> }'
```

The following is an example of **PATCH** payload data:

Patch Call Data

```
{
"metadata": {
  "annotations": {
    "quality.images.openshift.io/vulnerability.redhatcatalog":
       "{ 'name': 'Red Hat Container Catalog', 'description': 'Container health index', 'timestamp': '2016-
09-08T05:04:46Z', 'compliant': null, 'reference': 'https://access.redhat.com/errata/RHBA-2016:1566',
'summary': [{'label': 'Health index', 'data': '4', 'severityIndex': 1, 'reference': null}] }"
    }
  }
}
```

CHAPTER 4. REGISTRIES

4.1. WHERE DO YOUR CONTAINERS COME FROM?

There are tools you can use to scan and track the contents of your downloaded and deployed container images. However, there are many public sources of container images. When using public container registries, you can add a layer of protection by using trusted sources.

4.2. IMMUTABLE AND CERTIFIED CONTAINERS

Consuming security updates is particularly important when managing *immutable containers*. Immutable containers are containers that will never be changed while running. When you deploy immutable containers, you do not step into the running container to replace one or more binaries; you rebuild and redeploy an updated container image.

Red Hat certified images are:

- Free of known vulnerabilities in the platform components or layers.
- Compatible across the RHEL platforms, from bare metal to cloud.
- Supported by Red Hat.

The list of known vulnerabilities is constantly evolving, so you must track the contents of your deployed container images, as well as newly downloaded images, over time. You can use Red Hat Security Advisories (RHSAs) to alert you to any newly discovered issues in Red Hat certified container images, and direct you to the updated image.

Further Reading

- More on immutable containers in OpenShift Container Platform:
  - *OpenShift Container Platform Architecture*: Image Streams
  - *OpenShift Container Platform Developer Guide*: Referencing Images in Image Streams

4.3. RED HAT REGISTRY AND RED HAT CONTAINER CATALOG

Red Hat provides certified containers for Red Hat products and partner offerings via the *Red Hat Registry*, which is a public container registry hosted by Red Hat at registry.redhat.io. The *Red Hat Container Catalog* enables you to identify bug fix or security advisories associated with container images provided in the Red Hat Registry.

Container content is monitored for vulnerabilities by Red Hat and updated regularly. When Red Hat releases security updates, such as fixes to **glibc**, Drown, or Dirty Cow, any affected container images are also rebuilt and pushed to the Red Hat Registry.

Red Hat uses a "health index" for security risk with containers provided through the Red Hat Container Catalog. These containers consume software provided by Red Hat and the errata process, so old, stale containers are insecure whereas new, fresh containers are more secure.

To illustrate the age of containers, the Red Hat Container Catalog uses a grading system. A freshness grade is a measure of the oldest and most severe security errata available for an image. "A" is more up-to-date than "F". See Container Health Index grades as used inside the Red Hat Container Catalog for more details on this grading system.

Further Reading

- Red Hat Container Catalog FAQ
- Red Hat Product Security Center
- Red Hat Security Advisories

4.4. OPENSHIFT CONTAINER REGISTRY

OpenShift Container Platform includes the *OpenShift Container Registry*, a private registry that runs integrated with the platform that you can use to manage your container images. The OpenShift Container Registry provides role-based access controls that allow you to manage who can pull and push which container images.

OpenShift Container Platform also supports integration with other private registries you may already be using.

Further Reading

- *OpenShift Container Platform Architecture*: Infrastructure Components → Image Registry

CHAPTER 5. BUILD PROCESS

5.1. BUILD ONCE, DEPLOY EVERYWHERE

In a container environment, the software build process is the stage in the life cycle where application code is integrated with the required runtime libraries. Managing this build process is key to securing the software stack.

Using OpenShift Container Platform as the standard platform for container builds enables you to guarantee the security of the build environment. Adhering to a "build once, deploy everywhere" philosophy ensures that the product of the build process is exactly what is deployed in production.

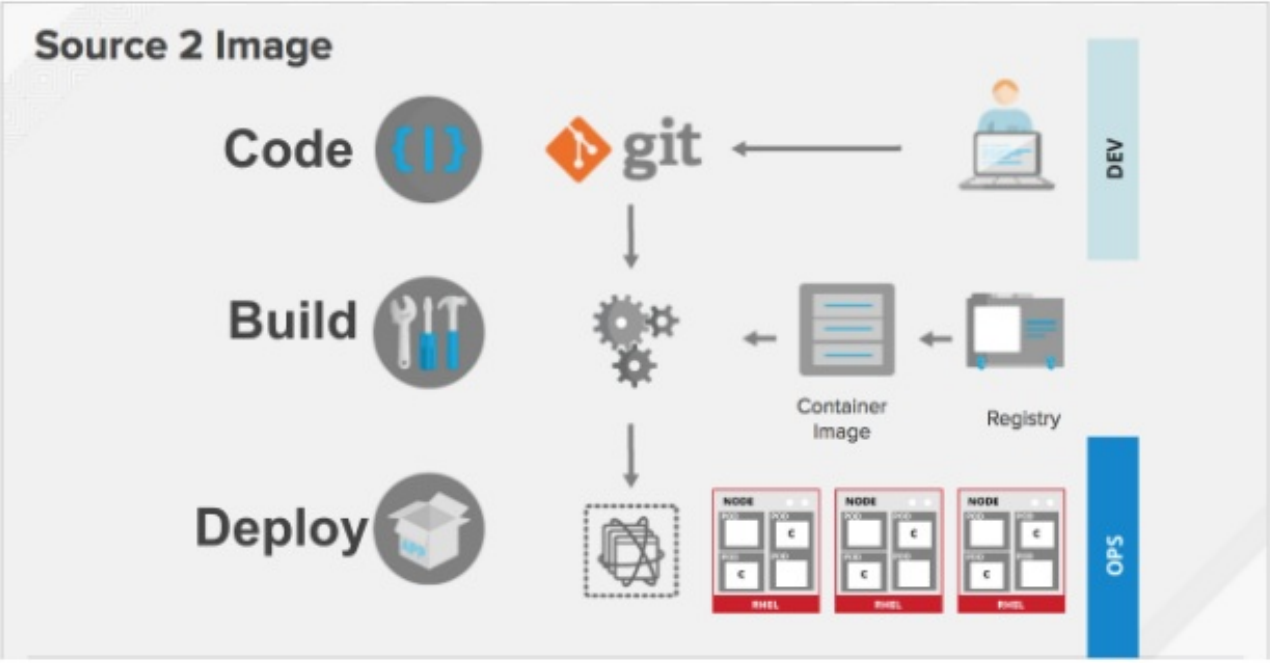
It is also important to maintain the immutability of your containers. You should not patch running containers, but rebuild and redeploy them.

5.2. BUILD MANAGEMENT AND SECURITY

You can use source-to-Image (S2I) to combine source code and base images. *Builder images* make use of S2I to enable your development and operations teams to collaborate on a reproducible build environment.

When developers commit code with Git for an application using build images, OpenShift Container Platform can perform the following functions:

- Trigger, either via webhooks on the code repository or other automated continuous integration (CI) process, to automatically assemble a new image from available artifacts, the S2I builder image, and the newly committed code.
- Automatically deploy the newly-built image for testing.
- Promote the tested image to production where it can be automatically deployed using CI process.



You can use OpenShift Container Registry to manage access to final images. Both S2I and native build images are automatically pushed to the OpenShift Container Registry.

In addition to the included Jenkins for CI, you can also integrate your own build / CI environment with OpenShift Container Platform using RESTful APIs, as well as use any API-compliant image registry.

Further Reading

- *OpenShift Container Platform Developer Guide*
  - How Builds Work
  - Triggering Builds
- *OpenShift Container Platform Architecture*: Source-to-Image (S2I) Build
- *OpenShift Container Platform Using Images*: Other Images → Jenkins

5.3. SECURING INPUTS DURING BUILDS

In some scenarios, build operations require credentials to access dependent resources, but it is undesirable for those credentials to be available in the final application image produced by the build. You can define input secrets for this purpose.

For example, when building a Node.js application, you can set up your private mirror for Node.js modules. In order to download modules from that private mirror, you have to supply a custom ***.npmrc*** file for the build that contains a URL, user name, and password. For security reasons, you do not want to expose your credentials in the application image.

Using this example scenario, you can add an input secret to a new **BuildConfig**:

1. Create the secret, if it does not exist:

```
$ oc create secret generic secret-npmrc --from-file=.npmrc=~/.npmrc
```

   This creates a new secret named ***secret-npmrc***, which contains the base64 encoded content of the ***~/.npmrc*** file.

2. Add the secret to the **source** section in the existing **BuildConfig**:

```
source:
  git:
    uri: https://github.com/sclorg/nodejs-ex.git
  secrets:
    - secret:
        name: secret-npmrc
```

3. To include the secret in a new **BuildConfig**, run the following command:

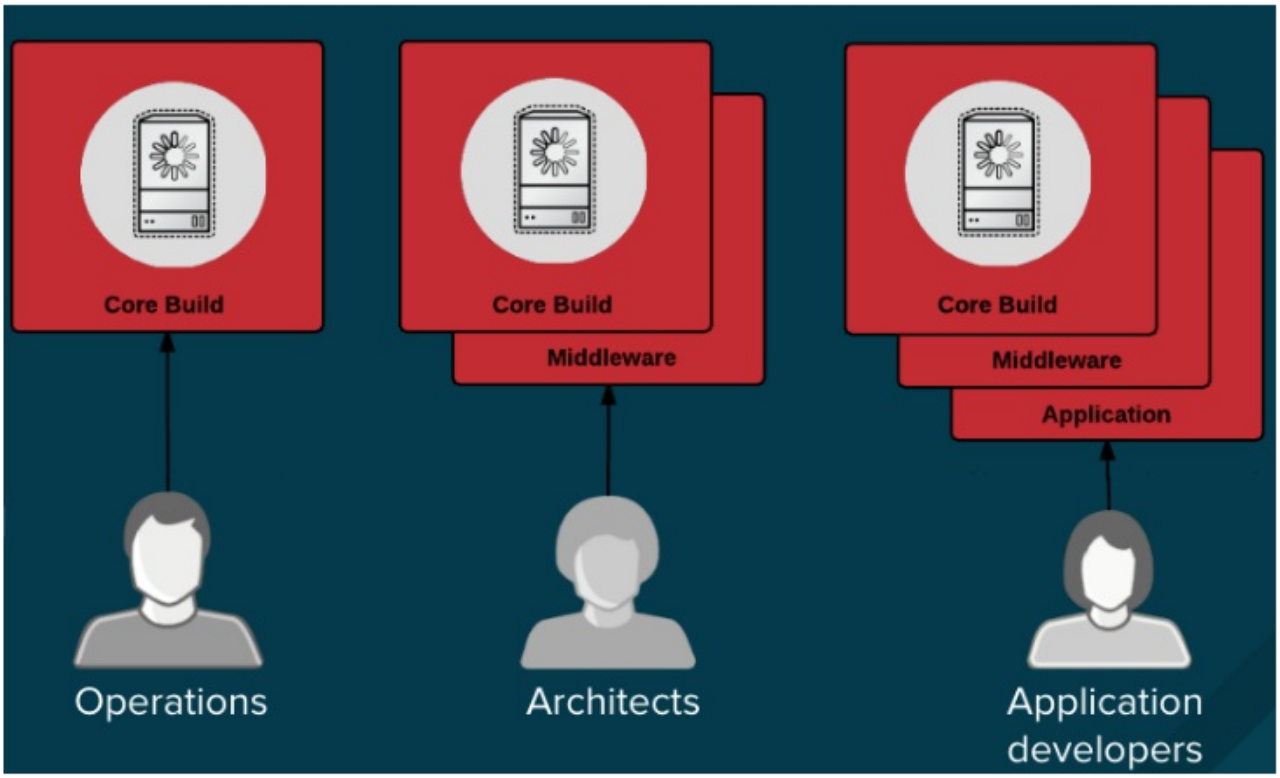
```
$ oc new-build \
    openshift/nodejs-010-centos7~https://github.com/sclorg/nodejs-ex.git \
    --build-secret secret-npmrc
```

Further Reading

- *OpenShift Container Platform Developer Guide*: Input Secrets

5.4. DESIGNING YOUR BUILD PROCESS

You can design your container image management and build process to use container layers so that you can separate control.



For example, an operations team manages base images, while architects manage middleware, runtimes, databases, and other solutions. Developers can then focus on application layers and just write code.

Because new vulnerabilities are identified daily, you need to proactively check container content over time. To do this, you should integrate automated security testing into your build or CI process. For example:

- SAST / DAST – Static and Dynamic security testing tools.
- Scanners for real-time checking against known vulnerabilities. Tools like these catalog the open source packages in your container, notify you of any known vulnerabilities, and update you when new vulnerabilities are discovered in previously scanned packages.

Your CI process should include policies that flag builds with issues discovered by security scans so that your team can take appropriate action to address those issues. You should sign your custom built containers to ensure that nothing is tampered with between build and deployment.

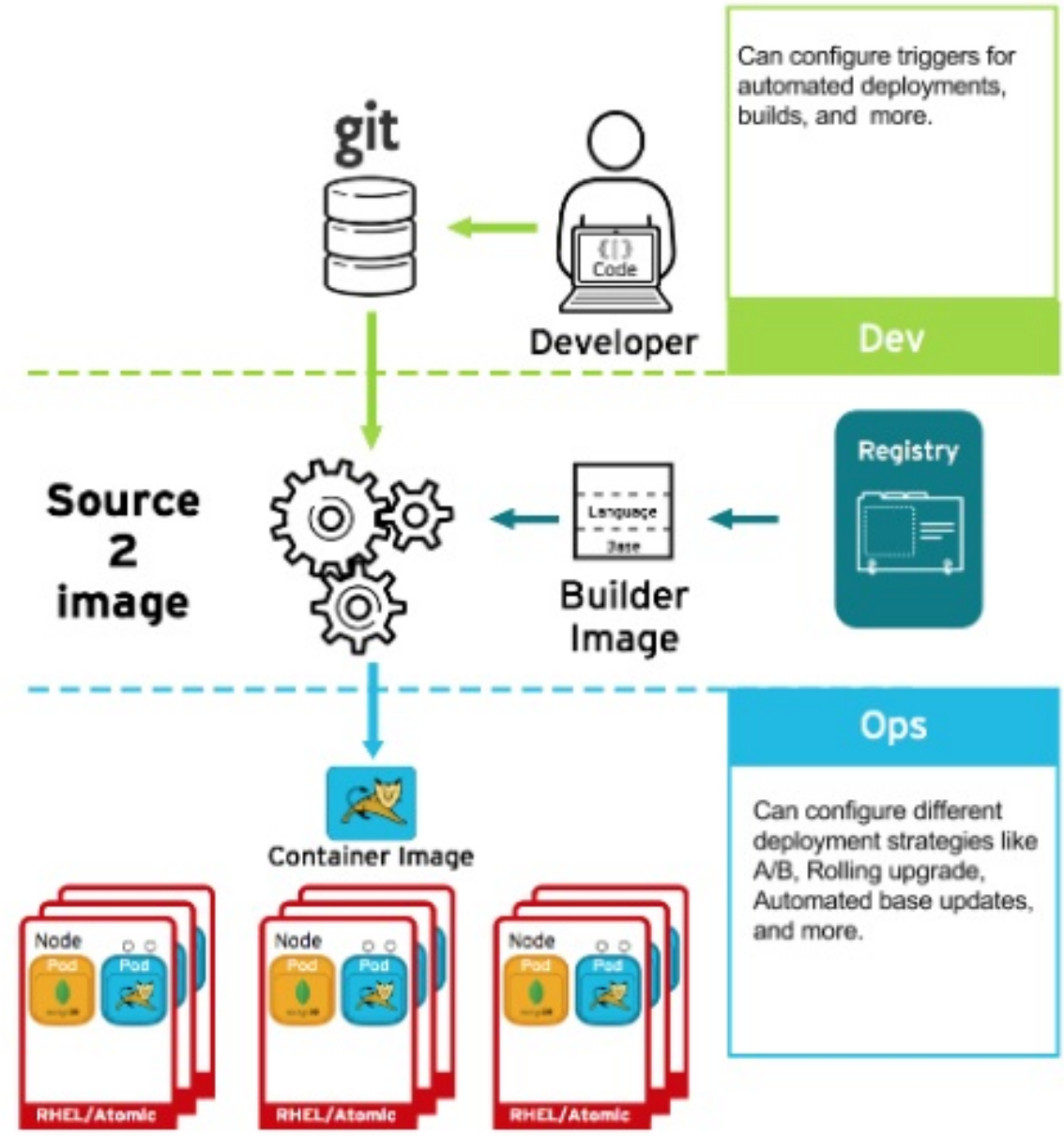
Further Reading

- *Red Hat Enterprise Linux Atomic Host Managing Containers* : Signing Container Images

CHAPTER 6. DEPLOYMENT

6.1. CONTROLLING WHAT CAN BE DEPLOYED IN A CONTAINER

If something happens during the build process, or if a vulnerability is discovered after an image has been deployed, you can use tooling for automated, policy-based deployment. You can use triggers to rebuild and replace images instead of patching running containers, which is not recommended.



For example, you build an application using three container image layers: core, middleware, and applications. An issue is discovered in the core image and that image is rebuilt. After the build is complete, the image is pushed to the OpenShift Container Registry. OpenShift Container Platform detects that the image has changed and automatically rebuilds and deploys the application image, based on the defined triggers. This change incorporates the fixed libraries and ensures that the production code is identical to the most current image.

The **oc set triggers** command can be used to set a deployment trigger for a deployment configuration. For example, to set an **ImageChangeTrigger** in a deployment configuration called **frontend**:

```
$ oc set triggers dc/frontend \
    --from-image=myproject/origin-ruby-sample:latest \
    -c helloworld
```

Further Reading

- *OpenShift Container Platform Developer Guide*
  - How Deployments Work
  - Setting Deployment Triggers
  - Application Life Cycle Management → Promoting Applications Across Environments

6.2. CONTROLLING WHAT IMAGE SOURCES CAN BE DEPLOYED

It is important that the intended images are actually being deployed, that they are from trusted sources, and they have not been altered. Cryptographic signing provides this assurance. OpenShift Container Platform enables cluster administrators to apply security policy that is broad or narrow, reflecting deployment environment and security requirements. Two parameters define this policy:

- one or more registries (with optional project namespace)
- trust type (accept, reject, or require public key(s))

With these policy parameters, registries or parts of registries, even individual images, may be whitelisted (accept), blacklisted (reject), or define a trust relationship using trusted public key(s) to ensure the source is cryptographically verified. The policy rules apply to nodes. Policy may be applied uniformly across all nodes or targeted for different node workloads (for example, build, zone, or environment).

Example Image Signature Policy File

```
{
    "default": [{"type": "reject"}],
    "transports": {
        "docker": {
            "access.redhat.com": [
                {
                    "type": "signedBy",
                    "keyType": "GPGKeys",
                    "keyPath": "/etc/pki/rpm-gpg/RPM-GPG-KEY-redhat-release"
                }
            ]
        },
        "atomic": {
            "172.30.1.1:5000/openshift": [
                {
                    "type": "signedBy",
                    "keyType": "GPGKeys",
                    "keyPath": "/etc/pki/rpm-gpg/RPM-GPG-KEY-redhat-release"
                }
            ],
            "172.30.1.1:5000/production": [
                {
                    "type": "signedBy",
                    "keyType": "GPGKeys",
```

```
                "keyPath": "/etc/pki/example.com/pubkey"
            }
        ],
        "172.30.1.1:5000": [{"type": "insecureAcceptAnything"}]
    }
  }
}
```

The policy can be saved onto a node as */etc/containers/policy.json*. This example enforces the following rules:

1. Require images from the Red Hat Registry (**access.redhat.com**) to be signed by the Red Hat public key.
2. Require images from the OpenShift Container Registry in the **openshift** namespace to be signed by the Red Hat public key.
3. Require images from the OpenShift Container Registry in the **production** namespace to be signed by the public key for **example.com**.
4. Reject all other registries not specified by the global **default** definition.

For specific instructions on configuring a host, see Enabling Image Signature Support. See the section below for details on Signature Transports. For more details on image signature policy, see the Signature verification policy file format source code documentation.

6.2.1. Signature Transports

A signature transport is a way to store and retrieve the binary signature blob. There are two types of signature transports.

- **atomic**: Managed by the OpenShift Container Platform API.
- **docker**: Served as a local file or by a web server.

The OpenShift Container Platform API manages signatures that use the **atomic** transport type. You must store the images that use this signature type in the the OpenShift Container Registry. Because the **docker/distributionextensions** API auto-discovers the image signature endpoint, no additional configuration is required.

Signatures that use the **docker** transport type are served by local file or web server. These signatures are more flexible: you can serve images from any container image registry and use an independent server to deliver binary signatures. According to the Signature access protocols, you access the signatures for each image directly; the root of the server directory does not display its file structure.

However, the **docker** transport type requires additional configuration. You must configure the nodes with the URI of the signature server by placing arbitrarily-named YAML files into a directory on the host system, */etc/containers/registries.d* by default. The YAML configuration files contain a registry URI and a signature server URI, or *sigstore*:

Example Registries.d File

```
docker:
    access.redhat.com:
        sigstore: https://access.redhat.com/webassets/docker/content/sigstore
```

In this example, the Red Hat Registry, **access.redhat.com**, is the signature server that provides signatures for the **docker** transport type. Its URI is defined in the **sigstore** parameter. You might name this file */etc/containers/registries.d/redhat.com.yaml* and use Ansible to automatically place the file on each node in your cluster. No service restart is required since policy and *registries.d* files are dynamically loaded by the container runtime.

For more details, see the Registries Configuration Directory or Signature access protocols source code documentation.

Further Reading

- *OpenShift Container Platform Cluster Administration Guide*
  - Default Scheduling
- *Red Hat Knowledgebase*
  - Container Image Signing Integration Guide
- *Source Code Reference*
  - Image signing policy
  - Signature transports
  - Signature format

6.3. SECRETS AND CONFIGMAPS

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

For example, to add a secret to your deployment configuration using the web console so that it can access a private image repository:

1. Create a new project.
2. Navigate to **Resources → Secrets** and create a new secret. Set **Secret Type** to **Image Secret** and **Authentication Type** to **Image Registry Credentials** to enter credentials for accessing a private image repository.
3. When creating a deployment configuration (for example, from the **Add to Project → Deploy Image** page), set the **Pull Secret** to your new secret.

ConfigMaps are similar to secrets, but are designed to support working with strings that do not contain sensitive information. The **ConfigMap** object holds key-value pairs of configuration data that can be consumed in pods or used to store configuration data for system components such as controllers.

Further Reading

- *OpenShift Container Platform Developer Guide*
  - Secrets
  - ConfigMaps

6.4. SECURITY CONTEXT CONSTRAINTS (SCCS)

You can use *security context constraints* (SCCs) to define a set of conditions that a pod (a collection of containers) must run with in order to be accepted into the system.

Some aspects that can be managed by SCCs include:

- Running of privileged containers.
- Capabilities a container can request to be added.
- Use of host directories as volumes.
- SELinux context of the container.
- Container user ID.

If you have the required permissions, you can adjust the default SCC policies to be more permissive.

Further Reading

- *OpenShift Container Platform Architecture*: Security Context Constraints
- *OpenShift Container Platform Installing Clusters*: Security Warning
  - Discusses privileged containers

6.5. CONTINUOUS DEPLOYMENT TOOLING

You can integrate your own continuous deployment (CD) tooling with OpenShift Container Platform.

By leveraging CI/CD and OpenShift Container Platform, you can automate the process of rebuilding the application to incorporate the latest fixes, testing, and ensuring that it is deployed everywhere within the environment.

CHAPTER 7. SECURING THE CONTAINER PLATFORM

7.1. CONTAINER ORCHESTRATION

APIs are key to automating container management at scale. APIs are used to:

- Validate and configure the data for pods, services, and replication controllers.
- Perform project validation on incoming requests and invoke triggers on other major system components.

Further Reading

- OpenShift Container Platform *Architecture*: How Is OpenShift Container Platform Secured?

7.2. AUTHENTICATION AND AUTHORIZATION

7.2.1. Controlling Access Using OAuth

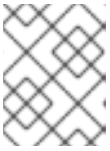
You can use API access control via authentication and authorization for securing your container platform. The OpenShift Container Platform master includes a built-in OAuth server. Users can obtain OAuth access tokens to authenticate themselves to the API.

As an administrator, you can configure OAuth to authenticate using an *identity provider*, such as LDAP, GitHub, or Google. The Deny All identity provider is used by default for new OpenShift Container Platform deployments, but you can configure this at initial installation time or post-installation. See Configuring authentication and user agent for a full list of identity providers.

For example, to configure the GitHub identity provider post-installation:

1. Edit the master configuration file at */etc/origin/master-config.yaml*.
2. Modify the **oauthConfig** stanza per the following:

```
oauthConfig:
  ...
  identityProviders:
  - name: github
    challenge: false
    login: true
    mappingMethod: claim
    provider:
      apiVersion: v1
      kind: GitHubIdentityProvider
      clientID: ...
      clientSecret: ...
      organizations:
      - myorganization1
      - myorganization2
      teams:
      - myorganization1/team-a
      - myorganization2/team-b
```



NOTE

See the GitHub section in Configuring Authentication for more detailed information and usage.

3. After saving your changes, restart the master services for the changes to take effect:

```
# master-restart api
# master-restart controllers
```

Further Reading

- *OpenShift Container Platform Architecture*
  - Additional Concepts → Authentication
  - Additional Concepts → Authorization
- *OpenShift Container Platform CLI Reference*
- *OpenShift Container Platform Developer Guide*: CLI Authentication

7.2.2. API Access Control and Management

Applications can have multiple, independent API services which have different endpoints that require management. OpenShift Container Platform includes a containerized version of the 3scale API gateway so that you can manage your APIs and control access.

3scale gives you a variety of standard options for API authentication and security, which can be used alone or in combination to issue credentials and control access: Standard API keys, Application ID and key pair, and OAuth 2.0.

You can restrict access to specific end points, methods, and services and apply access policy for groups of users. Application plans allow you to set rate limits for API usage and control traffic flow for groups of developers.

For a tutorial on using APIcast v2, the containerized 3scale API Gateway, see Running APIcast on Red Hat OpenShift.

7.2.3. Red Hat SSO

The Red Hat Single Sign-On (RH-SSO) Server enables you to secure your applications by providing Web SSO capabilities based on standards, including SAML 2.0, OpenID Connect, and OAuth 2.0. The Server can act as a SAML or OpenID Connect–based identity provider (IdP), mediating with your enterprise user directory or third-party identity provider for identity information and your applications using standards-based tokens. You can integrate Red Hat SSO with LDAP-based directory services including Microsoft Active Directory and Red Hat Enterprise Linux Identity Management.

See Red Hat JBoss SSO for OpenShift documentation for usage tutorials.

7.2.4. Secure Self-service Web Console

OpenShift Container Platform provides a self-service web console to ensure that teams do not access other environments without authorization. OpenShift Container Platform ensures a secure multi-tenant master by providing the following:

- Access to the master uses Transport Layer Security (TLS)
- Access to the API Server uses X.509 certificates or OAuth access tokens
- Project quota limits the damage that a rogue token could do
- Etcd is not exposed directly to the cluster

Further Reading

- *OpenShift Container Platform Architecture*: Infrastructure Components → Web Console
- *OpenShift Container Platform Developer Guide*: Web Console Authentication

7.3. MANAGING CERTIFICATES FOR THE PLATFORM

OpenShift Container Platform has multiple components within its framework that use REST-based HTTPS communication leveraging encryption via TLS certificates. OpenShift Container Platform's Ansible-based installer configures these certificates during installation. There are some primary components that generate this traffic:

- masters (API server and controllers)
- etcd
- nodes
- registry
- router

7.3.1. Configuring Custom Certificates

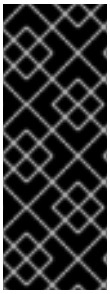
You can configure custom serving certificates for the public host names of the API server and web console during initial installation or when redeploying certificates. You can also use a custom CA.

During initial cluster installations using Ansible playbooks, custom certificates can be configured using the **openshift_master_overwrite_named_certificates** Ansible variable, which is configurable in the inventory file. For example:

```
openshift_master_named_certificates=[{"certfile": "/path/on/host/to/custom1.crt", "keyfile":
"/path/on/host/to/custom1.key", "cafile": "/path/on/host/to/custom-ca1.crt"}]
```

See Configuring Custom Certificates section for more options and instructions on how to run the installation playbook.

The installer provides Ansible playbooks for checking on the expiration dates of all cluster certificates. Additional playbooks can automatically redeploy all certificates at once using the current CA, redeploy specific certificates only, or redeploy a newly generated or custom CA on its own. See Redeploying Certificates for more on these playbooks.



IMPORTANT

The **cafile** certificate is imported to the **ca-bundle.crt** file on the masters during installation or during redeployment of certificates. The **ca-bundle.crt** file is mounted to every pod that runs in OpenShift Container Platform. Several OpenShift Container Platform components automatically trust the named certificates by default when they access the **masterPublicURL** endpoint. If you omit the **cafile** option from the certificates parameter, the functionality of Web Console and several other components is reduced.

Further Reading

- *OpenShift Container Platform Configuring Clusters*
  - Configuring Custom Certificates
  - Checking Certificate Expirations
  - Redeploying Certificates

CHAPTER 8. NETWORK SECURITY

8.1. NETWORK NAMESPACES

OpenShift Container Platform uses software-defined networking (SDN) to provide a unified cluster network that enables communication between containers across the cluster.

Using network namespaces, you can isolate pod networks. Each pod gets its own IP and port range to bind to, thereby isolating pod networks from each other on the node. Pods from different projects cannot send packets to or receive packets from pods and services of a different project. You can use this to isolate developer, test and production environments within a cluster.

OpenShift Container Platform also provides the ability to control egress traffic using either a router or firewall method. For example, you can use IP whitelisting to control database access.

Further Reading

- *OpenShift Container Platform Architecture*: Networking
- *OpenShift Container Platform Cluster Administration*: Managing Networking
- *Red Hat Enterprise Linux Atomic Host Managing Containers* : Running Super-Privileged Containers

8.2. ISOLATING APPLICATIONS

OpenShift Container Platform enables you to segment network traffic on a single cluster to make multi-tenant clusters that isolate users, teams, applications, and environments.

For example, to isolate a project network in the cluster and vice versa, run:

```
$ oc adm 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.

CHAPTER 9. ATTACHED STORAGE

9.1. PERSISTENT VOLUME PLUG-INS

Containers are useful for both stateless and stateful applications. Protecting attached storage is a key element of securing stateful services.

OpenShift Container Platform provides plug-ins for multiple types of storage, including NFS, AWS Elastic Block Stores (EBS), GCE Persistent Disks, GlusterFS, iSCSI, RADOS (Ceph) and Cinder. Data in transit is encrypted via HTTPS for all OpenShift Container Platform components communicating with each other.

You can mount **PersistentVolume** (PV) on a host in any way supported by your storage type. Different types of storage have different capabilities and each PV's access modes are set to the specific modes supported by that particular volume.

For example, NFS can support multiple read/write clients, but a specific NFS PV might be exported on the server as read-only. Each PV has its own set of access modes describing that specific PV's capabilities, such as **ReadWriteOnce**, **ReadOnlyMany**, and **ReadWriteMany**.

Further Reading

- *OpenShift Container Platform Architecture*: Additional Concepts → Storage
- *OpenShift Container Platform Configuring Clusters*: Configuring Persistent Storage → Volume Security

9.2. SHARED STORAGE

For shared storage providers like NFS, Ceph, and Gluster, the PV registers its group ID (GID) as an annotation on the PV resource. Then, when the PV is claimed by the pod, the annotated GID is added to the supplemental groups of the pod, giving that pod access to the contents of the shared storage.

Further Reading

- *OpenShift Container Platform Configuring Clusters*
  - Persistent Storage Using NFS
  - Persistent Storage Using Ceph RBD
  - Persistent Storage Using GlusterFS

9.3. BLOCK STORAGE

For block storage providers like AWS Elastic Block Store (EBS), GCE Persistent Disks, and iSCSI, OpenShift Container Platform uses SELinux capabilities to secure the root of the mounted volume for non-privileged pods, making the mounted volume owned by and only visible to the container with which it is associated.

Further Reading

- *OpenShift Container Platform Configuring Clusters*
  - Persistent Storage Using AWS Elastic Block Storage

- Persistent Storage Using GCE Persistent Disk
- Persistent Storage Using iSCSI

CHAPTER 10. MONITORING CLUSTER EVENTS AND LOGS

10.1. INTRODUCTION

In addition to security measures mentioned in other sections of this guide, the ability to monitor and audit an OpenShift Container Platform cluster is an important part of safeguarding the cluster and its users against inappropriate usage.

There are two main sources of cluster-level information that are useful for this purpose: events and logs.

10.2. CLUSTER EVENTS

Cluster administrators are encouraged to familiarize themselves with the *Event* resource type and review a list of events to determine which events are of interest. Depending on the master controller and plugin configuration, there are typically more potential event types than listed here.

Events are associated with a namespace, either the namespace of the resource they are related to or, for cluster events, the *default* namespace. The *default* namespace holds relevant events for monitoring or auditing a cluster, such as *Node* events and resource events related to infrastructure components.

The master API and **oc** command do not provide parameters to scope a listing of events to only those related to nodes. A simple approach would be to use grep:

```
$ oc get event -n default | grep Node
1h        20h        3        origin-node-1.example.local   Node      Normal    NodeHasDiskPressure   ...
```

A more flexible approach is to output the events in a form that other tools can process. For example, the following example uses the **jq** tool against JSON output to extract only *NodeHasDiskPressure* events:

```
$ oc get events -n default -o json \
  | jq '.items[] | select(.involvedObject.kind == "Node" and .reason == "NodeHasDiskPressure")'

{
  "apiVersion": "v1",
  "count": 3,
  "involvedObject": {
    "kind": "Node",
    "name": "origin-node-1.example.local",
    "uid": "origin-node-1.example.local"
  },
  "kind": "Event",
  "reason": "NodeHasDiskPressure",
  ...
}
```

Events related to resource creation, modification, or deletion can also be good candidates for detecting misuse of the cluster. The following query, for example, can be used to look for excessive pulling of images:

```
$ oc get events --all-namespaces -o json \
  | jq '[.items[] | select(.involvedObject.kind == "Pod" and .reason == "Pulling")] | length'

4
```

NOTE

When a namespace is deleted, its events are deleted as well. Events can also expire and are deleted to prevent filling up **etcd** storage. Events are not stored as a permanent record and frequent polling is necessary to capture statistics over time.

10.3. CLUSTER LOGS

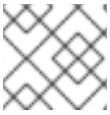
This section describes the types of operational logs produced on the cluster.

10.3.1. Service Logs

OpenShift Container Platform produces logs for services that run on static pods in a cluster:

- API (use **master-logs api api**)
- Controllers (use **master-logs controllers controllers**)
- etcd (use **master-logs etcd etcd**)
- atomic-openshift-node (use **journalctl -u atomic-openshift-node.service**)

These logs are intended more for debugging purposes than for security auditing. You can retrieve logs for each service with the **master-logs api api**, **master-logs controllers controllers**, or **master-logs etcd etcd** commands. If your cluster runs an aggregated logging stack, like an Ops cluster, cluster administrators can retrieve logs from the logging *.operations* indexes.



NOTE

The API server, controllers, and etcd static pods run in kube-system namespace.

10.3.2. Master API Audit Log

To log master API requests by users, administrators, or system components enable audit logging for the master API. This will create a file on each master host or, if there is no file configured, be included in the service's journal. Entries in the journal can be found by searching for **"AUDIT"**.

Audit log entries consist of one line recording each REST request when it is received and one line with the HTTP response code when it completes. For example, here is a record of the system administrator requesting a list of nodes:

```
2017-10-17T13:12:17.635085787Z AUDIT: id="410eda6b-88d4-4491-87ff-394804ca69a1"
ip="192.168.122.156" method="GET" user="system:admin" groups="\"system:cluster-
admins\",\"system:authenticated\"" as="<self>" asgroups="<lookup>" namespace="<none>"
uri="/api/v1/nodes"
2017-10-17T13:12:17.636081056Z AUDIT: id="410eda6b-88d4-4491-87ff-394804ca69a1"
response="200"
```

It might be useful to poll the log periodically for the number of recent requests per response code, as shown in the following example:

```
$ tail -5000 /var/log/origin/audit-ocp.log \
  | grep -Po 'response="..."' \
  | sort | uniq -c | sort -rn
```

```
3288 response="200"
   8 response="404"
   6 response="201"
```

The following list describes some of the response codes in more detail:

- **200** or **201** response codes indicate a successful request.
- **400** response codes may be of interest as they indicate a malformed request, which should not occur with most clients.
- **404** response codes are typically benign requests for a resource that does not exist.
- **500** - **599** response codes indicate server errors, which can be a result of bugs, system failures, or even malicious activity.

If an unusual number of error responses are found, the audit log entries for corresponding requests can be retrieved for further investigation.

NOTE

The IP address of the request is typically a cluster host or API load balancer, and there is no record of the IP address behind a load balancer proxy request (however, load balancer logs can be useful for determining request origin).

It can be useful to look for unusual numbers of requests by a particular user or group.

The following example lists the top 10 users by number of requests in the last 5000 lines of the audit log:

```
$ tail -5000 /var/log/origin/audit-ocp.log \
  | grep -Po ' user="(.*?)(?<!\\)"' \
  | sort | uniq -c | sort -rn | head -10

  976  user="system:openshift-master"
  270  user="system:node:origin-node-1.example.local"
  270  user="system:node:origin-master.example.local"
   66  user="system:anonymous"
   32  user="system:serviceaccount:kube-system:cronjob-controller"
   24  user="system:serviceaccount:kube-system:pod-garbage-collector"
   18  user="system:serviceaccount:kube-system:endpoint-controller"
   14  user="system:serviceaccount:openshift-infra:serviceaccount-pull-secrets-controller"
   11  user="test user"
    4  user="test \" user"
```

More advanced queries generally require the use of additional log analysis tools. Auditors will need a detailed familiarity with the OpenShift v1 API and Kubernetes v1 API to aggregate request summaries from the audit log according to which kind of resource is involved (the **uri** field). See REST API Reference for details.

More advanced audit logging capabilities are available. This feature enables providing an audit policy file to control which requests are logged and the level of detail to log. Advanced audit log entries provide more detail in JSON format and can be logged via a webhook as opposed to file or system journal.