Red Hat

OpenShift Container Platform 4.9

Security and compliance

Learning about and managing security for OpenShift Container Platform

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Learning about and managing security for OpenShift Container Platform

Legal Notice

Abstract

This document discusses container security, configuring certificates, and enabling encryption to help secure the cluster.

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CHAPTER 1. OPENSHIFT CONTAINER PLATFORM SECURITY AND COMPLIANCE

1.1. SECURITY OVERVIEW

It is important to understand how to properly secure various aspects of your OpenShift Container Platform cluster.

Container security

A good starting point to understanding OpenShift Container Platform security is to review the concepts in Understanding container security. This and subsequent sections provide 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. These sections also include information on the following topics:

- Why container security is important and how it compares with existing security standards.
- Which container security measures are provided by the host (RHCOS and 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 through authentication and authorization.
- How networking and attached storage are secured in OpenShift Container Platform.
- Containerized solutions for API management and SSO.

Auditing

OpenShift Container Platform auditing provides a security-relevant chronological set of records documenting the sequence of activities that have affected the system by individual users, administrators, or other components of the system. Administrators can configure the audit log policy and view audit logs.

Certificates

Certificates are used by various components to validate access to the cluster. Administrators can replace the default ingress certificate, add API server certificates, or add a service certificate .

You can also review more details about the types of certificates used by the cluster:

- User-provided certificates for the API server
- Proxy certificates
- Service CA certificates
- Node certificates
- Bootstrap certificates
- etcd certificates
- OLM certificates

- User-provided certificates for default ingress
- Ingress certificates
- Monitoring and cluster logging Operator component certificates
- Control plane certificates

Encrypting data
You can enable etcd encryption for your cluster to provide an additional layer of data security. For example, it can help protect the loss of sensitive data if an etcd backup is exposed to the incorrect parties.

Vulnerability scanning
Administrators can use the Container Security Operator (CSO) to run vulnerability scans and review information about detected vulnerabilities.

1.2. COMPLIANCE OVERVIEW

For many OpenShift Container Platform customers, regulatory readiness, or compliance, on some level is required before any systems can be put into production. That regulatory readiness can be imposed by national standards, industry standards, or the organization's corporate governance framework.

Compliance checking
Administrators can use the Compliance Operator to run compliance scans and recommend remediations for any issues found. The **oc-compliance** plug-in is an OpenShift CLI (**oc**) plug-in that provides a set of utilities to easily interact with the Compliance Operator.

File integrity checking
Administrators can use the File Integrity Operator to continually run file integrity checks on cluster nodes and provide a log of files that have been modified.

1.3. ADDITIONAL RESOURCES

- Understanding authentication
- Configuring the internal OAuth server
- Understanding identity provider configuration
- Using RBAC to define and apply permissions
- Managing security context constraints

CHAPTER 2. CONTAINER SECURITY

2.1. UNDERSTANDING CONTAINER SECURITY

Securing a containerized application relies on multiple levels of security:

- Container security begins with a trusted base container image and continues through the container build process as it moves through your CI/CD pipeline.

  IMPORTANT

  Image streams by default do not automatically update. This default behavior might create a security issue because security updates to images referenced by an image stream do not automatically occur. For information about how to override this default behavior, see Configuring periodic importing of imagestreamtags.

- When a container is deployed, its security depends on it running on secure operating systems and networks, and establishing firm boundaries between the container itself and the users and hosts that interact with it.

- Continued security relies on being able to scan container images for vulnerabilities and having an efficient way to correct and replace vulnerable images.

Beyond what a platform such as OpenShift Container Platform offers out of the box, your organization will likely have its own security demands. Some level of compliance verification might be needed before you can even bring OpenShift Container Platform into your data center.

Likewise, you may need to add your own agents, specialized hardware drivers, or encryption features to OpenShift Container Platform, before it can meet your organization’s security standards.

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. It then points you to specific OpenShift Container Platform documentation to help you achieve those security measures.

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 (RHCOS and 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 through authentication and authorization.
- How networking and attached storage are secured in OpenShift Container Platform.
- Containerized solutions for API management and SSO.

The goal of this guide is to understand the incredible security benefits of using OpenShift Container Platform for your containerized workloads and how the entire Red Hat ecosystem plays a part in making and keeping containers secure. It will also help you understand how you can engage with the OpenShift Container Platform to achieve your organization's security goals.

2.1.1. 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. A container might be part of a larger application that works closely with other containers.

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 operating system 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

See Understanding Linux containers from the Red Hat Customer Portal to find out more about Linux containers. To learn about RHEL container tools, see Building, running, and managing containers in the RHEL product documentation.

2.1.2. What is OpenShift Container Platform?

Automating how containerized applications are deployed, run, and managed is the job of a platform such as OpenShift Container Platform. At its core, OpenShift Container Platform relies on the Kubernetes project to provide the engine for orchestrating containers across many nodes in scalable data centers.

Kubernetes is a project, which can run using different operating systems and add-on components that offer no guarantees of supportability from the project. As a result, the security of different Kubernetes platforms can vary.

OpenShift Container Platform is designed to lock down Kubernetes security and integrate the platform with a variety of extended components. To do this, OpenShift Container Platform draws on the extensive Red Hat ecosystem of open source technologies that include the operating systems, authentication, storage, networking, development tools, base container images, and many other components.

OpenShift Container Platform can leverage Red Hat's experience in uncovering and rapidly deploying fixes for vulnerabilities in the platform itself as well as the containerized applications running on the platform. Red Hat's experience also extends to efficiently integrating new components with OpenShift Container Platform as they become available and adapting technologies to individual customer needs.

Additional resources

- OpenShift Container Platform architecture

- OpenShift Security Guide

2.2. UNDERSTANDING HOST AND VM SECURITY

Both containers and virtual machines provide ways of separating applications running on a host from the operating system itself. Understanding RHCOS, which is the operating system used by OpenShift Container Platform, will help you see how the host systems protect containers and hosts from each other.

2.2.1. Securing containers on Red Hat Enterprise Linux CoreOS (RHCOS)

Containers simplify the act of deploying many applications to run on the same host, using the same kernel and container runtime to spin up each container. The applications can be owned by many users and, because they are kept separate, can run different, and even incompatible, versions of those applications at the same time without issue.

In Linux, containers are just a special type of process, so securing containers is similar in many ways to securing any other running process. An environment for running containers starts with an operating system that can secure the host kernel from containers and other processes running on the host, as well as secure containers from each other.

Because OpenShift Container Platform 4.9 runs on RHCOS hosts, with the option of using Red Hat Enterprise Linux (RHEL) as worker nodes, the following concepts apply by default to any deployed OpenShift Container Platform cluster. These RHEL security features are at the core of what makes running containers in OpenShift Container Platform more secure:

- *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 computing resource simultaneously without creating a conflict. Container namespaces that are separate from the host by default include mount table, process table, network interface, user, control group, UTS, and IPC namespaces. Those containers that need direct access to host namespaces need to have elevated permissions to request that access. See Overview of Containers in Red Hat Systems from the RHEL 8 container documentation for details on the types of namespaces.

- *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. See page 94 of the OpenShift Security Guide for details about seccomp.

- Deploying containers using *RHCOS* reduces the attack surface by minimizing the host environment and tuning it for containers. The CRI-O container engine further reduces that attack surface by implementing only those features required by Kubernetes and OpenShift Container Platform to run and manage containers, as opposed to other container engines that implement desktop-oriented standalone features.

RHCOS is a version of Red Hat Enterprise Linux (RHEL) that is specially configured to work as control plane (master) and worker nodes on OpenShift Container Platform clusters. So RHCOS is tuned to efficiently run container workloads, along with Kubernetes and OpenShift Container Platform services.

To further protect RHCOS systems in OpenShift Container Platform clusters, most containers, except those managing or monitoring the host system itself, should run as a non-root user. Dropping the privilege level or creating containers with the least amount of privileges possible is recommended best practice for protecting your own OpenShift Container Platform clusters.

Additional resources

- How nodes enforce resource constraints
- Managing security context constraints
- Supported platforms for OpenShift clusters
- Requirements for a cluster with user-provisioned infrastructure
- Choosing how to configure RHCOS
- Ignition
- Kernel arguments
- Kernel modules
- FIPS cryptography
- Disk encryption
- Chrony time service
- OpenShift Container Platform cluster updates

2.2.2. Comparing virtualization and containers

Traditional virtualization provides another way to keep application environments separate on the same physical host. However, virtual machines work in a different way than containers. Virtualization relies on a hypervisor spinning up guest virtual machines (VMs), each of which has its own operating system (OS), represented by a running kernel, 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 might be able to use hypervisor bugs to gain access to another VM or the host kernel. And, when the OS needs to be patched, it must be patched on all guest VMs using that OS.

Containers can be run inside guest VMs, and there might be use cases where this is desirable. For example, you might be deploying a traditional application in a container, perhaps to lift-and-shift an application to the cloud.

Container separation on a single host, however, provides a more lightweight, flexible, and easier-to-scale deployment solution. This deployment model is particularly appropriate for cloud-native applications. Containers are generally much smaller than VMs and consume less memory and CPU.

See Linux Containers Compared to KVM Virtualization in the RHEL 7 container documentation to learn about the differences between container and VMs.

2.2.3. Securing OpenShift Container Platform

When you deploy OpenShift Container Platform, you have the choice of an installer-provisioned infrastructure (there are several available platforms) or your own user-provisioned infrastructure. Some low-level security-related configuration, such as enabling FIPS compliance or adding kernel modules required at first boot, might benefit from a user-provisioned infrastructure. Likewise, user-provisioned infrastructure is appropriate for disconnected OpenShift Container Platform deployments.

Keep in mind that, when it comes to making security enhancements and other configuration changes to OpenShift Container Platform, the goals should include:

- Keeping the underlying nodes as generic as possible. You want to be able to easily throw away and spin up similar nodes quickly and in prescriptive ways.
- Managing modifications to nodes through OpenShift Container Platform as much as possible, rather than making direct, one-off changes to the nodes.

In pursuit of those goals, most node changes should be done during installation through Ignition or later using MachineConfigs that are applied to sets of nodes by the Machine Config Operator. Examples of security-related configuration changes you can do in this way include:

- Adding kernel arguments
- Adding kernel modules
- Enabling support for FIPS cryptography
- Configuring disk encryption
- Configuring the chrony time service

Besides the Machine Config Operator, there are several other Operators available to configure OpenShift Container Platform infrastructure that are managed by the Cluster Version Operator (CVO). The CVO is able to automate many aspects of OpenShift Container Platform cluster updates.

2.3. HARDENING RHCOS

RHCOS was created and tuned to be deployed in OpenShift Container Platform with few if any changes needed to RHCOS nodes. Every organization adopting OpenShift Container Platform has its own requirements for system hardening. As a RHEL system with OpenShift-specific modifications and features added (such as Ignition, ostree, and a read-only **/usr** to provide limited immutability), RHCOS can be hardened just as you would any RHEL system. Differences lie in the ways you manage the hardening.

A key feature of OpenShift Container Platform and its Kubernetes engine is to be able to quickly scale applications and infrastructure up and down as needed. Unless it is unavoidable, you do not want to make direct changes to RHCOS by logging into a host and adding software or changing settings. You want to have the OpenShift Container Platform installer and control plane manage changes to RHCOS so new nodes can be spun up without manual intervention.

So, if you are setting out to harden RHCOS nodes in OpenShift Container Platform to meet your security needs, you should consider both what to harden and how to go about doing that hardening.

2.3.1. Choosing what to harden in RHCOS

The RHEL 8 Security Hardening guide describes how you should approach security for any RHEL system.

Use this guide to learn how to approach cryptography, evaluate vulnerabilities, and assess threats to various services. Likewise, you can learn how to scan for compliance standards, check file integrity, perform auditing, and encrypt storage devices.

With the knowledge of what features you want to harden, you can then decide how to harden them in RHCOS.

2.3.2. Choosing how to harden RHCOS

Direct modification of RHCOS systems in OpenShift Container Platform is discouraged. Instead, you should think of modifying systems in pools of nodes, such as worker nodes and control plane nodes. When a new node is needed, in non-bare metal installs, you can request a new node of the type you want and it will be created from an RHCOS image plus the modifications you created earlier.

There are opportunities for modifying RHCOS before installation, during installation, and after the cluster is up and running.

2.3.2.1. Hardening before installation

For bare metal installations, you can add hardening features to RHCOS before beginning the OpenShift Container Platform installation. For example, you can add kernel options when you boot the RHCOS installer to turn security features on or off, such as SELinux or various low-level settings, such as symmetric multithreading.

Although bare metal RHCOS installations are more difficult, they offer the opportunity of getting operating system changes in place before starting the OpenShift Container Platform installation. This can be important when you need to ensure that certain features, such as disk encryption or special networking settings, be set up at the earliest possible moment.

2.3.2.2. Hardening during installation

You can interrupt the OpenShift Container Platform installation process and change Ignition configs. Through Ignition configs, you can add your own files and systemd services to the RHCOS nodes. You can also make some basic security-related changes to the **install-config.yaml** file used for installation. Contents added in this way are available at each node's first boot.

2.3.2.3. Hardening after the cluster is running

After the OpenShift Container Platform cluster is up and running, there are several ways to apply hardening features to RHCOS:

- Daemon set: If you need a service to run on every node, you can add that service with a Kubernetes **DaemonSet** object.
- Machine config: **MachineConfig** objects contain a subset of Ignition configs in the same format. By applying machine configs to all worker or control plane nodes, you can ensure that the next node of the same type that is added to the cluster has the same changes applied.

All of the features noted here are described in the OpenShift Container Platform product documentation.

Additional resources

- OpenShift Security Guide

- Choosing how to configure RHCOS
- Modifying Nodes
- Manually creating the installation configuration file
- Creating the Kubernetes manifest and Ignition config files
- Installing RHCOS by using an ISO image
- Customizing nodes
- Adding kernel arguments to Nodes
- Installation configuration parameters - see **fips**
- Support for FIPS cryptography
- RHEL core crypto components

2.4. CONTAINER IMAGE SIGNATURES

Red Hat delivers signatures for the images in the Red Hat Container Registries. Those signatures can be automatically verified when being pulled to OpenShift Container Platform 4 clusters by using the Machine Config Operator (MCO).

Quay.io serves most of the images that make up OpenShift Container Platform, and only the release image is signed. Release images refer to the approved OpenShift Container Platform images, offering a degree of protection against supply chain attacks. However, some extensions to OpenShift Container Platform, such as logging, monitoring, and service mesh, are shipped as Operators from the Operator Lifecycle Manager (OLM). Those images ship from the Red Hat Ecosystem Catalog Container images registry.

To verify the integrity of those images between Red Hat registries and your infrastructure, enable signature verification.

2.4.1. Enabling signature verification for Red Hat Container Registries

Enabling container signature validation for Red Hat Container Registries requires writing a signature verification policy file specifying the keys to verify images from these registries. The registries are already defined in **/etc/containers/registries.d** by default.

Procedure

1. Create a Butane config file, **51-worker-rh-registry-trust.bu**, containing the necessary configuration for the worker nodes.

   NOTE

   See "Creating machine configs with Butane" for information about Butane.

```
variant: openshift
version: 4.9.0
metadata:
  name: 51-worker-rh-registry-trust
  labels:
    machineconfiguration.openshift.io/role: worker
storage:
  files:
  - path: /etc/containers/policy.json
    mode: 0644
    overwrite: true
    contents:
      inline: |
        {
          "default": [
            {
              "type": "insecureAcceptAnything"
            }
          ],
          "transports": {
            "docker": {
              "registry.access.redhat.com": [
                {
                  "type": "signedBy",
                  "keyType": "GPGKeys",
                  "keyPath": "/etc/pki/rpm-gpg/RPM-GPG-KEY-redhat-release"
                }
              ],
              "registry.redhat.io": [
                {
                  "type": "signedBy",
                  "keyType": "GPGKeys",
                  "keyPath": "/etc/pki/rpm-gpg/RPM-GPG-KEY-redhat-release"
                }
              ]
            },
            "docker-daemon": {
              "": [
                {
                  "type": "insecureAcceptAnything"
                }
              ]
            }
          }
        }
```

2. Use Butane to generate a machine config YAML file, **51-worker-rh-registry-trust.yaml**, containing the file to be written to disk on the worker nodes:

```
$ butane 51-worker-rh-registry-trust.bu -o 51-worker-rh-registry-trust.yaml
```

3. Apply the created machine config:

```
$ oc apply -f 51-worker-rh-registry-trust.yaml
```

4. Create a Butane config and corresponding machine config which writes the configuration to disk on the control plane nodes:

```
$ sed -e 's,\(machineconfiguration.openshift.io/role: \)worker,\1master,' \
   -e 's,\(name: 51-\)worker,\1master,' 51-worker-rh-registry-trust.bu \
   > 51-master-rh-registry-trust.bu
$ butane 51-master-rh-registry-trust.bu -o 51-master-rh-registry-trust.yaml
```

5. Apply the control plane machine config to the cluster:

```
$ oc apply -f 51-master-rh-registry-trust.yaml
```

2.4.2. Verifying the signature verification configuration

After you apply the machine configs to the cluster, the Machine Config Controller detects the new **MachineConfig** object and generates a new **rendered-worker-<hash>** version.

Prerequisites

- You enabled signature verification by using a machine config file.

Procedure

1. On the command line, run the following command to display information about a desired worker:

```
$ oc describe machineconfigpool/worker
```

Example output of initial worker monitoring

```
Name:         worker
Namespace:
Labels:       machineconfiguration.openshift.io/mco-built-in=
Annotations:  <none>
API Version:  machineconfiguration.openshift.io/v1
Kind:         MachineConfigPool
Metadata:
  Creation Timestamp:  2019-12-19T02:02:12Z
  Generation:          3
  Resource Version:    16229
  Self Link:           /apis/machineconfiguration.openshift.io/v1/machineconfigpools/worker
  UID:                 92697796-2203-11ea-b48c-fa163e3940e5
Spec:
  Configuration:
    Name:  rendered-worker-f6819366eb455a401c42f8d96ab25c02
    Source:
      API Version:  machineconfiguration.openshift.io/v1
      Kind:         MachineConfig
      Name:         00-worker
      API Version:  machineconfiguration.openshift.io/v1
      Kind:         MachineConfig
      Name:         01-worker-container-runtime
      API Version:  machineconfiguration.openshift.io/v1
      Kind:         MachineConfig
      Name:         01-worker-kubelet
      API Version:  machineconfiguration.openshift.io/v1
      Kind:         MachineConfig
      Name:         51-worker-rh-registry-trust
      API Version:  machineconfiguration.openshift.io/v1
      Kind:         MachineConfig
      Name:         99-worker-92697796-2203-11ea-b48c-fa163e3940e5-registries
      API Version:  machineconfiguration.openshift.io/v1
      Kind:         MachineConfig
      Name:         99-worker-ssh
  Machine Config Selector:
    Match Labels:
      machineconfiguration.openshift.io/role:  worker
  Node Selector:
    Match Labels:
      node-role.kubernetes.io/worker:
  Paused:                              false
Status:
  Conditions:
    Last Transition Time:  2019-12-19T02:03:27Z
    Message:
    Reason:
    Status:                False
    Type:                  RenderDegraded
    Last Transition Time:  2019-12-19T02:03:43Z
    Message:
    Reason:
    Status:                False
    Type:                  NodeDegraded
    Last Transition Time:  2019-12-19T02:03:43Z
    Message:
    Reason:
    Status:                False
    Type:                  Degraded
    Last Transition Time:  2019-12-19T02:28:23Z
    Message:
    Reason:
    Status:                False
    Type:                  Updated
    Last Transition Time:  2019-12-19T02:28:23Z
    Message:               All nodes are updating to rendered-worker-
f6819366eb455a401c42f8d96ab25c02
    Reason:
    Status:                True
    Type:                  Updating
  Configuration:
    Name:  rendered-worker-d9b3f4ffcfd65c30dcf591a0e8cf9b2e
    Source:
      API Version:            machineconfiguration.openshift.io/v1
      Kind:                   MachineConfig
      Name:                   00-worker
      API Version:            machineconfiguration.openshift.io/v1
      Kind:                   MachineConfig
      Name:                   01-worker-container-runtime
      API Version:            machineconfiguration.openshift.io/v1
      Kind:                   MachineConfig
      Name:                   01-worker-kubelet
      API Version:            machineconfiguration.openshift.io/v1
      Kind:                   MachineConfig
      Name:                   99-worker-92697796-2203-11ea-b48c-fa163e3940e5-registries
      API Version:            machineconfiguration.openshift.io/v1
```

```
     Kind:              MachineConfig
     Name:               99-worker-ssh
  Degraded Machine Count:     0
  Machine Count:              1
  Observed Generation:        3
  Ready Machine Count:        0
  Unavailable Machine Count:  1
  Updated Machine Count:      0
Events:                       <none>
```

2. Run the **oc describe** command again:

```
$ oc describe machineconfigpool/worker
```

Example output after the worker is updated

```
...
    Last Transition Time:  2019-12-19T04:53:09Z
    Message:               All nodes are updated with rendered-worker-
f6819366eb455a401c42f8d96ab25c02
    Reason:
    Status:                True
    Type:                  Updated
    Last Transition Time:  2019-12-19T04:53:09Z
    Message:
    Reason:
    Status:                False
    Type:                  Updating
  Configuration:
    Name:  rendered-worker-f6819366eb455a401c42f8d96ab25c02
    Source:
      API Version:           machineconfiguration.openshift.io/v1
      Kind:              MachineConfig
      Name:               00-worker
      API Version:           machineconfiguration.openshift.io/v1
      Kind:              MachineConfig
      Name:               01-worker-container-runtime
      API Version:           machineconfiguration.openshift.io/v1
      Kind:              MachineConfig
      Name:               01-worker-kubelet
      API Version:           machineconfiguration.openshift.io/v1
      Kind:              MachineConfig
      Name:               51-worker-rh-registry-trust
      API Version:           machineconfiguration.openshift.io/v1
      Kind:              MachineConfig
      Name:               99-worker-92697796-2203-11ea-b48c-fa163e3940e5-registries
      API Version:           machineconfiguration.openshift.io/v1
      Kind:              MachineConfig
      Name:               99-worker-ssh
  Degraded Machine Count:     0
  Machine Count:              3
  Observed Generation:        4
  Ready Machine Count:        3
  Unavailable Machine Count:  0
  Updated Machine Count:      3
...
```

NOTE

The **Observed Generation** parameter shows an increased count based on the generation of the controller-produced configuration. This controller updates this value even if it fails to process the specification and generate a revision. The **Configuration Source** value points to the **51-worker-rh-registry-trust** configuration.

3. Confirm that the **policy.json** file exists with the following command:

```
$ oc debug node/<node> -- chroot /host cat /etc/containers/policy.json
```

Example output

```
Starting pod/<node>-debug ...
To use host binaries, run `chroot /host`
{
  "default": [
    {
      "type": "insecureAcceptAnything"
    }
  ],
  "transports": {
    "docker": {
      "registry.access.redhat.com": [
        {
          "type": "signedBy",
          "keyType": "GPGKeys",
          "keyPath": "/etc/pki/rpm-gpg/RPM-GPG-KEY-redhat-release"
        }
      ],
      "registry.redhat.io": [
        {
          "type": "signedBy",
          "keyType": "GPGKeys",
          "keyPath": "/etc/pki/rpm-gpg/RPM-GPG-KEY-redhat-release"
        }
      ]
    },
    "docker-daemon": {
      "": [
        {
          "type": "insecureAcceptAnything"
        }
      ]
    }
  }
}
```

4. Confirm that the **registry.redhat.io.yaml** file exists with the following command:

```
$ oc debug node/<node> -- chroot /host cat
/etc/containers/registries.d/registry.redhat.io.yaml
```

Example output

```
Starting pod/<node>-debug ...
To use host binaries, run `chroot /host`
docker:
     registry.redhat.io:
         sigstore: https://registry.redhat.io/containers/sigstore
```

5. Confirm that the **registry.access.redhat.com.yaml** file exists with the following command:

```
$ oc debug node/<node> -- chroot /host cat
/etc/containers/registries.d/registry.access.redhat.com.yaml
```

Example output

```
Starting pod/<node>-debug ...
To use host binaries, run `chroot /host`
docker:
     registry.access.redhat.com:
         sigstore: https://access.redhat.com/webassets/docker/content/sigstore
```

2.4.3. Additional resources

- Machine Config Overview

2.5. UNDERSTANDING COMPLIANCE

For many OpenShift Container Platform customers, regulatory readiness, or compliance, on some level is required before any systems can be put into production. That regulatory readiness can be imposed by national standards, industry standards or the organization’s corporate governance framework.

2.5.1. Understanding compliance and risk management

FIPS compliance is one of the most critical components required in highly secure environments, to ensure that only supported cryptographic technologies are allowed on nodes.

IMPORTANT

The use of FIPS Validated / Modules in Process cryptographic libraries is only supported on OpenShift Container Platform deployments on the **x86_64** architecture.

To understand Red Hat’s view of OpenShift Container Platform compliance frameworks, refer to the Risk Management and Regulatory Readiness chapter of the OpenShift Security Guide Book .

Additional resources

- Installing a cluster in FIPS mode

2.6. SECURING CONTAINER CONTENT

To ensure the security of the content inside your containers you need to start with trusted base images, such as Red Hat Universal Base Images, and add trusted software. To check the ongoing security of your container images, there are both Red Hat and third-party tools for scanning images.

2.6.1. Securing 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, what versions are used, 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 operating system layers current?

By building your containers from Red Hat Universal Base Images (UBI) you are assured of a foundation for your container images that consists of the same RPM-packaged software that is included in Red Hat Enterprise Linux. No subscriptions are required to either use or redistribute UBI images.

To assure ongoing security of the containers themselves, security scanning features, used directly from RHEL or added to OpenShift Container Platform, can alert you when an image you are using has vulnerabilities. OpenSCAP image scanning is available in RHEL and the Container Security Operator can be added to check container images used in OpenShift Container Platform.

2.6.2. Creating redistributable images with UBI

To create containerized applications, you typically start with a trusted base image that offers the components that are usually provided by the operating system. These include the libraries, utilities, and other features the application expects to see in the operating system's file system.

Red Hat Universal Base Images (UBI) were created to encourage anyone building their own containers to start with one that is made entirely from Red Hat Enterprise Linux rpm packages and other content. These UBI images are updated regularly to keep up with security patches and free to use and redistribute with container images built to include your own software.

Search the Red Hat Ecosystem Catalog to both find and check the health of different UBI images. As someone creating secure container images, you might be interested in these two general types of UBI images:

- **UBI**: There are standard UBI images for RHEL 7 and 8 (**ubi7/ubi** and **ubi8/ubi**), as well as minimal images based on those systems (**ubi7/ubi-minimal** and **ubi8/ubi-mimimal**). All of these images are preconfigured to point to free repositories of RHEL software that you can add to the container images you build, using standard **yum** and **dnf** commands. Red Hat encourages people to use these images on other distributions, such as Fedora and Ubuntu.
- **Red Hat Software Collections**: Search the Red Hat Ecosystem Catalog for **rhscl/** to find images created to use as base images for specific types of applications. For example, there are Apache httpd (**rhscl/httpd-***), Python (**rhscl/python-***), Ruby (**rhscl/ruby-***), Node.js

(**rhscl/nodejs-***) and Perl (**rhscl/perl-***) rhscl images.

Keep in mind that while UBI images are freely available and redistributable, Red Hat support for these images is only available through Red Hat product subscriptions.

See Using Red Hat Universal Base Images in the Red Hat Enterprise Linux documentation for information on how to use and build on standard, minimal and init UBI images.

2.6.3. Security scanning in RHEL

For Red Hat Enterprise Linux (RHEL) systems, OpenSCAP scanning is available from the **openscap-utils** package. In RHEL, you can use the **openscap-podman** command to scan images for vulnerabilities. See Scanning containers and container images for vulnerabilities in the Red Hat Enterprise Linux documentation.

OpenShift Container Platform enables you to leverage RHEL 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 to provide metadata on those libraries such as known vulnerabilities.

2.6.3.1. Scanning OpenShift images

For the container images that are running in OpenShift Container Platform and are pulled from Red Hat Quay registries, you can use an Operator to list the vulnerabilities of those images. The Container Security Operator can be added to OpenShift Container Platform to provide vulnerability reporting for images added to selected namespaces.

Container image scanning for Red Hat Quay is performed by the Clair security scanner. In Red Hat Quay, Clair can search for and report vulnerabilities in images built from RHEL, CentOS, Oracle, Alpine, Debian, and Ubuntu operating system software.

2.6.4. Integrating external scanning

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

2.6.4.1. 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 2.1. Annotation key format

Component	Description	Acceptable values

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

2.6.4.1.1. 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 2.2. 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 or more details. Required so user may validate the data.	String
scannerVersion	No	Scanner version	String
compliant	No	Compliance pass or fail	Boolean
summary	No	Summary of issues found	List (see table below)

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

Table 2.3. 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 or more details. Optional.	String

2.6.4.1.2. 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 the Container images section of the Red Hat Ecosystem Catalog annotation for an image with health index data with an external URL for additional details:

Red Hat Ecosystem Catalog annotation

```
{
  "name": "Red Hat Ecosystem 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 }
  ]
}
```

2.6.4.2. 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.

2.6.4.2.1. Example annotate CLI command

Replace **<image>** with an image digest, for example **sha256:401e359e0f45bfdcf004e258b72e253fd07fba8cc5c6f2ed4f4608fb119ecc2**:

```
$ oc annotate image <image> \
    quality.images.openshift.io/vulnerability.redhatcatalog='{ \
    "name": "Red Hat Ecosystem Catalog", \
    "description": "Container health index", \
    "timestamp": "2020-06-01T05:04:46Z", \
    "compliant": null, \
    "scannerVersion": "1.2", \
    "reference": "https://access.redhat.com/errata/RHBA-2020:2347", \
    "summary": "[ \
      { "label": "Health index", "data": "B", "severityIndex": 1, "reference": null } ]" }'
```

2.6.4.3. Controlling pod execution

Use the **images.openshift.io/deny-execution** image policy to programmatically control if an image can be run.

2.6.4.3.1. Example annotation

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

2.6.4.4. Integration reference

In most cases, external tools such as vulnerability scanners 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 4.9 REST APIs to write the annotation. See OpenShift Container Platform REST APIs for general information on the REST APIs.

2.6.4.4.1. 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 Ecosystem Catalog', 'description': 'Container health index', 'timestamp': '2020-06-01T05:04:46Z', 'compliant': null, 'reference': 'https://access.redhat.com/errata/RHBA-2020:2347', 'summary': [{'label': 'Health index', 'data': '4', 'severityIndex': 1, 'reference': null}] }"
    }
  }
}
```

Additional resources

- Image stream objects

2.7. USING CONTAINER REGISTRIES SECURELY

Container registries store container images to:

- Make images accessible to others
- Organize images into repositories that can include multiple versions of an image
- Optionally limit access to images, based on different authentication methods, or make them publicly available

There are public container registries, such as Quay.io and Docker Hub where many people and organizations share their images. The Red Hat Registry offers supported Red Hat and partner images, while the Red Hat Ecosystem Catalog offers detailed descriptions and health checks for those images. To manage your own registry, you could purchase a container registry such as Red Hat Quay.

From a security standpoint, some registries provide special features to check and improve the health of your containers. For example, Red Hat Quay offers container vulnerability scanning with Clair security scanner, build triggers to automatically rebuild images when source code changes in GitHub and other locations, and the ability to use role-based access control (RBAC) to secure access to images.

2.7.1. Knowing where 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.

2.7.2. 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. From an operational standpoint, you rebuild and redeploy an updated container image to replace a container instead of changing it.

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. Alternatively, you can go to the Red Hat Ecosystem Catalog to look up that and other security-related issues for each Red Hat image.

2.7.3. Getting containers from Red Hat Registry and Ecosystem Catalog

Red Hat lists certified container images for Red Hat products and partner offerings from the Container Images section of the Red Hat Ecosystem Catalog. From that catalog, you can see details of each image, including CVE, software packages listings, and health scores.

Red Hat images are actually stored in what is referred to as the *Red Hat Registry*, which is represented by a public container registry (**registry.access.redhat.com**) and an authenticated registry (**registry.redhat.io**). Both include basically the same set of container images, with **registry.redhat.io** including some additional images that require authentication with Red Hat subscription credentials.

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** to reflect the security risk for each container provided through the Red Hat Ecosystem Catalog. Because containers consume software provided by Red Hat and the errata process, old, stale containers are insecure whereas new, fresh containers are more secure.

To illustrate the age of containers, the Red Hat Ecosystem 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 Ecosystem Catalog for more details on this grading system.

See the Red Hat Product Security Center for details on security updates and vulnerabilities related to Red Hat software. Check out Red Hat Security Advisories to search for specific advisories and CVEs.

2.7.4. OpenShift Container Registry

OpenShift Container Platform includes the *OpenShift Container Registry*, a private registry running as an integrated component of 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 that you might already be using, such as Red Hat Quay.

Additional resources

- Integrated OpenShift Container Platform registry

2.7.5. Storing containers using Red Hat Quay

Red Hat Quay is an enterprise-quality container registry product from Red Hat. Development for Red Hat Quay is done through the upstream Project Quay. Red Hat Quay is available to deploy on-premise or through the hosted version of Red Hat Quay at Quay.io.

Security-related features of Red Hat Quay include:

- **Time machine**: Allows images with older tags to expire after a set period of time or based on a user-selected expiration time.
- **Repository mirroring**: Lets you mirror other registries for security reasons, such hosting a public repository on Red Hat Quay behind a company firewall, or for performance reasons, to keep registries closer to where they are used.
- **Action log storage**: Save Red Hat Quay logging output to Elasticsearch storage to allow for later search and analysis.
- **Clair security scanning**: Scan images against a variety of Linux vulnerability databases, based on the origins of each container image.
- **Internal authentication**: Use the default local database to handle RBAC authentication to Red Hat Quay or choose from LDAP, Keystone (OpenStack), JWT Custom Authentication, or External Application Token authentication.
- **External authorization (OAuth)**: Allow authorization to Red Hat Quay from GitHub, GitHub Enterprise, or Google Authentication.
- **Access settings**: Generate tokens to allow access to Red Hat Quay from docker, rkt, anonymous access, user-created accounts, encrypted client passwords, or prefix username autocompletion.

Ongoing integration of Red Hat Quay with OpenShift Container Platform continues, with several OpenShift Container Platform Operators of particular interest. The Quay Bridge Operator lets you replace the internal OpenShift Container Platform registry with Red Hat Quay. The Quay Container Security Operator lets you check vulnerabilities of images running in OpenShift Container Platform that were pulled from Red Hat Quay registries.

2.8. SECURING THE BUILD PROCESS

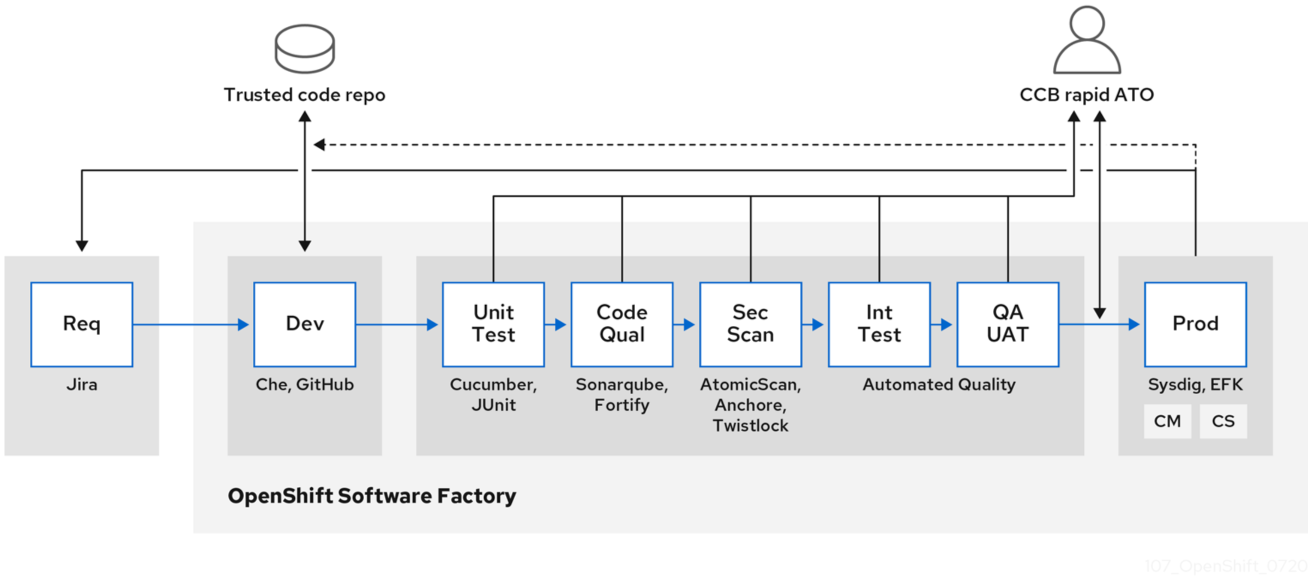
In a container environment, the software build process is the stage in the life cycle where application code is integrated with the required runtime libraries. Managing this build process is key to securing the software stack.

2.8.1. Building once, deploying everywhere

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.

As your software moves through the stages of building, testing, and production, it is important that the tools making up your software supply chain be trusted. The following figure illustrates the process and tools that could be incorporated into a trusted software supply chain for containerized software:



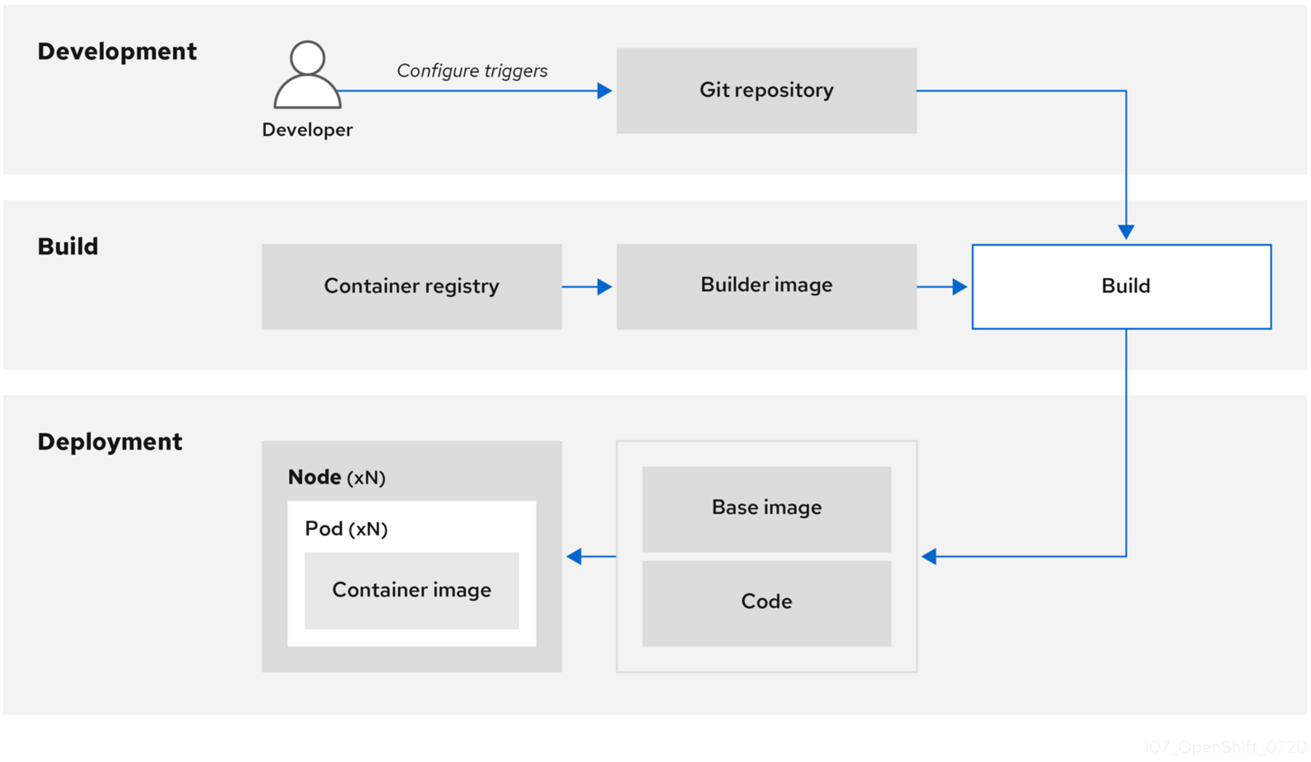
OpenShift Container Platform can be integrated with trusted code repositories (such as GitHub) and development platforms (such as Che) for creating and managing secure code. Unit testing could rely on Cucumber and JUnit. You could inspect your containers for vulnerabilities and compliance issues with Anchore or Twistlock, and use image scanning tools such as AtomicScan or Clair. Tools such as Sysdig could provide ongoing monitoring of your containerized applications.

2.8.2. Managing builds

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. With Red Hat S2I images available as Universal Base Image (UBI) images, you can now freely redistribute your software with base images built from real RHEL RPM packages. Red Hat has removed subscription restrictions to allow this.

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

- Trigger, either by using 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 a CI process.



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

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

2.8.3. 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. To download modules from that private mirror, you must 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** object:

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** object:

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

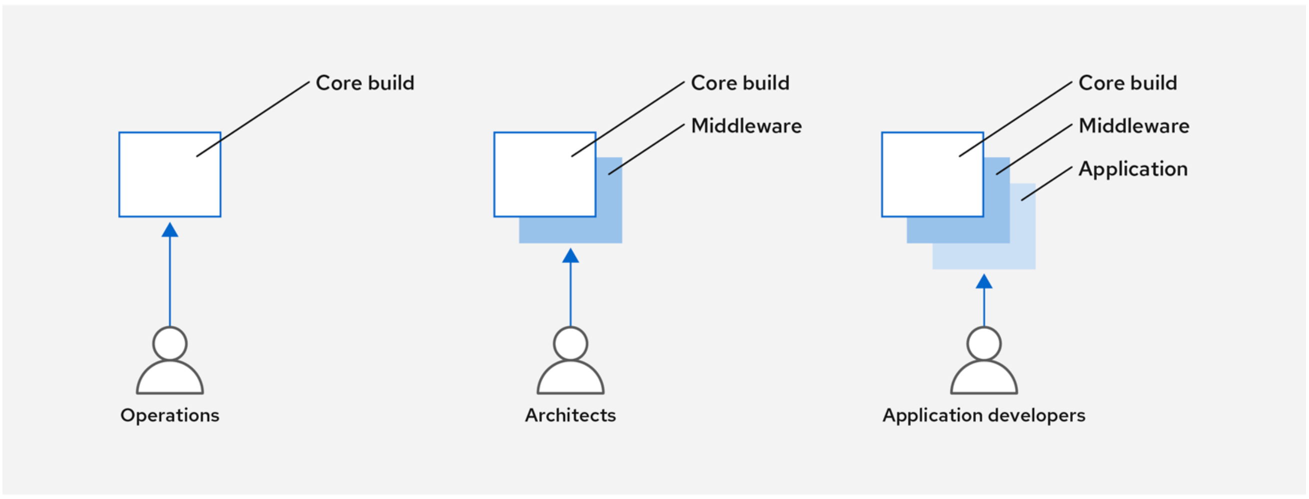
```
      - destinationDir: .
        secret:
          name: secret-npmrc
```

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

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

2.8.4. 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 focus on writing 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.

Using GitOps methodology, you can use the same CI/CD mechanisms to manage not only your application configurations, but also your OpenShift Container Platform infrastructure.

2.8.5. Building Knative serverless applications

Relying on Kubernetes and Kourier, you can build, deploy and manage serverless applications using Knative in OpenShift Container Platform. As with other builds, you can use S2I images to build your containers, then serve them using Knative services. View Knative application builds through the **Topology** view of the OpenShift Container Platform web console.

2.8.6. Additional resources

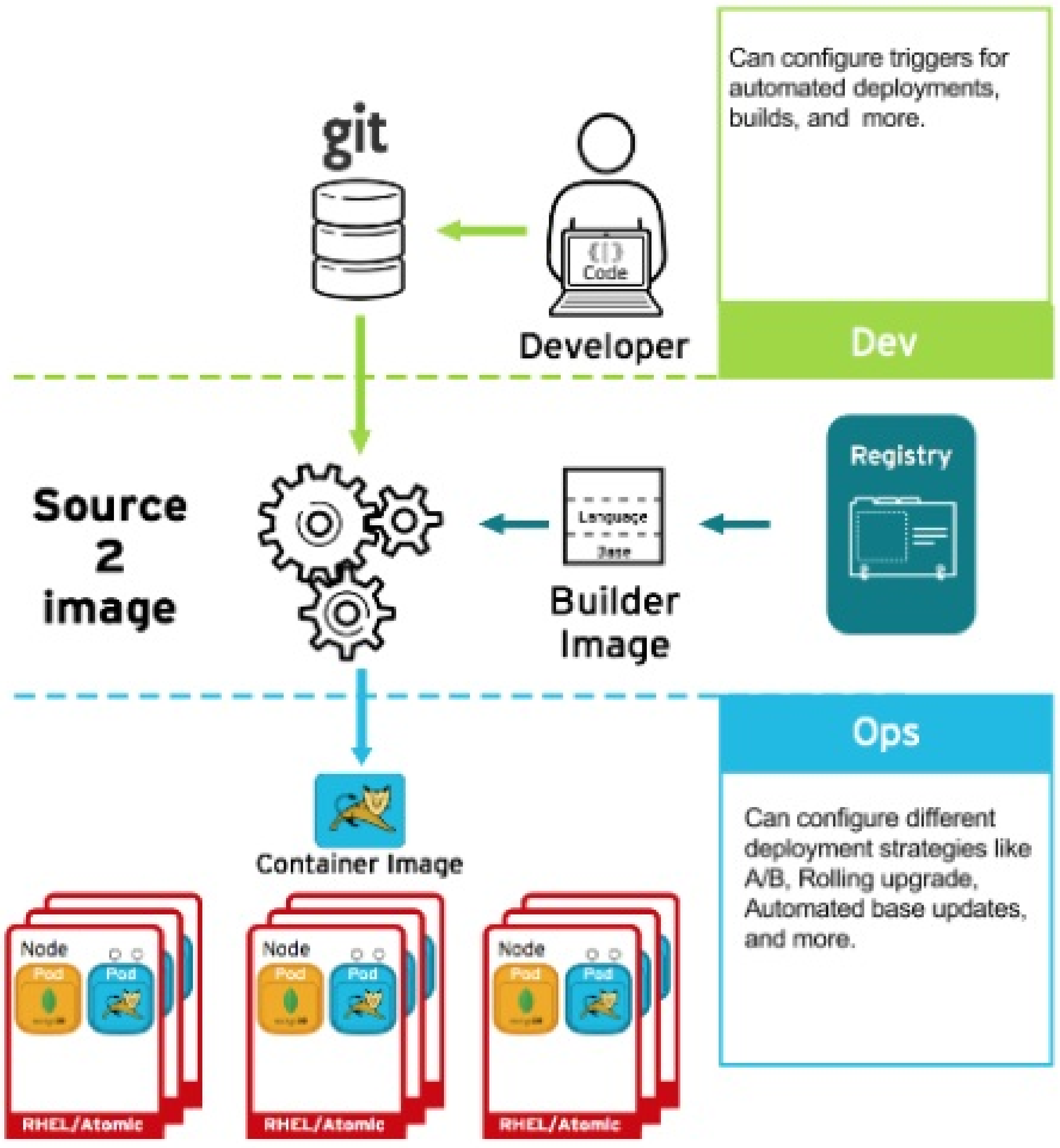
- Understanding image builds
- Triggering and modifying builds
- Creating build inputs
- Input secrets and config maps
- Understanding Knative Serving
- Viewing application composition using the Topology view

2.9. DEPLOYING CONTAINERS

You can use a variety of techniques to make sure that the containers you deploy hold the latest production-quality content and that they have not been tampered with. These techniques include setting up build triggers to incorporate the latest code and using signatures to ensure that the container comes from a trusted source and has not been modified.

2.9.1. Controlling container deployments with triggers

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 to remediate. You can use triggers to rebuild and replace images, ensuring the immutable containers process, instead of patching running containers, which is not recommended.


Can configure triggers for automated deployments, builds, and more.
git
Code
Developer
Dev
Source 2 image
Language
Base
Builder Image
Registry
Ops
Can configure different deployment strategies like A/B, Rolling upgrade, Automated base updates, and more.
Container Image
Node
Pod
Pod
RHEL/Atomic

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 your 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.

You can use the **oc set triggers** command to set a deployment trigger. For example, to set a trigger for a deployment called deployment-example:

```
$ oc set triggers deploy/deployment-example \
    --from-image=example:latest \
    --containers=web
```

2.9.2. Controlling what image sources can be deployed

It is important that the intended images are actually being deployed, that the images including the contained content 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, such as accept, reject, or require public key(s)

You can use these policy parameters to allow, deny, or require a trust relationship for entire registries, parts of registries, or individual images. Using trusted public keys, you can ensure that 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": "reject"}]
        }
    }
}
```

The policy can be saved onto a node as **/etc/containers/policy.json**. Saving this file to a node is best accomplished using a new **MachineConfig** object. This example enforces the following rules:

- Require images from the Red Hat Registry (**registry.access.redhat.com**) to be signed by the Red Hat public key.
- Require images from your OpenShift Container Registry in the **openshift** namespace to be signed by the Red Hat public key.

- Require images from your OpenShift Container Registry in the **production** namespace to be signed by the public key for **example.com**.
- Reject all other registries not specified by the global **default** definition.

2.9.3. Using 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 your OpenShift Container Registry. Because the docker/distribution **extensions** 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.

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 the Machine Config Operator 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.

2.9.4. Creating secrets and config maps

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 so that it can access a private image repository, do the following:

Procedure

1. Log in to the OpenShift Container Platform web console.
2. Create a new project.

3. 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.

4. When creating a deployment configuration (for example, from the **Add to Project** → **Deploy Image** page), set the **Pull Secret** to your new secret.

Config maps 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.

2.9.5. Automating continuous deployment

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.

Additional resources

- Input secrets and config maps

2.10. SECURING THE CONTAINER PLATFORM

OpenShift Container Platform and Kubernetes 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.

Security-related features in OpenShift Container Platform that are based on Kubernetes include:

- Multitenancy, which combines Role-Based Access Controls and network policies to isolate containers at multiple levels.

- Admission plug-ins, which form boundaries between an API and those making requests to the API.

OpenShift Container Platform uses Operators to automate and simplify the management of Kubernetes-level security features.

2.10.1. Isolating containers with multitenancy

Multitenancy allows applications on an OpenShift Container Platform cluster that are owned by multiple users, and run across multiple hosts and namespaces, to remain isolated from each other and from outside attacks. You obtain multitenancy by applying role-based access control (RBAC) to Kubernetes namespaces.

In Kubernetes, *namespaces* are areas where applications can run in ways that are separate from other applications. OpenShift Container Platform uses and extends namespaces by adding extra annotations, including MCS labeling in SELinux, and identifying these extended namespaces as *projects*. Within the scope of a project, users can maintain their own cluster resources, including service accounts, policies, constraints, and various other objects.

RBAC objects are assigned to projects to authorize selected users to have access to those projects. That authorization takes the form of rules, roles, and bindings:

- Rules define what a user can create or access in a project.
- Roles are collections of rules that you can bind to selected users or groups.
- Bindings define the association between users or groups and roles.

Local RBAC roles and bindings attach a user or group to a particular project. Cluster RBAC can attach cluster-wide roles and bindings to all projects in a cluster. There are default cluster roles that can be assigned to provide **admin**, **basic-user**, **cluster-admin**, and **cluster-status** access.

2.10.2. Protecting control plane with admission plug-ins

While RBAC controls access rules between users and groups and available projects, *admission plug-ins* define access to the OpenShift Container Platform master API. Admission plug-ins form a chain of rules that consist of:

- Default admissions plug-ins: These implement a default set of policies and resources limits that are applied to components of the OpenShift Container Platform control plane.
- Mutating admission plug-ins: These plug-ins dynamically extend the admission chain. They call out to a webhook server and can both authenticate a request and modify the selected resource.
- Validating admission plug-ins: These validate requests for a selected resource and can both validate the request and ensure that the resource does not change again.

API requests go through admissions plug-ins in a chain, with any failure along the way causing the request to be rejected. Each admission plug-in is associated with particular resources and only responds to requests for those resources.

2.10.2.1. Security context constraints (SCCs)

You can use *security context constraints* (SCCs) to define a set of conditions that a pod must run with 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, if required.

2.10.2.2. Granting roles to service accounts

You can assign roles to service accounts, in the same way that users are assigned role-based access. There are three default service accounts created for each project. A service account:

- is limited in scope to a particular project
- derives its name from its project
- is automatically assigned an API token and credentials to access the OpenShift Container Registry

Service accounts associated with platform components automatically have their keys rotated.

2.10.3. Authentication and authorization

2.10.3.1. 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 identity provider is used by default for new OpenShift Container Platform deployments, but you can configure this at initial installation time or post-installation.

2.10.3.2. 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 endpoints, 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 in the 3scale documentation.

2.10.3.3. Red Hat Single Sign-On

The Red Hat Single Sign-On server enables you to secure your applications by providing web single sign-on 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 Single Sign-On with LDAP-based directory services including Microsoft Active Directory and Red Hat Enterprise Linux Identity Management.

2.10.3.4. 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 multitenant 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
- The etcd service is not exposed directly to the cluster

2.10.4. 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 installer configures these certificates during installation. There are some primary components that generate this traffic:

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

2.10.4.1. Configuring custom certificates

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

Additional resources

- Introduction to OpenShift Container Platform
- Using RBAC to define and apply permissions
- About admission plug-ins
- Managing security context constraints
- SCC reference commands
- Examples of granting roles to service accounts
- Configuring the internal OAuth server
- Understanding identity provider configuration
- Certificate types and descriptions
- Proxy certificates

2.11. SECURING NETWORKS

Network security can be managed at several levels. At the pod level, network namespaces can prevent containers from seeing other pods or the host system by restricting network access. Network policies give you control over allowing and rejecting connections. You can manage ingress and egress traffic to and from your containerized applications.

2.11.1. Using network namespaces

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

Network policy mode, by default, makes all pods in a project accessible from other pods and network endpoints. To isolate one or more pods in a project, you can create **NetworkPolicy** objects in that project to indicate the allowed incoming connections. Using multitenant mode, you can provide project-level isolation for pods and services.

2.11.2. Isolating pods with network policies

Using *network policies*, you can isolate pods from each other in the same project. Network policies can deny all network access to a pod, only allow connections for the ingress controller, reject connections from pods in other projects, or set similar rules for how networks behave.

Additional resources

- About network policy

2.11.3. Using multiple pod networks

Each running container has only one network interface by default. The Multus CNI plug-in lets you create multiple CNI networks, and then attach any of those networks to your pods. In that way, you can do things like separate private data onto a more restricted network and have multiple network interfaces on each node.

Additional resources

- Using multiple networks

2.11.4. Isolating applications

OpenShift Container Platform enables you to segment network traffic on a single cluster to make multitenant clusters that isolate users, teams, applications, and environments from non-global resources.

Additional resources

- Configuring network isolation using OpenShiftSDN

2.11.5. Securing ingress traffic

There are many security implications related to how you configure access to your Kubernetes services from outside of your OpenShift Container Platform cluster. Besides exposing HTTP and HTTPS routes, ingress routing allows you to set up NodePort or LoadBalancer ingress types. NodePort exposes an application’s service API object from each cluster worker. LoadBalancer lets you assign an external load balancer to an associated service API object in your OpenShift Container Platform cluster.

Additional resources

- Configuring ingress cluster traffic

2.11.6. Securing egress traffic

OpenShift Container Platform 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. A cluster administrator can assign one or more egress IP addresses to a project in an OpenShift Container Platform SDN network provider. Likewise, a cluster administrator can prevent egress traffic from going outside of an OpenShift Container Platform cluster using an egress firewall.

By assigning a fixed egress IP address, you can have all outgoing traffic assigned to that IP address for a particular project. With the egress firewall, you can prevent a pod from connecting to an external network, prevent a pod from connecting to an internal network, or limit a pod’s access to specific internal subnets.

Additional resources

- Configuring an egress firewall to control access to external IP addresses
- Configuring egress IPs for a project

2.12. SECURING ATTACHED STORAGE

OpenShift Container Platform supports multiple types of storage, both for on-premise and cloud providers. In particular, OpenShift Container Platform can use storage types that support the Container Storage Interface.

2.12.1. Persistent volume plug-ins

Containers are useful for both stateless and stateful applications. Protecting attached storage is a key element of securing stateful services. Using the Container Storage Interface (CSI), OpenShift Container Platform can incorporate storage from any storage back end that supports the CSI interface.

OpenShift Container Platform provides plug-ins for multiple types of storage, including:

- Red Hat OpenShift Container Storage *
- AWS Elastic Block Stores (EBS) *
- AWS Elastic File System (EFS) *
- Azure Disk *
- Azure File *
- OpenStack Cinder *
- GCE Persistent Disks *
- VMware vSphere *
- Network File System (NFS)
- FlexVolume
- Fibre Channel

- iSCSI

Plug-ins for those storage types with dynamic provisioning are marked with an asterisk (*). Data in transit is encrypted via HTTPS for all OpenShift Container Platform components communicating with each other.

You can mount a persistent volume (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**.

2.12.2. Shared storage

For shared storage providers like NFS, 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.

2.12.3. 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.

Additional resources

- Understanding persistent storage
- Configuring CSI volumes
- Dynamic provisioning
- Persistent storage using NFS
- Persistent storage using AWS Elastic Block Store
- Persistent storage using GCE Persistent Disk

2.13. MONITORING CLUSTER EVENTS AND LOGS

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 logging.

2.13.1. Watching cluster events

Cluster administrators are encouraged to familiarize themselves with the **Event** resource type and review the list of system events to determine which events are of interest. 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
```

Example output

```
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")'
```

Example output

```
{
  "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'
```

Example output

```
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.

2.13.2. Logging

Using the **oc log** command, you can view container logs, build configs and deployments in real time. Different can users have access different access to logs:

- Users who have access to a project are able to see the logs for that project by default.
- Users with admin roles can access all container logs.

To save your logs for further audit and analysis, you can enable the **cluster-logging** add-on feature to collect, manage, and view system, container, and audit logs. You can deploy, manage, and upgrade OpenShift Logging through the OpenShift Elasticsearch Operator and Red Hat OpenShift Logging Operator.

2.13.3. Audit logs

With *audit logs*, you can follow a sequence of activities associated with how a user, administrator, or other OpenShift Container Platform component is behaving. API audit logging is done on each server.

Additional resources

- List of system events
- Understanding OpenShift Logging
- Viewing audit logs

CHAPTER 3. CONFIGURING CERTIFICATES

3.1. REPLACING THE DEFAULT INGRESS CERTIFICATE

3.1.1. Understanding the default ingress certificate

By default, OpenShift Container Platform uses the Ingress Operator to create an internal CA and issue a wildcard certificate that is valid for applications under the **.apps** sub-domain. Both the web console and CLI use this certificate as well.

The internal infrastructure CA certificates are self-signed. While this process might be perceived as bad practice by some security or PKI teams, any risk here is minimal. The only clients that implicitly trust these certificates are other components within the cluster. Replacing the default wildcard certificate with one that is issued by a public CA already included in the CA bundle as provided by the container userspace allows external clients to connect securely to applications running under the **.apps** sub-domain.

3.1.2. Replacing the default ingress certificate

You can replace the default ingress certificate for all applications under the **.apps** subdomain. After you replace the certificate, all applications, including the web console and CLI, will have encryption provided by specified certificate.

Prerequisites

- You must have a wildcard certificate for the fully qualified **.apps** subdomain and its corresponding private key. Each should be in a separate PEM format file.
- The private key must be unencrypted. If your key is encrypted, decrypt it before importing it into OpenShift Container Platform.
- The certificate must include the **subjectAltName** extension showing ***.apps.<clustername>.<domain>**.
- The certificate file can contain one or more certificates in a chain. The wildcard certificate must be the first certificate in the file. It can then be followed with any intermediate certificates, and the file should end with the root CA certificate.
- Copy the root CA certificate into an additional PEM format file.

Procedure

1. Create a config map that includes only the root CA certificate used to sign the wildcard certificate:

```
$ oc create configmap custom-ca \
    --from-file=ca-bundle.crt=</path/to/example-ca.crt> \ 1
    -n openshift-config
```

1 **</path/to/example-ca.crt>** is the path to the root CA certificate file on your local file system.

2. Update the cluster-wide proxy configuration with the newly created config map:

```
$ oc patch proxy/cluster \
    --type=merge \
    --patch='{"spec":{"trustedCA":{"name":"custom-ca"}}}'
```

3. Create a secret that contains the wildcard certificate chain and key:

```
$ oc create secret tls <secret> \ 1
    --cert=</path/to/cert.crt> \ 2
    --key=</path/to/cert.key> \ 3
    -n openshift-ingress
```

1 **<secret>** is the name of the secret that will contain the certificate chain and private key.

2 **</path/to/cert.crt>** is the path to the certificate chain on your local file system.

3 **</path/to/cert.key>** is the path to the private key associated with this certificate.

4. Update the Ingress Controller configuration with the newly created secret:

```
$ oc patch ingresscontroller.operator default \
    --type=merge -p \
    '{"spec":{"defaultCertificate": {"name": "<secret>"}}}' \ 1
    -n openshift-ingress-operator
```

1 Replace **<secret>** with the name used for the secret in the previous step.

3.2. ADDING API SERVER CERTIFICATES

The default API server certificate is issued by an internal OpenShift Container Platform cluster CA. Clients outside of the cluster will not be able to verify the API server's certificate by default. This certificate can be replaced by one that is issued by a CA that clients trust.

3.2.1. Add an API server named certificate

The default API server certificate is issued by an internal OpenShift Container Platform cluster CA. You can add one or more alternative certificates that the API server will return based on the fully qualified domain name (FQDN) requested by the client, for example when a reverse proxy or load balancer is used.

Prerequisites

- You must have a certificate for the FQDN and its corresponding private key. Each should be in a separate PEM format file.
- The private key must be unencrypted. If your key is encrypted, decrypt it before importing it into OpenShift Container Platform.
- The certificate must include the **subjectAltName** extension showing the FQDN.
- The certificate file can contain one or more certificates in a chain. The certificate for the API server FQDN must be the first certificate in the file. It can then be followed with any intermediate certificates, and the file should end with the root CA certificate.

> **WARNING**
>
> Do not provide a named certificate for the internal load balancer (host name **api-int.<cluster_name>.<base_domain>**). Doing so will leave your cluster in a degraded state.

Procedure

1. Create a secret that contains the certificate chain and private key in the **openshift-config** namespace.

```
$ oc create secret tls <secret> \ (1)
     --cert=</path/to/cert.crt> \ (2)
     --key=</path/to/cert.key> \ (3)
     -n openshift-config
```

(1) **<secret>** is the name of the secret that will contain the certificate chain and private key.

(2) **</path/to/cert.crt>** is the path to the certificate chain on your local file system.

(3) **</path/to/cert.key>** is the path to the private key associated with this certificate.

2. Update the API server to reference the created secret.

```
$ oc patch apiserver cluster \
     --type=merge -p \
     '{"spec":{"servingCerts": {"namedCertificates":
     [{"names": ["<FQDN>"], (1)
     "servingCertificate": {"name": "<secret>"}}]}}}' (2)
```

(1) Replace **<FQDN>** with the FQDN that the API server should provide the certificate for.

(2) Replace **<secret>** with the name used for the secret in the previous step.

3. Examine the **apiserver/cluster** object and confirm the secret is now referenced.

```
$ oc get apiserver cluster -o yaml
```

Example output

```
...
spec:
  servingCerts:
    namedCertificates:
    - names:
      - <FQDN>
      servingCertificate:
        name: <secret>
...
```

4. Check the **kube-apiserver** operator, and verify that a new revision of the Kubernetes API server rolls out. It may take a minute for the operator to detect the configuration change and trigger a new deployment. While the new revision is rolling out, **PROGRESSING** will report **True**.

   ```
   $ oc get clusteroperators kube-apiserver
   ```

   Do not continue to the next step until **PROGRESSING** is listed as **False**, as shown in the following output:

   Example output

   ```
   NAME           VERSION   AVAILABLE   PROGRESSING   DEGRADED   SINCE
   kube-apiserver   4.9.0     True        False         False      145m
   ```

   If **PROGRESSING** is showing **True**, wait a few minutes and try again.

3.3. SECURING SERVICE TRAFFIC USING SERVICE SERVING CERTIFICATE SECRETS

3.3.1. Understanding service serving certificates

Service serving certificates are intended to support complex middleware applications that require encryption. These certificates are issued as TLS web server certificates.

The **service-ca** controller uses the **x509.SHA256WithRSA** signature algorithm to generate service certificates.

The generated certificate and key are in PEM format, stored in **tls.crt** and **tls.key** respectively, within a created secret. The certificate and key are automatically replaced when they get close to expiration.

The service CA certificate, which issues the service certificates, is valid for 26 months and is automatically rotated when there is less than 13 months validity left. After rotation, the previous service CA configuration is still trusted until its expiration. This allows a grace period for all affected services to refresh their key material before the expiration. If you do not upgrade your cluster during this grace period, which restarts services and refreshes their key material, you might need to manually restart services to avoid failures after the previous service CA expires.

NOTE

You can use the following command to manually restart all pods in the cluster. Be aware that running this command causes a service interruption, because it deletes every running pod in every namespace. These pods will automatically restart after they are deleted.

```
$ for I in $(oc get ns -o jsonpath='{range .items[*]} {.metadata.name}{"\n"} {end}'); \
    do oc delete pods --all -n $I; \
    sleep 1; \
    done
```

3.3.2. Add a service certificate

To secure communication to your service, generate a signed serving certificate and key pair into a secret in the same namespace as the service.

The generated certificate is only valid for the internal service DNS name **<service.name>.<service.namespace>.svc**, and is only valid for internal communications. If your service is a headless service (no **clusterIP** value set), the generated certificate also contains a wildcard subject in the format of ***.<service.name>.<service.namespace>.svc**.

IMPORTANT

Because the generated certificates contain wildcard subjects for headless services, you must not use the service CA if your client must differentiate between individual pods. In this case:

- Generate individual TLS certificates by using a different CA.
- Do not accept the service CA as a trusted CA for connections that are directed to individual pods and must not be impersonated by other pods. These connections must be configured to trust the CA that was used to generate the individual TLS certificates.

Prerequisites:

- You must have a service defined.

Procedure

1. Annotate the service with **service.beta.openshift.io/serving-cert-secret-name**:

```
$ oc annotate service <service_name> \ 1
    service.beta.openshift.io/serving-cert-secret-name=<secret_name> 2
```

1 Replace **<service_name>** with the name of the service to secure.

2 **<secret_name>** will be the name of the generated secret containing the certificate and key pair. For convenience, it is recommended that this be the same as **<service_name>**.

For example, use the following command to annotate the service **test1**:

```
$ oc annotate service test1 service.beta.openshift.io/serving-cert-secret-name=test1
```

2. Examine the service to confirm that the annotations are present:

```
$ oc describe service <service_name>
```

Example output

```
...
Annotations:              service.beta.openshift.io/serving-cert-secret-name: <service_name>
                     service.beta.openshift.io/serving-cert-signed-by: openshift-service-serving-
```

```
signer@1556850837
...
```

3. After the cluster generates a secret for your service, your **Pod** spec can mount it, and the pod will run after it becomes available.

Additional Resources

- You can use a service certificate to configure a secure route using reencrypt TLS termination. For more information, see Creating a re-encrypt route with a custom certificate .

3.3.3. Add the service CA bundle to a config map

A Pod can access the service CA certificate by mounting a **ConfigMap** object that is annotated with **service.beta.openshift.io/inject-cabundle=true**. Once annotated, the cluster automatically injects the service CA certificate into the **service-ca.crt** key on the config map. Access to this CA certificate allows TLS clients to verify connections to services using service serving certificates.

IMPORTANT

After adding this annotation to a config map all existing data in it is deleted. It is recommended to use a separate config map to contain the **service-ca.crt**, instead of using the same config map that stores your pod configuration.

Procedure

1. Annotate the config map with **service.beta.openshift.io/inject-cabundle=true**:

```
$ oc annotate configmap <config_map_name> \ 1
    service.beta.openshift.io/inject-cabundle=true
```

1 Replace **<config_map_name>** with the name of the config map to annotate.

NOTE

Explicitly referencing the **service-ca.crt** key in a volume mount will prevent a pod from starting until the config map has been injected with the CA bundle. This behavior can be overridden by setting the **optional** field to **true** for the volume's serving certificate configuration.

For example, use the following command to annotate the config map **test1**:

```
$ oc annotate configmap test1 service.beta.openshift.io/inject-cabundle=true
```

2. View the config map to ensure that the service CA bundle has been injected:

```
$ oc get configmap <config_map_name> -o yaml
```

The CA bundle is displayed as the value of the **service-ca.crt** key in the YAML output:

```
apiVersion: v1
```

```
data:
  service-ca.crt: |
    -----BEGIN CERTIFICATE-----
...
```

3.3.4. Add the service CA bundle to an API service

You can annotate an **APIService** object with **service.beta.openshift.io/inject-cabundle=true** to have its **spec.caBundle** field populated with the service CA bundle. This allows the Kubernetes API server to validate the service CA certificate used to secure the targeted endpoint.

Procedure

1. Annotate the API service with **service.beta.openshift.io/inject-cabundle=true**:

   ```
   $ oc annotate apiservice <api_service_name> \ (1)
        service.beta.openshift.io/inject-cabundle=true
   ```

   (1) Replace **<api_service_name>** with the name of the API service to annotate.

   For example, use the following command to annotate the API service **test1**:

   ```
   $ oc annotate apiservice test1 service.beta.openshift.io/inject-cabundle=true
   ```

2. View the API service to ensure that the service CA bundle has been injected:

   ```
   $ oc get apiservice <api_service_name> -o yaml
   ```

   The CA bundle is displayed in the **spec.caBundle** field in the YAML output:

   ```
   apiVersion: apiregistration.k8s.io/v1
   kind: APIService
   metadata:
     annotations:
       service.beta.openshift.io/inject-cabundle: "true"
   ...
   spec:
     caBundle: <CA_BUNDLE>
   ...
   ```

3.3.5. Add the service CA bundle to a custom resource definition

You can annotate a **CustomResourceDefinition** (CRD) object with **service.beta.openshift.io/inject-cabundle=true** to have its **spec.conversion.webhook.clientConfig.caBundle** field populated with the service CA bundle. This allows the Kubernetes API server to validate the service CA certificate used to secure the targeted endpoint.

NOTE

The service CA bundle will only be injected into the CRD if the CRD is configured to use a webhook for conversion. It is only useful to inject the service CA bundle if a CRD's webhook is secured with a service CA certificate.

Procedure

1. Annotate the CRD with **service.beta.openshift.io/inject-cabundle=true**:

```
$ oc annotate crd <crd_name> \ 1
    service.beta.openshift.io/inject-cabundle=true
```

1 Replace **<crd_name>** with the name of the CRD to annotate.

For example, use the following command to annotate the CRD **test1**:

```
$ oc annotate crd test1 service.beta.openshift.io/inject-cabundle=true
```

2. View the CRD to ensure that the service CA bundle has been injected:

```
$ oc get crd <crd_name> -o yaml
```

The CA bundle is displayed in the **spec.conversion.webhook.clientConfig.caBundle** field in the YAML output:

```
apiVersion: apiextensions.k8s.io/v1
kind: CustomResourceDefinition
metadata:
  annotations:
    service.beta.openshift.io/inject-cabundle: "true"
...
spec:
  conversion:
    strategy: Webhook
    webhook:
      clientConfig:
        caBundle: <CA_BUNDLE>
...
```

3.3.6. Add the service CA bundle to a mutating webhook configuration

You can annotate a **MutatingWebhookConfiguration** object with **service.beta.openshift.io/inject-cabundle=true** to have the **clientConfig.caBundle** field of each webhook populated with the service CA bundle. This allows the Kubernetes API server to validate the service CA certificate used to secure the targeted endpoint.

NOTE

Do not set this annotation for admission webhook configurations that need to specify different CA bundles for different webhooks. If you do, then the service CA bundle will be injected for all webhooks.

Procedure

1. Annotate the mutating webhook configuration with **service.beta.openshift.io/inject-cabundle=true**:

```
$ oc annotate mutatingwebhookconfigurations <mutating_webhook_name> \ 1
```

```
    service.beta.openshift.io/inject-cabundle=true
```

1. Replace **<mutating_webhook_name>** with the name of the mutating webhook configuration to annotate.

For example, use the following command to annotate the mutating webhook configuration **test1**:

```
$ oc annotate mutatingwebhookconfigurations test1 service.beta.openshift.io/inject-cabundle=true
```

2. View the mutating webhook configuration to ensure that the service CA bundle has been injected:

```
$ oc get mutatingwebhookconfigurations <mutating_webhook_name> -o yaml
```

The CA bundle is displayed in the **clientConfig.caBundle** field of all webhooks in the YAML output:

```
apiVersion: admissionregistration.k8s.io/v1
kind: MutatingWebhookConfiguration
metadata:
  annotations:
    service.beta.openshift.io/inject-cabundle: "true"
...
webhooks:
- myWebhook:
  - v1beta1
  clientConfig:
    caBundle: <CA_BUNDLE>
...
```

3.3.7. Add the service CA bundle to a validating webhook configuration

You can annotate a **ValidatingWebhookConfiguration** object with **service.beta.openshift.io/inject-cabundle=true** to have the **clientConfig.caBundle** field of each webhook populated with the service CA bundle. This allows the Kubernetes API server to validate the service CA certificate used to secure the targeted endpoint.

NOTE

Do not set this annotation for admission webhook configurations that need to specify different CA bundles for different webhooks. If you do, then the service CA bundle will be injected for all webhooks.

Procedure

1. Annotate the validating webhook configuration with **service.beta.openshift.io/inject-cabundle=true**:

```
$ oc annotate validatingwebhookconfigurations <validating_webhook_name> \ (1)
    service.beta.openshift.io/inject-cabundle=true
```

1 Replace **<validating_webhook_name>** with the name of the validating webhook configuration to annotate.

For example, use the following command to annotate the validating webhook configuration **test1**:

```
$ oc annotate validatingwebhookconfigurations test1 service.beta.openshift.io/inject-cabundle=true
```

2. View the validating webhook configuration to ensure that the service CA bundle has been injected:

```
$ oc get validatingwebhookconfigurations <validating_webhook_name> -o yaml
```

The CA bundle is displayed in the **clientConfig.caBundle** field of all webhooks in the YAML output:

```
apiVersion: admissionregistration.k8s.io/v1
kind: ValidatingWebhookConfiguration
metadata:
  annotations:
    service.beta.openshift.io/inject-cabundle: "true"
...
webhooks:
- myWebhook:
  - v1beta1
  clientConfig:
    caBundle: <CA_BUNDLE>
...
```

3.3.8. Manually rotate the generated service certificate

You can rotate the service certificate by deleting the associated secret. Deleting the secret results in a new one being automatically created, resulting in a new certificate.

Prerequisites

- A secret containing the certificate and key pair must have been generated for the service.

Procedure

1. Examine the service to determine the secret containing the certificate. This is found in the **serving-cert-secret-name** annotation, as seen below.

```
$ oc describe service <service_name>
```

Example output

```
...
service.beta.openshift.io/serving-cert-secret-name: <secret>
...
```

2. Delete the generated secret for the service. This process will automatically recreate the secret.

```
$ oc delete secret <secret> 1
```

1 Replace **<secret>** with the name of the secret from the previous step.

3. Confirm that the certificate has been recreated by obtaining the new secret and examining the **AGE**.

```
$ oc get secret <service_name>
```

Example output

```
NAME            TYPE              DATA   AGE
<service.name>    kubernetes.io/tls   2      1s
```

3.3.9. Manually rotate the service CA certificate

The service CA is valid for 26 months and is automatically refreshed when there is less than 13 months validity left.

If necessary, you can manually refresh the service CA by using the following procedure.

> **WARNING**
>
> A manually-rotated service CA does not maintain trust with the previous service CA. You might experience a temporary service disruption until the pods in the cluster are restarted, which ensures that pods are using service serving certificates issued by the new service CA.

Prerequisites

- You must be logged in as a cluster admin.

Procedure

1. View the expiration date of the current service CA certificate by using the following command.

```
$ oc get secrets/signing-key -n openshift-service-ca \
     -o template='{{index .data "tls.crt"}}' \
     | base64 --decode \
     | openssl x509 -noout -enddate
```

2. Manually rotate the service CA. This process generates a new service CA which will be used to sign the new service certificates.

```
$ oc delete secret/signing-key -n openshift-service-ca
```

3. To apply the new certificates to all services, restart all the pods in your cluster. This command ensures that all services use the updated certificates.

```
$ for I in $(oc get ns -o jsonpath='{range .items[*]} {.metadata.name}{"\n"} {end}'); \
    do oc delete pods --all -n $I; \
    sleep 1; \
    done
```

WARNING

This command will cause a service interruption, as it goes through and deletes every running pod in every namespace. These pods will automatically restart after they are deleted.

CHAPTER 4. CERTIFICATE TYPES AND DESCRIPTIONS

4.1. USER-PROVIDED CERTIFICATES FOR THE API SERVER

4.1.1. Purpose

The API server is accessible by clients external to the cluster at **api.<cluster_name>.<base_domain>**. You might want clients to access the API server at a different hostname or without the need to distribute the cluster-managed certificate authority (CA) certificates to the clients. The administrator must set a custom default certificate to be used by the API server when serving content.

4.1.2. Location

The user-provided certificates must be provided in a **kubernetes.io/tls** type **Secret** in the **openshift-config** namespace. Update the API server cluster configuration, the **apiserver/cluster** resource, to enable the use of the user-provided certificate.

4.1.3. Management

User-provided certificates are managed by the user.

4.1.4. Expiration

API server client certificate expiration is less than five minutes.

User-provided certificates are managed by the user.

4.1.5. Customization

Update the secret containing the user-managed certificate as needed.

Additional resources

- Adding API server certificates

4.2. PROXY CERTIFICATES

4.2.1. Purpose

Proxy certificates allow users to specify one or more custom certificate authority (CA) certificates used by platform components when making egress connections.

The **trustedCA** field of the Proxy object is a reference to a config map that contains a user-provided trusted certificate authority (CA) bundle. This bundle is merged with the Red Hat Enterprise Linux CoreOS (RHCOS) trust bundle and injected into the trust store of platform components that make egress HTTPS calls. For example, **image-registry-operator** calls an external image registry to download images. If **trustedCA** is not specified, only the RHCOS trust bundle is used for proxied HTTPS connections. Provide custom CA certificates to the RHCOS trust bundle if you want to use your own certificate infrastructure.

The **trustedCA** field should only be consumed by a proxy validator. The validator is responsible for reading the certificate bundle from required key **ca-bundle.crt** and copying it to a config map named

trusted-ca-bundle in the **openshift-config-managed** namespace. The namespace for the config map referenced by **trustedCA** is **openshift-config**:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: user-ca-bundle
  namespace: openshift-config
data:
  ca-bundle.crt: |
    -----BEGIN CERTIFICATE-----
    Custom CA certificate bundle.
    -----END CERTIFICATE-----
```

Additional resources

- Configuring the cluster-wide proxy

4.2.2. Managing proxy certificates during installation

The **additionalTrustBundle** value of the installer configuration is used to specify any proxy-trusted CA certificates during installation. For example:

```
$ cat install-config.yaml
```

Example output

```
...
proxy:
  httpProxy: http://<https://username:password@proxy.example.com:123/>
  httpsProxy: https://<https://username:password@proxy.example.com:123/>
 noProxy: <123.example.com,10.88.0.0/16>
additionalTrustBundle: |
    -----BEGIN CERTIFICATE-----
   <MY_HTTPS_PROXY_TRUSTED_CA_CERT>
    -----END CERTIFICATE-----
...
```

4.2.3. Location

The user-provided trust bundle is represented as a config map. The config map is mounted into the file system of platform components that make egress HTTPS calls. Typically, Operators mount the config map to **/etc/pki/ca-trust/extracted/pem/tls-ca-bundle.pem**, but this is not required by the proxy. A proxy can modify or inspect the HTTPS connection. In either case, the proxy must generate and sign a new certificate for the connection.

Complete proxy support means connecting to the specified proxy and trusting any signatures it has generated. Therefore, it is necessary to let the user specify a trusted root, such that any certificate chain connected to that trusted root is also trusted.

If using the RHCOS trust bundle, place CA certificates in **/etc/pki/ca-trust/source/anchors**.

See Using shared system certificates in the Red Hat Enterprise Linux documentation for more information.

4.2.4. Expiration

The user sets the expiration term of the user-provided trust bundle.

The default expiration term is defined by the CA certificate itself. It is up to the CA administrator to configure this for the certificate before it can be used by OpenShift Container Platform or RHCOS.

NOTE

Red Hat does not monitor for when CAs expire. However, due to the long life of CAs, this is generally not an issue. However, you might need to periodically update the trust bundle.

4.2.5. Services

By default, all platform components that make egress HTTPS calls will use the RHCOS trust bundle. If **trustedCA** is defined, it will also be used.

Any service that is running on the RHCOS node is able to use the trust bundle of the node.

4.2.6. Management

These certificates are managed by the system and not the user.

4.2.7. Customization

Updating the user-provided trust bundle consists of either:

- updating the PEM-encoded certificates in the config map referenced by **trustedCA,** or
- creating a config map in the namespace **openshift-config** that contains the new trust bundle and updating **trustedCA** to reference the name of the new config map.

The mechanism for writing CA certificates to the RHCOS trust bundle is exactly the same as writing any other file to RHCOS, which is done through the use of machine configs. When the Machine Config Operator (MCO) applies the new machine config that contains the new CA certificates, the node is rebooted. During the next boot, the service **coreos-update-ca-trust.service** runs on the RHCOS nodes, which automatically update the trust bundle with the new CA certificates. For example:

```
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  labels:
    machineconfiguration.openshift.io/role: worker
  name: 50-examplecorp-ca-cert
spec:
  config:
    ignition:
      version: 3.1.0
    storage:
      files:
      - contents:
          source: data:text/plain;charset=utf-
8;base64,LS0tLS1CRUdJTiBDRVJUSUZJQ0FURS0tLS0tCk1JSUVORENDQXh5Z0F3SUJBZ0lKQU5
1bkkwRDY2MmNuTUEwR0NTcUdTSWIzRFFFQkN3VUFNSUdsTVFzd0NRWUQKV1FRR0V3SlZVek
VYTUJVR0ExVUVDQXdPVG05eWRHZ2dRMkZ5YjJ4cGJtRXhFREFPQmdOVkJBY01CMUpoYkdWcA
```

```
pBMmd4RmpBVUJnTlZCQW9NRFZKbFpDQklZWFFzSUVsdVl5NHhFekFSQmdOVkJBc01DbEpsWk
NCSVlYUWdTVlF4Ckh6QVpCZ05WQkFNTUVsSmxaQ0JJWVhRZ1NWUWdVbTl2ZENCRFFURWhN
QjhHQ1NxR1NJYjNEUUVKQVJZU2FXNW0KWGpDQnBURUxNQWtHQTFVRUJoTUNWVk14RnpBV
kJnTlZCQWdNRGs1dmNuUm9JRU5oY205c2FXNWhNUkF3RGdZRApXUVFIREFkU1lXeGxhV2RvTV
JZd0ZBWURWUVFLREExU1pXUWdTR0YwTENCSmJtTXVNUk13RVFZRFZRUUxEQXBTCkFXUWd
TR0YwSUVsVU1Sc3dHUVlEVlFRRERCSlNaV1FnU0dGMElFbFVJRkp2YjNRZ1EwRXhJVEFmQmdrc
WhraUcKMHcwQkNRRVdFbWx1Wm05elpXTkFjbVZrYUdGMExtTnZiVENDQVNJd0RRWUpLb1pJaH
ZjTkFRRUJCUUFEZ2dFUApCRENDQVFvQ2dnRUJBTFF0OU9KUWg2R0M1TFQxZzgwcU5oMHU1
MEJRNHNaL3laOGFFVHh0KzVsblBWWDZNSEt6CmQvaTdsRHFUZlRjZkxMMm55VUJkMmZRRGsx
QjBmeHJza2hHSUlaM2lmUDFQczRsdFRrdjhoUlNvYjNWdE5xU28KSHhrS2Z2RDJQS2pUUHhEUFdZ
eXJ1eTlpckxxaW9NZmZpM2kvZ0N1dDBaV3RBeU8zTVZlNXFXRi9lbkt3Z1BFUwpZOXBvK1RkQ3ZS
Qi9SVU9iQmFNNzYxRWNyTFNNMUdxSE51ZVNmcW5obzNBakxRNmRCblBXbG82MzhabTFWZWJ
LCkNFTHloa0xXTVNGa0t3RG1uZTBqUTAyWTRnMDc1dkNLdkNzQ0F3RUFBYU5qTUdFd0hRWUR
WUjBPQkJZRUZlN1lKNXlDK1VlaElJUGV1TDhacXczUHpiZ2NaTUI4R0ExVWRJd1FZTUJhQUZlN1l0
eUMrVWVoSUlQZXVMOFpxdzNQegpjZ2NaTUE4R0ExVWRFd0VCL3dRRk1BTUJBZjh3RGdZRFZS
MFBBUUgvQkFRREFnR0dNQTBHQ1NxR1NJYjNEUUVCCkR3VUFBNElCQVFCRE52RDJWbTlzQT
VBOUFsT0pSOCtlbjVYejloWGN4SkI1cGh4Y1pROGpGb0cwNFZzaHZkMGUKTUVuVXJNY2ZGZ0laN
G5qTUtUUUNNNFpGVVBBaWV5THg0ZjUySHVEb3BwM2U1SnlJTWZXK0tGY05JcEt3Q3NhawpwU2
9LdElVT3NVSks3cUJWWnhjckl5ZVFWMnFjWU9lWmh0UzV3QnFJd09BaEZ3bENFVDdaZTU4UUhtUz
Q4c2xxqCjVlVGtSaml2QWxFeHJGektjbGpDNGF4S1Fsbk92VkF6eitHbTMyVTB4UEJGNEJ5ZVBWeEN
KVUh3MVRzeVRtZWwKU3hORXA3eUhvWGN3bitmWG5hK3Q1SldoMWd4VVp0eTMKLS0tLS1FTkQ
gQ0VSVElGSUNBVEUtLS0tLQo=
        mode: 0644
        overwrite: true
        path: /etc/pki/ca-trust/source/anchors/examplecorp-ca.crt
```

The trust store of machines must also support updating the trust store of nodes.

4.2.8. Renewal

There are no Operators that can auto-renew certificates on the RHCOS nodes.

> **NOTE**
>
> Red Hat does not monitor for when CAs expire. However, due to the long life of CAs, this is generally not an issue. However, you might need to periodically update the trust bundle.

4.3. SERVICE CA CERTIFICATES

4.3.1. Purpose

service-ca is an Operator that creates a self-signed CA when an OpenShift Container Platform cluster is deployed.

4.3.2. Expiration

A custom expiration term is not supported. The self-signed CA is stored in a secret with qualified name **service-ca/signing-key** in fields **tls.crt** (certificate(s)), **tls.key** (private key), and **ca-bundle.crt** (CA bundle).

Other services can request a service serving certificate by annotating a service resource with **service.beta.openshift.io/serving-cert-secret-name: <secret name>**. In response, the Operator generates a new certificate, as **tls.crt**, and private key, as **tls.key** to the named secret. The certificate is valid for two years.

Other services can request that the CA bundle for the service CA be injected into API service or config map resources by annotating with **service.beta.openshift.io/inject-cabundle: true** to support validating certificates generated from the service CA. In response, the Operator writes its current CA bundle to the **CABundle** field of an API service or as **service-ca.crt** to a config map.

As of OpenShift Container Platform 4.3.5, automated rotation is supported and is backported to some 4.2.z and 4.3.z releases. For any release supporting automated rotation, the service CA is valid for 26 months and is automatically refreshed when there is less than 13 months validity left. If necessary, you can manually refresh the service CA.

The service CA expiration of 26 months is longer than the expected upgrade interval for a supported OpenShift Container Platform cluster, such that non-control plane consumers of service CA certificates will be refreshed after CA rotation and prior to the expiration of the pre-rotation CA.

WARNING

A manually-rotated service CA does not maintain trust with the previous service CA. You might experience a temporary service disruption until the pods in the cluster are restarted, which ensures that pods are using service serving certificates issued by the new service CA.

4.3.3. Management

These certificates are managed by the system and not the user.

4.3.4. Services

Services that use service CA certificates include:

- cluster-autoscaler-operator
- cluster-monitoring-operator
- cluster-authentication-operator
- cluster-image-registry-operator
- cluster-ingress-operator
- cluster-kube-apiserver-operator
- cluster-kube-controller-manager-operator
- cluster-kube-scheduler-operator
- cluster-networking-operator
- cluster-openshift-apiserver-operator
- cluster-openshift-controller-manager-operator
- cluster-samples-operator

- machine-config-operator
- console-operator
- insights-operator
- machine-api-operator
- operator-lifecycle-manager

This is not a comprehensive list.

Additional resources

- Manually rotate service serving certificates
- Securing service traffic using service serving certificate secrets

4.4. NODE CERTIFICATES

4.4.1. Purpose

Node certificates are signed by the cluster; they come from a certificate authority (CA) that is generated by the bootstrap process. After the cluster is installed, the node certificates are auto-rotated.

4.4.2. Management

These certificates are managed by the system and not the user.

Additional resources

- Working with nodes

4.5. BOOTSTRAP CERTIFICATES

4.5.1. Purpose

The kubelet, in OpenShift Container Platform 4 and later, uses the bootstrap certificate located in **/etc/kubernetes/kubeconfig** to initially bootstrap. This is followed by the bootstrap initialization process and authorization of the kubelet to create a CSR .

In that process, the kubelet generates a CSR while communicating over the bootstrap channel. The controller manager signs the CSR, resulting in a certificate that the kubelet manages.

4.5.2. Management

These certificates are managed by the system and not the user.

4.5.3. Expiration

This bootstrap CA is valid for 10 years.

The kubelet-managed certificate is valid for one year and rotates automatically at around the 80 percent mark of that one year.

4.5.4. Customization

You cannot customize the bootstrap certificates.

4.6. ETCD CERTIFICATES

4.6.1. Purpose

etcd certificates are signed by the etcd-signer; they come from a certificate authority (CA) that is generated by the bootstrap process.

4.6.2. Expiration

The CA certificates are valid for 10 years. The peer, client, and server certificates are valid for three years.

4.6.3. Management

These certificates are only managed by the system and are automatically rotated.

4.6.4. Services

etcd certificates are used for encrypted communication between etcd member peers, as well as encrypted client traffic. The following certificates are generated and used by etcd and other processes that communicate with etcd:

- Peer certificates: Used for communication between etcd members.
- Client certificates: Used for encrypted server-client communication. Client certificates are currently used by the API server only, and no other service should connect to etcd directly except for the proxy. Client secrets (**etcd-client**, **etcd-metric-client**, **etcd-metric-signer**, and **etcd-signer**) are added to the **openshift-config**, **openshift-monitoring**, and **openshift-kube-apiserver** namespaces.
- Server certificates: Used by the etcd server for authenticating client requests.
- Metric certificates: All metric consumers connect to proxy with metric-client certificates.

Additional resources

- Restoring to a previous cluster state

4.7. OLM CERTIFICATES

4.7.1. Management

All certificates for OpenShift Lifecycle Manager (OLM) components (**olm-operator**, **catalog-operator**, **packageserver**, and **marketplace-operator**) are managed by the system.

When installing Operators that include webhooks or API services in their **ClusterServiceVersion** (CSV) object, OLM creates and rotates the certificates for these resources. Certificates for resources in the **openshift-operator-lifecycle-manager** namespace are managed by OLM.

OLM will not update the certificates of Operators that it manages in proxy environments. These certificates must be managed by the user using the subscription config.

4.8. USER-PROVIDED CERTIFICATES FOR DEFAULT INGRESS

4.8.1. Purpose

Applications are usually exposed at **<route_name>.apps.<cluster_name>.<base_domain>**. The **<cluster_name>** and **<base_domain>** come from the installation config file. **<route_name>** is the host field of the route, if specified, or the route name. For example, **hello-openshift-default.apps.username.devcluster.openshift.com**. **hello-openshift** is the name of the route and the route is in the default namespace. You might want clients to access the applications without the need to distribute the cluster-managed CA certificates to the clients. The administrator must set a custom default certificate when serving application content.

WARNING

The Ingress Operator generates a default certificate for an Ingress Controller to serve as a placeholder until you configure a custom default certificate. Do not use operator-generated default certificates in production clusters.

4.8.2. Location

The user-provided certificates must be provided in a **tls** type **Secret** resource in the **openshift-ingress** namespace. Update the **IngressController** CR in the **openshift-ingress-operator** namespace to enable the use of the user-provided certificate. For more information on this process, see Setting a custom default certificate.

4.8.3. Management

User-provided certificates are managed by the user.

4.8.4. Expiration

User-provided certificates are managed by the user.

4.8.5. Services

Applications deployed on the cluster use user-provided certificates for default ingress.

4.8.6. Customization

Update the secret containing the user-managed certificate as needed.

Additional resources

- Replacing the default ingress certificate

4.9. INGRESS CERTIFICATES

4.9.1. Purpose

The Ingress Operator uses certificates for:

- Securing access to metrics for Prometheus.
- Securing access to routes.

4.9.2. Location

To secure access to Ingress Operator and Ingress Controller metrics, the Ingress Operator uses service serving certificates. The Operator requests a certificate from the **service-ca** controller for its own metrics, and the **service-ca** controller puts the certificate in a secret named **metrics-tls** in the **openshift-ingress-operator** namespace. Additionally, the Ingress Operator requests a certificate for each Ingress Controller, and the **service-ca** controller puts the certificate in a secret named **router-metrics-certs-<name>**, where **<name>** is the name of the Ingress Controller, in the **openshift-ingress** namespace.

Each Ingress Controller has a default certificate that it uses for secured routes that do not specify their own certificates. Unless you specify a custom certificate, the Operator uses a self-signed certificate by default. The Operator uses its own self-signed signing certificate to sign any default certificate that it generates. The Operator generates this signing certificate and puts it in a secret named **router-ca** in the **openshift-ingress-operator** namespace. When the Operator generates a default certificate, it puts the default certificate in a secret named **router-certs-<name>** (where **<name>** is the name of the Ingress Controller) in the **openshift-ingress** namespace.

WARNING

The Ingress Operator generates a default certificate for an Ingress Controller to serve as a placeholder until you configure a custom default certificate. Do not use Operator-generated default certificates in production clusters.

4.9.3. Workflow

Figure 4.1. Custom certificate workflow

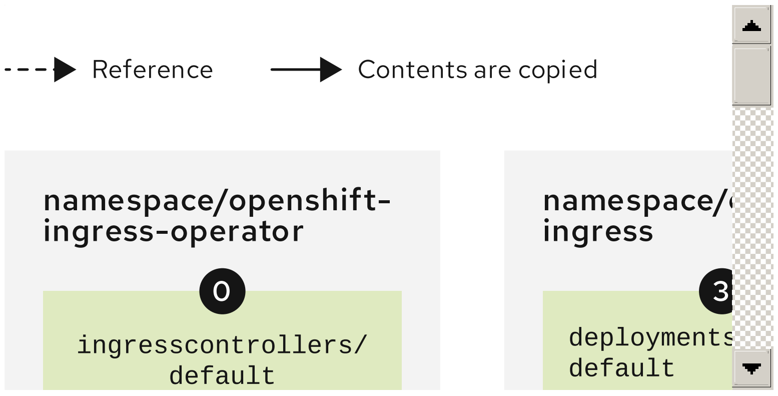
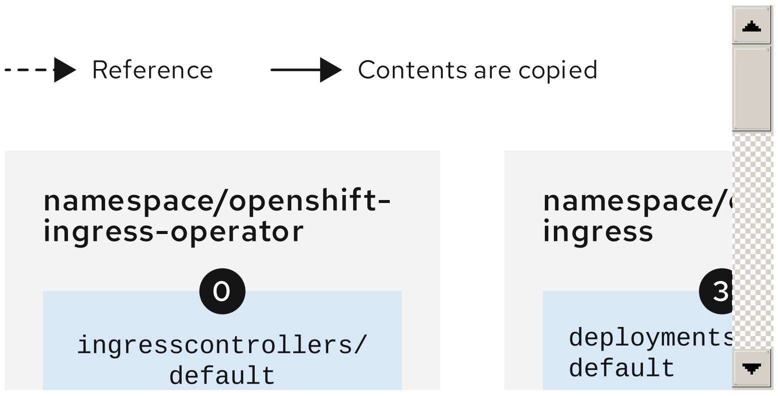


Figure 4.2. Default certificate workflow



0 An empty **defaultCertificate** field causes the Ingress Operator to use its self-signed CA to generate a serving certificate for the specified domain.

1 The default CA certificate and key generated by the Ingress Operator. Used to sign Operator-generated default serving certificates.

2 In the default workflow, the wildcard default serving certificate, created by the Ingress Operator and signed using the generated default CA certificate. In the custom workflow, this is the user-provided certificate.

3 The router deployment. Uses the certificate in **secrets/router-certs-default** as its default front-end server certificate.

4 In the default workflow, the contents of the wildcard default serving certificate (public and private parts) are copied here to enable OAuth integration. In the custom workflow, this is the user-provided certificate.

5 The public (certificate) part of the default serving certificate. Replaces the **configmaps/router-ca** resource.

6 The user updates the cluster proxy configuration with the CA certificate that signed the **ingresscontroller** serving certificate. This enables components like **auth**, **console**, and the registry to trust the serving certificate.

7 The cluster-wide trusted CA bundle containing the combined Red Hat Enterprise Linux CoreOS (RHCOS) and user-provided CA bundles or an RHCOS-only bundle if a user bundle is not provided.

8 The custom CA certificate bundle, which instructs other components (for example, **auth** and **console**) to trust an **ingresscontroller** configured with a custom certificate.

9 The **trustedCA** field is used to reference the user-provided CA bundle.

10 The Cluster Network Operator injects the trusted CA bundle into the **proxy-ca** config map.

11 OpenShift Container Platform 4.9 and newer use **default-ingress-cert**.

4.9.4. Expiration

The expiration terms for the Ingress Operator's certificates are as follows:

- The expiration date for metrics certificates that the **service-ca** controller creates is two years after the date of creation.
- The expiration date for the Operator's signing certificate is two years after the date of creation.
- The expiration date for default certificates that the Operator generates is two years after the date of creation.

You cannot specify custom expiration terms on certificates that the Ingress Operator or **service-ca** controller creates.

You cannot specify expiration terms when installing OpenShift Container Platform for certificates that the Ingress Operator or **service-ca** controller creates.

4.9.5. Services

Prometheus uses the certificates that secure metrics.

The Ingress Operator uses its signing certificate to sign default certificates that it generates for Ingress Controllers for which you do not set custom default certificates.

Cluster components that use secured routes may use the default Ingress Controller's default certificate.

Ingress to the cluster via a secured route uses the default certificate of the Ingress Controller by which the route is accessed unless the route specifies its own certificate.

4.9.6. Management

Ingress certificates are managed by the user. See Replacing the default ingress certificate for more information.

4.9.7. Renewal

The **service-ca** controller automatically rotates the certificates that it issues. However, it is possible to use **oc delete secret <secret>** to manually rotate service serving certificates.

The Ingress Operator does not rotate its own signing certificate or the default certificates that it generates. Operator-generated default certificates are intended as placeholders for custom default certificates that you configure.

4.10. MONITORING AND OPENSHIFT LOGGING OPERATOR COMPONENT CERTIFICATES

4.10.1. Expiration

Monitoring components secure their traffic with service CA certificates. These certificates are valid for 2 years and are replaced automatically on rotation of the service CA, which is every 13 months.

If the certificate lives in the **openshift-monitoring** or **openshift-logging** namespace, it is system managed and rotated automatically.

4.10.2. Management

These certificates are managed by the system and not the user.

4.11. CONTROL PLANE CERTIFICATES

4.11.1. Location

Control plane certificates are included in these namespaces:

- openshift-config-managed
- openshift-kube-apiserver
- openshift-kube-apiserver-operator
- openshift-kube-controller-manager
- openshift-kube-controller-manager-operator
- openshift-kube-scheduler

4.11.2. Management

Control plane certificates are managed by the system and rotated automatically.

In the rare case that your control plane certificates have expired, see Recovering from expired control plane certificates.

CHAPTER 5. COMPLIANCE OPERATOR

5.1. COMPLIANCE OPERATOR RELEASE NOTES

The Compliance Operator lets OpenShift Container Platform administrators describe the required compliance state of a cluster and provides them with an overview of gaps and ways to remediate them.

These release notes track the development of the Compliance Operator in the OpenShift Container Platform.

For an overview of the Compliance Operator, see Understanding the Compliance Operator .

5.1.1. Making open source more inclusive

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

5.1.2. OpenShift Compliance Operator 0.1.44

The following advisory is available for the OpenShift Compliance Operator 0.1.44:

- RHBA-2021:4530 OpenShift Compliance Operator Bug Fix and Enhancement Update

5.1.2.1. New features and enhancements

- In this release, the **strictNodeScan** option is now added to the **ComplianceScan**, **ComplianceSuite** and **ScanSetting** CRs. This option defaults to **true** which matches the previous behavior, where an error occurred if a scan was not able to be scheduled on a node. Setting the option to **false** allows the Compliance Operator to be more permissive about scheduling scans. Environments with ephemeral nodes can set the **strictNodeScan** value to false, which allows a compliance scan to proceed, even if some of the nodes in the cluster are not available for scheduling.

- You can now customize the node that is used to schedule the result server workload by configuring the **nodeSelector** and **tolerations** attributes of the **ScanSetting** object. These attributes are used to place the **ResultServer** pod, the pod that is used to mount a PV storage volume and store the raw Asset Reporting Format (ARF) results. Previously, the **nodeSelector** and the **tolerations** parameters defaulted to selecting one of the control plane nodes and tolerating the **node-role.kubernetes.io/master taint**. This did not work in environments where control plane nodes are not permitted to mount PVs. This feature provides a way for you to select the node and tolerate a different taint in those environments.

- The Compliance Operator can now remediate **KubeletConfig** objects.

- A comment containing an error message is now added to help content developers differentiate between objects that do not exist in the cluster versus objects that cannot be fetched.

- Rule objects now contain two new attributes, **checkType** and **description**. These attributes allow you to determine if the rule pertains to a node check or platform check, and also allow you to review what the rule does.

- This enhancement removes the requirement that you have to extend an existing profile in order to create a tailored profile. This means the **extends** field in the **TailoredProfile** CRD is no longer mandatory. You can now select a list of rule objects to create a tailored profile. Note that you must select whether your profile applies to nodes or the platform by setting the **compliance.openshift.io/product-type:** annotation or by setting the **-node** suffix for the **TailoredProfile** CR.

- In this release, the Compliance Operator is now able to schedule scans on all nodes irrespective of their taints. Previously, the scan pods would only tolerated the **node-role.kubernetes.io/master taint**, meaning that they would either ran on nodes with no taints or only on nodes with the **node-role.kubernetes.io/master** taint. In deployments that use custom taints for their nodes, this resulted in the scans not being scheduled on those nodes. Now, the scan pods tolerate all node taints.

5.1.2.2. Templating and variable use

- In this release, the remediation template now allows multi-value variables.
- With this update, the Compliance Operator can change remediations based on variables that are set in the compliance profile. This is useful for remediations that include deployment-specific values such as time outs, NTP server host names, or similar. Additionally, the **ComplianceCheckResult** objects now use the label **compliance.openshift.io/check-has-value** that lists the variables a check can use.

5.1.2.3. Bug fixes

- Previously, while performing a scan, an unexpected termination occurred in one of the scanner containers of the pods. In this release, the Compliance Operator uses the latest OpenSCAP version 1.3.5 to avoid a crash.
- Previously, using **autoReplyRemediations** to apply remediations triggered an update of the cluster nodes. This was disruptive if some of the remediations did not include all of the required input variables. Now, if a remediation is missing one or more required input variables, it is assigned a state of **NeedsReview**. If one or more remediations are in a **NeedsReview** state, the machine config pool remains paused, and the remediations are not applied until all of the required variables are set. This helps minimize disruption to the nodes.
- The RBAC Role and Role Binding used for Prometheus metrics are changed to 'ClusterRole' and 'ClusterRoleBinding' to ensure that monitoring works without customization.
- Previously, if an error occurred while parsing a profile, rules or variables objects were removed and deleted from the profile. Now, if an error occurs during parsing, the **profileparser** annotates the object with a temporary annotation that prevents the object from being deleted until after parsing completes. (BZ#1988259).
- Previously, an error occurred if titles or descriptions were missing from a tailored profile. Because the XCCDF standard requires titles and descriptions for tailored profiles, titles and descriptions are now required to be set in **TailoredProfile** CRs.
- Previously, when using tailored profiles, **TailoredProfile** variable values were allowed to be set using only a specific selection set. This restriction is now removed, and **TailoredProfile** variables can be set to any value.

5.1.3. Release Notes for Compliance Operator 0.1.39

The following advisory is available for the OpenShift Compliance Operator 0.1.39:

- RHBA-2021:3214 OpenShift Compliance Operator Bug Fix and Enhancement Update

5.1.3.1. New features and enhancements

- Previously, the Compliance Operator was unable to parse Payment Card Industry Data Security Standard (PCI DSS) references. Now, the Operator can parse compliance content that ships with PCI DSS profiles.

- Previously, the Compliance Operator was unable to execute rules for AU-5 control in the moderate profile. Now, permission is added to the Operator so that it can read **Prometheusrules.monitoring.coreos.com** objects and run the rules that cover AU-5 control in the moderate profile.

5.1.4. Additional resources

Understanding the Compliance Operator

5.2. INSTALLING THE COMPLIANCE OPERATOR

Before you can use the Compliance Operator, you must ensure it is deployed in the cluster.

5.2.1. Installing the Compliance Operator through the web console

Prerequisites

- You must have **admin** privileges.

Procedure

1. In the OpenShift Container Platform web console, navigate to **Operators** → **OperatorHub**.

2. Search for the Compliance Operator, then click **Install**.

3. Keep the default selection of **Installation mode** and **namespace** to ensure that the Operator will be installed to the **openshift-compliance** namespace.

4. Click **Install**.

Verification

To confirm that the installation is successful:

1. Navigate to the **Operators** → **Installed Operators** page.

2. Check that the Compliance Operator is installed in the **openshift-compliance** namespace and its status is **Succeeded**.

If the Operator is not installed successfully:

1. Navigate to the **Operators** → **Installed Operators** page and inspect the **Status** column for any errors or failures.

2. Navigate to the **Workloads** → **Pods** page and check the logs in any pods in the **openshift-compliance** project that are reporting issues.

5.2.2. Installing the Compliance Operator using the CLI

Prerequisites

- You must have **admin** privileges.

Procedure

1. Create a **Namespace** object YAML file by running:

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

   Example output

   ```
   apiVersion: v1
   kind: Namespace
   metadata:
     name: openshift-compliance
   ```

2. Create the **OperatorGroup** object YAML file by running:

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

   Example output

   ```
   apiVersion: operators.coreos.com/v1
   kind: OperatorGroup
   metadata:
     name: compliance-operator
     namespace: openshift-compliance
   spec:
     targetNamespaces:
     - openshift-compliance
   ```

3. Create the **Subscription** object YAML file by running:

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

   Example output

   ```
   apiVersion: operators.coreos.com/v1alpha1
   kind: Subscription
   metadata:
     name: compliance-operator-sub
     namespace: openshift-compliance
   spec:
     channel: "release-0.1"
     installPlanApproval: Automatic
     name: compliance-operator
     source: redhat-operators
     sourceNamespace: openshift-marketplace
   ```

NOTE

If you are setting the global scheduler feature and enable **defaultNodeSelector**, you must create the namespace manually and update the annotations of the **openshift-compliance** namespace, or the namespace where the Compliance Operator was installed, with **openshift.io/node-selector: “”**. This removes the default node selector and prevents deployment failures.

Verification

1. Verify the installation succeeded by inspecting the CSV file:

```
$ oc get csv -n openshift-compliance
```

2. Verify that the Compliance Operator is up and running:

```
$ oc get deploy -n openshift-compliance
```

5.2.3. Additional resources

- The Compliance Operator is supported in a restricted network environment. For more information, see Using Operator Lifecycle Manager on restricted networks .

5.3. COMPLIANCE OPERATOR SCANS

The **ScanSetting** and **ScanSettingBinding** APIs are recommended to run compliance scans with the Compliance Operator. For more information on these API objects, run:

```
$ oc explain scansettings
```

or

```
$ oc explain scansettingbindings
```

5.3.1. Running compliance scans

You can run a scan using the Center for Internet Security (CIS) profiles. For convenience, the Compliance Operator creates a **ScanSetting** object with reasonable defaults on startup. This **ScanSetting** object is named **default**.

Procedure

1. Inspect the **ScanSetting** object by running:

```
$ oc describe scansettings default -n openshift-compliance
```

Example output

```
apiVersion: compliance.openshift.io/v1alpha1
kind: ScanSetting
metadata:
  name: default
  namespace: openshift-compliance
rawResultStorage:
  pvAccessModes:
  - ReadWriteOnce 1
  rotation: 3 2
  size: 1Gi 3
roles:
- worker 4
- master 5
scanTolerations: 6
- effect: NoSchedule
  key: node-role.kubernetes.io/master
  operator: Exists
schedule: 0 1 * * * 7
```

1 The Compliance Operator creates a persistent volume (PV) that contains the results of the scans. By default, the PV will use access mode **ReadWriteOnce** because the Compliance Operator cannot make any assumptions about the storage classes configured on the cluster. Additionally, **ReadWriteOnce** access mode is available on most clusters. If you need to fetch the scan results, you can do so by using a helper pod, which also binds the volume. Volumes that use the **ReadWriteOnce** access mode can be mounted by only one pod at time, so it is important to remember to delete the helper pods. Otherwise, the Compliance Operator will not be able to reuse the volume for subsequent scans.

2 The Compliance Operator keeps results of three subsequent scans in the volume; older scans are rotated.

3 The Compliance Operator will allocate one GB of storage for the scan results.

4 5 If the scan setting uses any profiles that scan cluster nodes, scan these node roles.

6 The default scan setting object also scans the control plane nodes.

7 The default scan setting object runs scans at 01:00 each day.

As an alternative to the default scan setting, you can use **default-auto-apply**, which has the following settings:

```
apiVersion: compliance.openshift.io/v1alpha1
kind: ScanSetting
metadata:
  name: default-auto-apply
  namespace: openshift-compliance
autoUpdateRemediations: true 1
autoApplyRemediations: true 2
rawResultStorage:
  pvAccessModes:
    - ReadWriteOnce
  rotation: 3
  size: 1Gi
schedule: 0 1 * * *
roles:
  - worker
  - master
```

```
scanTolerations:
  - effect: NoSchedule
    key: node-role.kubernetes.io/master
    operator: Exists
```

1 2 Setting **autoUpdateRemediations** and **autoApplyRemediations** flags to **true** allows you to easily create **ScanSetting** objects that auto-remediate without extra steps.

2. Create a **ScanSettingBinding** object that binds to the default **ScanSetting** object and scans the cluster using the **cis** and **cis-node** profiles. For example:

```
apiVersion: compliance.openshift.io/v1alpha1
kind: ScanSettingBinding
metadata:
  name: cis-compliance
profiles:
  - name: ocp4-cis-node
    kind: Profile
    apiGroup: compliance.openshift.io/v1alpha1
  - name: ocp4-cis
    kind: Profile
    apiGroup: compliance.openshift.io/v1alpha1
settingsRef:
  name: default
  kind: ScanSetting
  apiGroup: compliance.openshift.io/v1alpha1
```

3. Create the **ScanSettingBinding** object by running:

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

At this point in the process, the **ScanSettingBinding** object is reconciled and based on the **Binding** and the **Bound** settings. The Compliance Operator creates a **ComplianceSuite** object and the associated **ComplianceScan** objects.

4. Follow the compliance scan progress by running:

```
$ oc get compliancescan -w -n openshift-compliance
```

The scans progress through the scanning phases and eventually reach the **DONE** phase when complete. In most cases, the result of the scan is **NON-COMPLIANT**. You can review the scan results and start applying remediations to make the cluster compliant. See Managing Compliance Operator remediation for more information.

5.4. UNDERSTANDING THE COMPLIANCE OPERATOR

The Compliance Operator lets OpenShift Container Platform administrators describe the required compliance state of a cluster and provides them with an overview of gaps and ways to remediate them. The Compliance Operator assesses compliance of both the Kubernetes API resources of OpenShift Container Platform, as well as the nodes running the cluster. The Compliance Operator uses OpenSCAP, a NIST-certified tool, to scan and enforce security policies provided by the content.

IMPORTANT

The Compliance Operator is available for Red Hat Enterprise Linux CoreOS (RHCOS) deployments only.

5.4.1. Compliance Operator profiles

There are several profiles available as part of the Compliance Operator installation.

View the available profiles:

```
$ oc get -n <namespace> profiles.compliance
```

Example output

```
NAME              AGE
ocp4-cis          4h52m
ocp4-cis-node     4h52m
ocp4-e8           4h52m
ocp4-moderate     4h52m
rhcos4-e8         4h52m
rhcos4-moderate   4h52m
```

These profiles represent different compliance benchmarks.

View the details of a profile:

```
$ oc get -n <namespace> -oyaml profiles.compliance <profile name>
```

Example output

```
apiVersion: compliance.openshift.io/v1alpha1
description: |-
  This profile contains configuration checks for Red Hat
  Enterprise Linux CoreOS that align to the Australian
  Cyber Security Centre (ACSC) Essential Eight.
  A copy of the Essential Eight in Linux Environments guide can
  be found at the ACSC website: ...
id: xccdf_org.ssgproject.content_profile_e8
kind: Profile
metadata:
  annotations:
    compliance.openshift.io/product: redhat_enterprise_linux_coreos_4
    compliance.openshift.io/product-type: Node
    creationTimestamp: "2020-09-07T11:42:51Z"
    generation: 1
  labels:
    compliance.openshift.io/profile-bundle: rhcos4
    name: rhcos4-e8
  namespace: openshift-compliance
rules:
- rhcos4-accounts-no-uid-except-zero
- rhcos4-audit-rules-dac-modification-chmod
- rhcos4-audit-rules-dac-modification-chown
- rhcos4-audit-rules-execution-chcon
- rhcos4-audit-rules-execution-restorecon
- rhcos4-audit-rules-execution-semanage
- rhcos4-audit-rules-execution-setfiles
- rhcos4-audit-rules-execution-setsebool
- rhcos4-audit-rules-execution-seunshare
- rhcos4-audit-rules-kernel-module-loading
- rhcos4-audit-rules-login-events
- rhcos4-audit-rules-login-events-faillock
- rhcos4-audit-rules-login-events-lastlog
- rhcos4-audit-rules-login-events-tallylog
- rhcos4-audit-rules-networkconfig-modification
- rhcos4-audit-rules-sysadmin-actions
- rhcos4-audit-rules-time-adjtimex
- rhcos4-audit-rules-time-clock-settime
- rhcos4-audit-rules-time-settimeofday
- rhcos4-audit-rules-time-stime
- rhcos4-audit-rules-time-watch-localtime
- rhcos4-audit-rules-usergroup-modification
- rhcos4-auditd-data-retention-flush
- rhcos4-auditd-freq
- rhcos4-auditd-local-events
- rhcos4-auditd-log-format
- rhcos4-auditd-name-format
- rhcos4-auditd-write-logs
- rhcos4-configure-crypto-policy
- rhcos4-configure-ssh-crypto-policy
- rhcos4-no-empty-passwords
- rhcos4-selinux-policytype
- rhcos4-selinux-state
- rhcos4-service-auditd-enabled
- rhcos4-sshd-disable-empty-passwords
- rhcos4-sshd-disable-gssapi-auth
- rhcos4-sshd-disable-rhosts
- rhcos4-sshd-disable-root-login
- rhcos4-sshd-disable-user-known-hosts
- rhcos4-sshd-do-not-permit-user-env
- rhcos4-sshd-enable-strictmodes
- rhcos4-sshd-print-last-log
- rhcos4-sshd-set-loglevel-info
- rhcos4-sshd-use-priv-separation
- rhcos4-sysctl-kernel-dmesg-restrict
- rhcos4-sysctl-kernel-kexec-load-disabled
- rhcos4-sysctl-kernel-kptr-restrict
- rhcos4-sysctl-kernel-randomize-va-space
- rhcos4-sysctl-kernel-unprivileged-bpf-disabled
- rhcos4-sysctl-kernel-yama-ptrace-scope
- rhcos4-sysctl-net-core-bpf-jit-harden
title: Australian Cyber Security Centre (ACSC) Essential Eight
```

View the rules within a desired profile:

```
$ oc get -n <namespace> -oyaml rules.compliance <rule_name>
```

Example output

```
apiVersion: compliance.openshift.io/v1alpha1
description: '<code>auditd</code><code>augenrules</code><code>.rules</code>
<code>/etc/audit/rules.d</code><pre>-w /var/log/tallylog -p wa -k logins -w /var/run/faillock -p wa -k
logins -w /var/log/lastlog -p wa -k logins</pre><code>auditd</code><code>auditctl</code>
<code>/etc/audit/audit.rules</code><pre>-w /var/log/tallylog -p wa -k logins -w /var/run/faillock -p wa
-k logins -w /var/log/lastlog -p wa -k logins</pre>file in order to watch for unattempted manual edits of
files involved in storing logon events:'
id: xccdf_org.ssgproject.content_rule_audit_rules_login_events
kind: Rule
metadata:
  annotations:
    compliance.openshift.io/rule: audit-rules-login-events
    control.compliance.openshift.io/NIST-800-53: AU-2(d);AU-12(c);AC-6(9);CM-6(a)
    policies.open-cluster-management.io/controls: AU-2(d),AU-12(c),AC-6(9),CM-6(a)
    policies.open-cluster-management.io/standards: NIST-800-53
    creationTimestamp: "2020-09-07T11:43:03Z"
    generation: 1
  labels:
    compliance.openshift.io/profile-bundle: rhcos4
  name: rhcos4-audit-rules-login-events
  namespace: openshift-compliance
  rationale: |-
    Manual editing of these files may indicate nefarious activity,
    such as an attacker attempting to remove evidence of an
    intrusion.
  severity: medium
  title: Record Attempts to Alter Logon and Logout Events
  warning: |-
    <ul><li><code>audit_rules_login_events_tallylog</code></li>
    <li><code>audit_rules_login_events_faillock</code></li>
    <li><code>audit_rules_login_events_lastlog</code></li></ul>
    This rule checks for multiple syscalls related to login
    events and was written with DISA STIG in mind.
    Other policies should use separate rule for
    each syscall that needs to be checked.
```

Each profile has the product name that it applies to added as a prefix to the profile's name. **ocp4-e8** applies the Essential 8 benchmark to the OpenShift Container Platform product, while **rhcos4-e8** applies the Essential 8 benchmark to the Red Hat Enterprise Linux CoreOS (RHCOS) product.

5.5. MANAGING THE COMPLIANCE OPERATOR

This section describes the lifecycle of security content, including how to use an updated version of compliance content and how to create a custom **ProfileBundle** object.

5.5.1. Updating security content

Security content is shipped as container images that the **ProfileBundle** objects refer to. To accurately track updates to **ProfileBundles** and the custom resources parsed from the bundles such as rules or profiles, identify the container image with the compliance content using a digest instead of a tag:

Example output

```
  apiVersion: compliance.openshift.io/v1alpha1
```

```
kind: ProfileBundle
metadata:
  name: rhcos4
spec:
  contentImage: quay.io/user/ocp4-openscap-
content@sha256:a1749f5150b19a9560a5732fe48a89f07bffc79c0832aa8c49ee5504590ae687 1
  contentFile: ssg-rhcos4-ds.xml
```

1 Security container image.

Each **ProfileBundle** is backed by a deployment. When the Compliance Operator detects that the container image digest has changed, the deployment is updated to reflect the change and parse the content again. Using the digest instead of a tag ensures that you use a stable and predictable set of profiles.

5.5.2. Using image streams

The **contentImage** reference points to a valid **ImageStreamTag**, and the Compliance Operator ensures that the content stays up to date automatically.

NOTE

ProfileBundle objects also accept **ImageStream** references.

Example image stream

```
$ oc get is -n openshift-compliance
```

Example output

```
NAME            IMAGE REPOSITORY                                                        TAGS
UPDATED
openscap-ocp4-ds   image-registry.openshift-image-registry.svc:5000/openshift-
compliance/openscap-ocp4-ds   latest   32 seconds ago
```

Procedure

1. Ensure that the lookup policy is set to local:

```
$ oc patch is openscap-ocp4-ds \
    -p '{"spec":{"lookupPolicy":{"local":true}}}' \
    --type=merge
    imagestream.image.openshift.io/openscap-ocp4-ds patched
    -n openshift-compliance
```

2. Use the name of the **ImageStreamTag** for the **ProfileBundle** by retrieving the **istag** name:

```
$ oc get istag -n openshift-compliance
```

Example output

```
NAME                 IMAGE REFERENCE
UPDATED
openscap-ocp4-ds:latest   image-registry.openshift-image-registry.svc:5000/openshift-
compliance/openscap-ocp4-
ds@sha256:46d7ca9b7055fe56ade818ec3e62882cfcc2d27b9bf0d1cbae9f4b6df2710c96   3
minutes ago
```

3. Create the **ProfileBundle**:

```
$ cat << EOF | oc create -f -
apiVersion: compliance.openshift.io/v1alpha1
kind: ProfileBundle
metadata:
  name: mybundle
   spec:
     contentImage: openscap-ocp4-ds:latest
     contentFile: ssg-rhcos4-ds.xml
EOF
```

This **ProfileBundle** will track the image and any changes that are applied to it, such as updating the tag to point to a different hash, will immediately be reflected in the **ProfileBundle**.

5.5.3. ProfileBundle CR example

The bundle object needs two pieces of information: the URL of a container image that contains the **contentImage** and the file that contains the compliance content. The **contentFile** parameter is relative to the root of the file system. The built-in **rhcos4 ProfileBundle** object can be defined in the example below:

```
apiVersion: compliance.openshift.io/v1alpha1
kind: ProfileBundle
metadata:
  name: rhcos4
spec:
  contentImage: quay.io/complianceascode/ocp4:latest (1)
  contentFile: ssg-rhcos4-ds.xml (2)
```

(1) Content image location.

(2) Location of the file containing the compliance content.

IMPORTANT

The base image used for the content images must include **coreutils**.

5.5.4. Additional resources

- The Compliance Operator is supported in a restricted network environment. For more information, see Using Operator Lifecycle Manager on restricted networks .

5.6. TAILORING THE COMPLIANCE OPERATOR

While the Compliance Operator comes with ready-to-use profiles, they must be modified to fit the organizations' needs and requirements. The process of modifying a profile is called *tailoring*.

The Compliance Operator provides an object to easily tailor profiles called a **TailoredProfile**. This assumes that you are extending a pre-existing profile, and allows you to enable and disable rules and values which come from the **ProfileBundle**.

NOTE

You will only be able to use rules and variables that are available as part of the **ProfileBundle** that the profile you want to extend belongs to.

5.6.1. Using tailored profiles

While the **TailoredProfile** CR enables the most common tailoring operations, the XCCDF standard allows even more flexibility in tailoring OpenSCAP profiles. In addition, if your organization has been using OpenScap previously, you may have an existing XCCDF tailoring file and can reuse it.

The **ComplianceSuite** object contains an optional **TailoringConfigMap** attribute that you can point to a custom tailoring file. The value of the **TailoringConfigMap** attribute is a name of a config map, which must contain a key called **tailoring.xml** and the value of this key is the tailoring contents.

Procedure

1. Browse the available rules for the Red Hat Enterprise Linux CoreOS (RHCOS) **ProfileBundle**:

```
$ oc get rules.compliance -l compliance.openshift.io/profile-bundle=rhcos4
```

2. Browse the available variables in the same **ProfileBundle**:

```
$ oc get variables.compliance -l compliance.openshift.io/profile-bundle=rhcos4
```

3. Choose which rules you want to add to the **TailoredProfile**. This **TailoredProfile** example disables two rules and changes one value. Use the **rationale** value to describe why these changes were made:

Example output

```
apiVersion: compliance.openshift.io/v1alpha1
kind: TailoredProfile
metadata:
  name: nist-moderate-modified
spec:
  extends: rhcos4-moderate
  title: My modified NIST moderate profile
  disableRules:
  - name: rhcos4-file-permissions-node-config
    rationale: This breaks X application.
  - name: rhcos4-account-disable-post-pw-expiration
    rationale: No need to check this as it comes from the IdP
  setValues:
  - name: rhcos4-var-selinux-state
    rationale: Organizational requirements
    value: permissive
```

Table 5.1. Attributes for spec variables

Attribute	Description
extends	Name of the **Profile** object upon which this**TailoredProfile** is built.
title	Human-readable title of the **TailoredProfile**.
disableRules	A list of name and rationale pairs. Each name refers to a name of a rule object that is to be disabled. The rationale value is human-readable text describing why the rule is disabled.
enableRules	A list of name and rationale pairs. Each name refers to a name of a rule object that is to be enabled. The rationale value is human-readable text describing why the rule is enabled.
description	Human-readable text describing the **TailoredProfile**.
setValues	A list of name, rationale, and value groupings. Each name refers to a name of the value set. The rationale is human-readable text describing the set. The value is the actual setting.

4. Add the profile to the **ScanSettingsBinding** object:

```
$ cat nist-moderate-modified.yaml
```

Example output

```
apiVersion: compliance.openshift.io/v1alpha1
kind: ScanSettingBinding
metadata:
  name: nist-moderate-modified
profiles:
  - apiGroup: compliance.openshift.io/v1alpha1
    kind: Profile
    name: ocp4-moderate
  - apiGroup: compliance.openshift.io/v1alpha1
    kind: TailoredProfile
    name: nist-moderate-modified
settingsRef:
  apiGroup: compliance.openshift.io/v1alpha1
  kind: ScanSetting
  name: default
```

5. Create the **TailoredProfile**:

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

Example output

```
scansettingbinding.compliance.openshift.io/nist-moderate-modified created
```

5.7. RETRIEVING COMPLIANCE OPERATOR RAW RESULTS

When proving compliance for your OpenShift Container Platform cluster, you might need to provide the scan results for auditing purposes.

5.7.1. Obtaining Compliance Operator raw results from a persistent volume

Procedure

The Compliance Operator generates and stores the raw results in a persistent volume. These results are in Asset Reporting Format (ARF).

1. Explore the **ComplianceSuite** object:

```
$ oc get compliancesuites nist-moderate-modified -o json \
    | jq '.status.scanStatuses[].resultsStorage'
    {
      "name": "rhcos4-moderate-worker",
      "namespace": "openshift-compliance"
    }
    {
      "name": "rhcos4-moderate-master",
      "namespace": "openshift-compliance"
    }
```

This shows the persistent volume claims where the raw results are accessible.

2. Verify the raw data location by using the name and namespace of one of the results:

```
$ oc get pvc -n openshift-compliance rhcos4-moderate-worker
```

Example output

```
NAME                 STATUS   VOLUME                                     CAPACITY   ACCESS MODES
STORAGECLASS   AGE
rhcos4-moderate-worker   Bound pvc-548f6cfe-164b-42fe-ba13-a07cfbc77f3a   1Gi      RWO
gp2         92m
```

3. Fetch the raw results by spawning a pod that mounts the volume and copying the results:

Example pod

```
apiVersion: "v1"
kind: Pod
metadata:
  name: pv-extract
spec:
  containers:
    - name: pv-extract-pod
      image: registry.access.redhat.com/ubi8/ubi
      command: ["sleep", "3000"]
      volumeMounts:
      - mountPath: "/workers-scan-results"
        name: workers-scan-vol
  volumes:
    - name: workers-scan-vol
      persistentVolumeClaim:
        claimName: rhcos4-moderate-worker
```

4. After the pod is running, download the results:

```
$ oc cp pv-extract:/workers-scan-results .
```

IMPORTANT

Spawning a pod that mounts the persistent volume will keep the claim as **Bound**. If the volume's storage class in use has permissions set to **ReadWriteOnce**, the volume is only mountable by one pod at a time. You must delete the pod upon completion, or it will be possible for the Operator to schedule a pod and continue storing results in this location.

5. After the extraction is complete, the pod can be deleted:

```
$ oc delete pod pv-extract
```

5.8. MANAGING COMPLIANCE OPERATOR REMEDIATION

Each **ComplianceCheckResult** represents a result of one compliance rule check. If the rule can be remediated automatically, a **ComplianceRemediation** object with the same name, owned by the **ComplianceCheckResult** is created. Unless requested, the remediations are not applied automatically, which gives an OpenShift Container Platform administrator the opportunity to review what the remediation does and only apply a remediation once it has been verified.

5.8.1. Reviewing a remediation

Review both the **ComplianceRemediation** object and the **ComplianceCheckResult** object that owns the remediation. The **ComplianceCheckResult** object contains human-readable descriptions of what the check does and the hardening trying to prevent, as well as other **metadata** like the severity and the associated security controls. The **ComplianceRemediation** object represents a way to fix the problem described in the **ComplianceCheckResult**.

Below is an example of a check and a remediation called **sysctl-net-ipv4-conf-all-accept-redirects**. This example is redacted to only show **spec** and **status** and omits **metadata**:

```
spec:
  apply: false
  current:
  object:
    apiVersion: machineconfiguration.openshift.io/v1
    kind: MachineConfig
    spec:
      config:
        ignition:
          version: 3.2.0
        storage:
          files:
            - path: /etc/sysctl.d/75-sysctl_net_ipv4_conf_all_accept_redirects.conf
              mode: 0644
              contents:
                source: data:,net.ipv4.conf.all.accept_redirects%3D0
  outdated: {}
status:
  applicationState: NotApplied
```

The remediation payload is stored in the **spec.current** attribute. The payload can be any Kubernetes object, but because this remediation was produced by a node scan, the remediation payload in the above example is a **MachineConfig** object. For Platform scans, the remediation payload is often a different kind of an object (for example, a **ConfigMap** or **Secret** object), but typically applying that remediation is up to the administrator, because otherwise the Compliance Operator would have required a very broad set of permissions to manipulate any generic Kubernetes object. An example of remediating a Platform check is provided later in the text.

To see exactly what the remediation does when applied, the **MachineConfig** object contents use the Ignition objects for the configuration. See the Ignition specification for further information about the format. In our example, **the spec.config.storage.files[0].path** attribute specifies the file that is being create by this remediation (**/etc/sysctl.d/75-sysctl_net_ipv4_conf_all_accept_redirects.conf**) and the **spec.config.storage.files[0].contents.source** attribute specifies the contents of that file.

NOTE

The contents of the files are URL-encoded.

Use the following Python script to view the contents:

```
$ echo "net.ipv4.conf.all.accept_redirects%3D0" | python3 -c "import sys, urllib.parse;
print(urllib.parse.unquote(''.join(sys.stdin.readlines())))"
```

Example output

```
net.ipv4.conf.all.accept_redirects=0
```

5.8.2. Applying a remediation

The boolean attribute **spec.apply** controls whether the remediation should be applied by the Compliance Operator. You can apply the remediation by setting the attribute to **true**:

```
$ oc patch complianceremediations/<scan_name>-sysctl-net-ipv4-conf-all-accept-redirects --patch
'{"spec":{"apply":true}}' --type=merge
```

After the Compliance Operator processes the applied remediation, the **status.ApplicationState** attribute would change to **Applied** or to **Error** if incorrect. When a machine config remediation is applied, that remediation along with all other applied remediations are rendered into a **MachineConfig** object named **75-$scan-name-$suite-name**. That **MachineConfig** object is subsequently rendered by the Machine Config Operator and finally applied to all the nodes in a machine config pool by an instance of the machine control daemon running on each node.

Note that when the Machine Config Operator applies a new **MachineConfig** object to nodes in a pool, all the nodes belonging to the pool are rebooted. This might be inconvenient when applying multiple remediations, each of which re-renders the composite **75-$scan-name-$suite-name MachineConfig** object. To prevent applying the remediation immediately, you can pause the machine config pool by setting the **.spec.paused** attribute of a **MachineConfigPool** object to **true**.

The Compliance Operator can apply remediations automatically. Set **autoApplyRemediations: true** in the **ScanSetting** top-level object.

WARNING

Applying remediations automatically should only be done with careful consideration.

5.8.3. Remediating a platform check manually

Checks for Platform scans typically have to be remediated manually by the administrator for two reasons:

- It is not always possible to automatically determine the value that must be set. One of the checks requires that a list of allowed registries is provided, but the scanner has no way of knowing which registries the organization wants to allow.
- Different checks modify different API objects, requiring automated remediation to possess **root** or superuser access to modify objects in the cluster, which is not advised.

Procedure

1. The example below uses the **ocp4-ocp-allowed-registries-for-import** rule, which would fail on a default OpenShift Container Platform installation. Inspect the rule **oc get rule.compliance/ocp4-ocp-allowed-registries-for-import -oyaml**, the rule is to limit the registries the users are allowed to import images from by setting the **allowedRegistriesForImport** attribute, The *warning* attribute of the rule also shows the API object checked, so it can be modified and remediate the issue:

```
$ oc edit image.config.openshift.io/cluster
```

Example output

```
apiVersion: config.openshift.io/v1
kind: Image
metadata:
  annotations:
    release.openshift.io/create-only: "true"
  creationTimestamp: "2020-09-10T10:12:54Z"
  generation: 2
  name: cluster
  resourceVersion: "363096"
  selfLink: /apis/config.openshift.io/v1/images/cluster
  uid: 2dcb614e-2f8a-4a23-ba9a-8e33cd0ff77e
spec:
  allowedRegistriesForImport:
```

```
  - domainName: registry.redhat.io
status:
  externalRegistryHostnames:
  - default-route-openshift-image-registry.apps.user-cluster-09-10-12-
07.devcluster.openshift.com
  internalRegistryHostname: image-registry.openshift-image-registry.svc:5000
```

2. Re-run the scan:

```
$ oc annotate compliancescans/<scan_name> compliance.openshift.io/rescan=
```

5.8.4. Updating remediations

When a new version of compliance content is used, it might deliver a new and different version of a remediation than the previous version. The Compliance Operator will keep the old version of the remediation applied. The OpenShift Container Platform administrator is also notified of the new version to review and apply. A ComplianceRemediation object that had been applied earlier, but was updated changes its status to **Outdated**. The outdated objects are labeled so that they can be searched for easily.

The previously applied remediation contents would then be stored in the **spec.outdated** attribute of a **ComplianceRemediation** object and the new updated contents would be stored in the **spec.current** attribute. After updating the content to a newer version, the administrator then needs to review the remediation. As long as the **spec.outdated** attribute exists, it would be used to render the resulting **MachineConfig** object. After the **spec.outdated** attribute is removed, the Compliance Operator re-renders the resulting **MachineConfig** object, which causes the Operator to push the configuration to the nodes.

Procedure

1. Search for any outdated remediations:

```
$ oc get complianceremediations -lcomplianceoperator.openshift.io/outdated-remediation=
```

Example output

```
NAME                              STATE
workers-scan-no-empty-passwords   Outdated
```

The currently applied remediation is stored in the **Outdated** attribute and the new, unapplied remediation is stored in the **Current** attribute. If you are satisfied with the new version, remove the **Outdated** field. If you want to keep the updated content, remove the **Current** and **Outdated** attributes.

2. Apply the newer version of the remediation:

```
$ oc patch complianceremediations workers-scan-no-empty-passwords --type json -p
'[{"op":"remove", "path":/spec/outdated}]'
```

3. The remediation state will switch from **Outdated** to **Applied**:

```
$ oc get complianceremediations workers-scan-no-empty-passwords
```

Example output

```
NAME                             STATE
workers-scan-no-empty-passwords   Applied
```

4. The nodes will apply the newer remediation version and reboot.

5.8.5. Unapplying a remediation

It might be required to unapply a remediation that was previously applied.

Procedure

1. Toggle the flag to **false**:

```
$ oc patch complianceremediations/<scan_name>-sysctl-net-ipv4-conf-all-accept-redirects
```

2. The remediation status will change to **NotApplied** and the composite **MachineConfig** object would be re-rendered to not include the remediation.

IMPORTANT

All affected nodes with the remediation will be rebooted.

5.8.6. Inconsistent remediations

The **ScanSetting** object lists the node roles that the compliance scans generated from the **ScanSetting** or **ScanSettingBinding** objects would scan. Each node role usually maps to a machine config pool.

IMPORTANT

It is expected that all machines in a machine config pool are identical and all scan results from the nodes in a pool should be identical.

If some of the results are different from others, the Compliance Operator flags a **ComplianceCheckResult** object where some of the nodes will report as **INCONSISTENT**. All **ComplianceCheckResult** objects are also labeled with **compliance.openshift.io/inconsistent-check**.

Because the number of machines in a pool might be quite large, the Compliance Operator attempts to find the most common state and list the nodes that differ from the common state. The most common state is stored in the **compliance.openshift.io/most-common-status** annotation and the annotation **compliance.openshift.io/inconsistent-source** contains pairs of **hostname:status** of check statuses that differ from the most common status. If no common state can be found, all the **hostname:status** pairs are listed in the **compliance.openshift.io/inconsistent-source annotation**.

If possible, a remediation is still created so that the cluster can converge to a compliant status. However, this might not always be possible and correcting the difference between nodes must be done manually. The compliance scan must be re-run to get a consistent result by annotating the scan with the **compliance.openshift.io/rescan=** option:

```
$ oc annotate compliancescans/<scan_name> compliance.openshift.io/rescan=
```

5.8.7. Filters for failed compliance check results

By default, the **ComplianceCheckResult** objects are labeled with several useful labels that allow you to query the checks and decide on the next steps after the results are generated.

List checks that belong to a specific suite:

```
$ oc get compliancecheckresults -l compliance.openshift.io/suite=example-compliancesuite
```

List checks that belong to a specific scan:

```
$ oc get compliancecheckresults -l compliance.openshift.io/scan=example-compliancescan
```

Not all **ComplianceCheckResult** objects create **ComplianceRemediation** objects. Only **ComplianceCheckResult** objects that can be remediated automatically do. A **ComplianceCheckResult** object has a related remediation if it is labeled with the **compliance.openshift.io/automated-remediation** label. The name of the remediation is the same as the name of the check.

List all failing checks that can be remediated automatically:

```
$ oc get compliancecheckresults -l 'compliance.openshift.io/check-
status=FAIL,compliance.openshift.io/automated-remediation'
```

List all failing checks that must be remediated manually:

```
$ oc get compliancecheckresults -l 'compliance.openshift.io/check-
status=FAIL,!compliance.openshift.io/automated-remediation'
```

The manual remediation steps are typically stored in the **description** attribute in the **ComplianceCheckResult** object.

5.9. PERFORMING ADVANCED COMPLIANCE OPERATOR TASKS

The Compliance Operator includes options for advanced users for the purpose of debugging or integration with existing tooling.

5.9.1. Using the ComplianceSuite and ComplianceScan objects directly

While it is recommended that users take advantage of the **ScanSetting** and **ScanSettingBinding** objects to define the suites and scans, there are valid use cases to define the **ComplianceSuite** objects directly:

- Specifying only a single rule to scan. This can be useful for debugging together with the **debug: true** attribute which increases the OpenSCAP scanner verbosity, as the debug mode tends to get quite verbose otherwise. Limiting the test to one rule helps to lower the amount of debug information.
- Providing a custom nodeSelector. In order for a remediation to be applicable, the nodeSelector must match a pool.
- Pointing the Scan to a bespoke config map with a tailoring file.
- For testing or development when the overhead of parsing profiles from bundles is not required.

The following example shows a **ComplianceSuite** that scans the worker machines with only a single rule:

```
apiVersion: compliance.openshift.io/v1alpha1
kind: ComplianceSuite
metadata:
  name: workers-compliancesuite
spec:
  scans:
    - name: workers-scan
      profile: xccdf_org.ssgproject.content_profile_moderate
      content: ssg-rhcos4-ds.xml
      contentImage: quay.io/complianceascode/ocp4:latest
      debug: true
      rule: xccdf_org.ssgproject.content_rule_no_direct_root_logins
      nodeSelector:
      node-role.kubernetes.io/worker: ""
```

The **ComplianceSuite** object and the **ComplianceScan** objects referred to above specify several attributes in a format that OpenSCAP expects.

To find out the profile, content, or rule values, you can start by creating a similar Suite from **ScanSetting** and **ScanSettingBinding** or inspect the objects parsed from the **ProfileBundle** objects like rules or profiles. Those objects contain the **xccdf_org** identifiers you can use to refer to them from a **ComplianceSuite**.

5.9.2. Using raw tailored profiles

While the **TailoredProfile** CR enables the most common tailoring operations, the XCCDF standard allows even more flexibility in tailoring OpenSCAP profiles. In addition, if your organization has been using OpenScap previously, you may have an existing XCCDF tailoring file and can reuse it.

The **ComplianceSuite** object contains an optional **TailoringConfigMap** attribute that you can point to a custom tailoring file. The value of the **TailoringConfigMap** attribute is a name of a config map which must contain a key called **tailoring.xml** and the value of this key is the tailoring contents.

Procedure

1. Create the **ConfigMap** object from a file:

   ```
   $ oc create configmap <scan_name> --from-file=tailoring.xml=/path/to/the/tailoringFile.xml
   ```

2. Reference the tailoring file in a scan that belongs to a suite:

   ```
   apiVersion: compliance.openshift.io/v1alpha1
   kind: ComplianceSuite
   metadata:
     name: workers-compliancesuite
   spec:
     debug: true
     scans:
       - name: workers-scan
         profile: xccdf_org.ssgproject.content_profile_moderate
         content: ssg-rhcos4-ds.xml
         contentImage: quay.io/complianceascode/ocp4:latest
         debug: true
   ```

```
tailoringConfigMap:
    name: <scan_name>
nodeSelector:
  node-role.kubernetes.io/worker: ""
```

5.9.3. Performing a rescan

Typically you will want to re-run a scan on a defined schedule, like every Monday or daily. It can also be useful to re-run a scan once after fixing a problem on a node. To perform a single scan, annotate the scan with the **compliance.openshift.io/rescan=** option:

```
$ oc annotate compliancescans/<scan_name> compliance.openshift.io/rescan=
```

IMPORTANT

When the scan setting **default-auto-apply** label is applied, remediations are applied automatically and outdated remediations automatically update. If there are remediations that were not applied due to dependencies, or remediations that had been outdated, rescanning applies the remediations and might trigger a reboot. Only remediations that use **MachineConfig** objects trigger reboots. If there are no updates or dependencies to be applied, no reboot occurs.

5.9.4. Setting custom storage size for results

While the custom resources such as **ComplianceCheckResult** represent an aggregated result of one check across all scanned nodes, it can be useful to review the raw results as produced by the scanner. The raw results are produced in the ARF format and can be large (tens of megabytes per node), it is impractical to store them in a Kubernetes resource backed by the **etcd** key-value store. Instead, every scan creates a persistent volume (PV) which defaults to 1GB size. Depending on your environment, you may want to increase the PV size accordingly. This is done using the **rawResultStorage.size** attribute that is exposed in both the **ScanSetting** and **ComplianceScan** resources.

A related parameter is **rawResultStorage.rotation** which controls how many scans are retained in the PV before the older scans are rotated. The default value is 3, setting the rotation policy to 0 disables the rotation. Given the default rotation policy and an estimate of 100MB per a raw ARF scan report, you can calculate the right PV size for your environment.

5.9.4.1. Using custom result storage values

Because OpenShift Container Platform can be deployed in a variety of public clouds or bare metal, the Compliance Operator cannot determine available storage configurations. By default, the Compliance Operator will try to create the PV for storing results using the default storage class of the cluster, but a custom storage class can be configured using the **rawResultStorage.StorageClassName** attribute.

IMPORTANT

If your cluster does not specify a default storage class, this attribute must be set.

Configure the **ScanSetting** custom resource to use a standard storage class and create persistent volumes that are 10GB in size and keep the last 10 results:

Example ScanSetting CR

```
apiVersion: compliance.openshift.io/v1alpha1
kind: ScanSetting
metadata:
  name: default
  namespace: openshift-compliance
rawResultStorage:
  storageClassName: standard
  rotation: 10
  size: 10Gi
roles:
- worker
- master
scanTolerations:
- effect: NoSchedule
  key: node-role.kubernetes.io/master
  operator: Exists
schedule: '0 1 * * *'
```

5.9.5. Applying remediations generated by suite scans

Although you can use the **autoApplyRemediations** boolean parameter in a **ComplianceSuite** object, you can alternatively annotate the object with **compliance.openshift.io/apply-remediations**. This allows the Operator to apply all of the created remediations.

Procedure

- Apply the **compliance.openshift.io/apply-remediations** annotation by running:

```
$ oc annotate compliancesuites/<suite-_name> compliance.openshift.io/apply-remediations=
```

5.9.6. Automatically update remediations

In some cases, a scan with newer content might mark remediations as **OUTDATED**. As an administrator, you can apply the **compliance.openshift.io/remove-outdated** annotation to apply new remediations and remove the outdated ones.

Procedure

- Apply the **compliance.openshift.io/remove-outdated** annotation:

```
$ oc annotate compliancesuites/<suite_name> compliance.openshift.io/remove-outdated=
```

Alternatively, set the **autoUpdateRemediations** flag in a **ScanSetting** or **ComplianceSuite** object to update the remediations automatically.

5.10. TROUBLESHOOTING THE COMPLIANCE OPERATOR

This section describes how to troubleshoot the Compliance Operator. The information can be useful either to diagnose a problem or provide information in a bug report. Some general tips:

- The Compliance Operator emits Kubernetes events when something important happens. You can either view all events in the cluster using the command:

```
$ oc get events -n openshift-compliance
```

Or view events for an object like a scan using the command:

```
$ oc describe compliancescan/<scan_name>
```

- The Compliance Operator consists of several controllers, approximately one per API object. It could be useful to filter only those controllers that correspond to the API object having issues. If a **ComplianceRemediation** cannot be applied, view the messages from the **remediationctrl** controller. You can filter the messages from a single controller by parsing with **jq**:

```
$ oc logs compliance-operator-775d7bddbd-gj58f | jq -c 'select(.logger == "profilebundlectrl")'
```

- The timestamps are logged as seconds since UNIX epoch in UTC. To convert them to a human-readable date, use **date -d @timestamp --utc**, for example:

```
$ date -d @1596184628.955853 --utc
```

- Many custom resources, most importantly **ComplianceSuite** and **ScanSetting**, allow the **debug** option to be set. Enabling this option increases verbosity of the OpenSCAP scanner pods, as well as some other helper pods.

- If a single rule is passing or failing unexpectedly, it could be helpful to run a single scan or a suite with only that rule to find the rule ID from the corresponding **ComplianceCheckResult** object and use it as the **rule** attribute value in a **Scan** CR. Then, together with the **debug** option enabled, the **scanner** container logs in the scanner pod would show the raw OpenSCAP logs.

5.10.1. Anatomy of a scan

The following sections outline the components and stages of Compliance Operator scans.

5.10.1.1. Compliance sources

The compliance content is stored in **Profile** objects that are generated from a **ProfileBundle** object. The Compliance Operator creates a **ProfileBundle** object for the cluster and another for the cluster nodes.

```
$ oc get profilebundle.compliance
```

```
$ oc get profile.compliance
```

The **ProfileBundle** objects are processed by deployments labeled with the **Bundle** name. To troubleshoot an issue with the **Bundle**, you can find the deployment and view logs of the pods in a deployment:

```
$ oc logs -lprofile-bundle=ocp4 -c profileparser
```

```
$ oc get deployments,pods -lprofile-bundle=ocp4
```

```
$ oc logs pods/<pod-name>
$ oc describe pod/<pod-name> -c profileparser
```

5.10.1.2. The ScanSetting and ScanSettingBinding objects lifecycle and debugging

With valid compliance content sources, the high-level **ScanSetting** and **ScanSettingBinding** objects can be used to generate **ComplianceSuite** and **ComplianceScan** objects:

```
apiVersion: compliance.openshift.io/v1alpha1
kind: ScanSetting
metadata:
  name: my-companys-constraints
debug: true
# For each role, a separate scan will be created pointing
# to a node-role specified in roles
roles:
  - worker
---
apiVersion: compliance.openshift.io/v1alpha1
kind: ScanSettingBinding
metadata:
  name: my-companys-compliance-requirements
profiles:
  # Node checks
  - name: rhcos4-e8
    kind: Profile
    apiGroup: compliance.openshift.io/v1alpha1
  # Cluster checks
  - name: ocp4-e8
    kind: Profile
    apiGroup: compliance.openshift.io/v1alpha1
settingsRef:
  name: my-companys-constraints
  kind: ScanSetting
  apiGroup: compliance.openshift.io/v1alpha1
```

Both **ScanSetting** and **ScanSettingBinding** objects are handled by the same controller tagged with **logger=scansettingbindingctrl**. These objects have no status. Any issues are communicated in form of events:

```
Events:
  Type     Reason        Age    From                    Message
  ----     ------        ----   ----                    -------
  Normal   SuiteCreated  9m52s  scansettingbindingctrl  ComplianceSuite openshift-compliance/my-
companys-compliance-requirements created
```

Now a **ComplianceSuite** object is created. The flow continues to reconcile the newly created **ComplianceSuite**.

5.10.1.3. ComplianceSuite custom resource lifecycle and debugging

The **ComplianceSuite** CR is a wrapper around **ComplianceScan** CRs. The **ComplianceSuite** CR is handled by controller tagged with **logger=suitectrl**. This controller handles creating scans from a suite, reconciling and aggregating individual Scan statuses into a single Suite status. If a suite is set to execute periodically, the **suitectrl** also handles creating a **CronJob** CR that re-runs the scans in the suite after the initial run is done:

```
$ oc get cronjobs
```

Example output

```
NAME                                    SCHEDULE    SUSPEND   ACTIVE   LAST SCHEDULE   AGE
<cron_name>                                 0 1 * * *   False     0       <none>          151m
```

For the most important issues, events are emitted. View them with **oc describe compliancesuites/<name>**. The **Suite** objects also have a **Status** subresource that is updated when any of **Scan** objects that belong to this suite update their **Status** subresource. After all expected scans are created, control is passed to the scan controller.

5.10.1.4. ComplianceScan custom resource lifecycle and debugging

The **ComplianceScan** CRs are handled by the **scanctrl** controller. This is also where the actual scans happen and the scan results are created. Each scan goes through several phases:

5.10.1.4.1. Pending phase

The scan is validated for correctness in this phase. If some parameters like storage size are invalid, the scan transitions to DONE with ERROR result, otherwise proceeds to the Launching phase.

5.10.1.4.2. Launching phase

In this phase, several config maps that contain either environment for the scanner pods or directly the script that the scanner pods will be evaluating. List the config maps:

```
$ oc get cm -lcompliance.openshift.io/scan-name=rhcos4-e8-
worker,complianceoperator.openshift.io/scan-script=
```

These config maps will be used by the scanner pods. If you ever needed to modify the scanner behavior, change the scanner debug level or print the raw results, modifying the config maps is the way to go. Afterwards, a persistent volume claim is created per scan to store the raw ARF results:

```
$ oc get pvc -lcompliance.openshift.io/scan-name=<scan_name>
```

The PVCs are mounted by a per-scan **ResultServer** deployment. A **ResultServer** is a simple HTTP server where the individual scanner pods upload the full ARF results to. Each server can run on a different node. The full ARF results might be very large and you cannot presume that it would be possible to create a volume that could be mounted from multiple nodes at the same time. After the scan is finished, the **ResultServer** deployment is scaled down. The PVC with the raw results can be mounted from another custom pod and the results can be fetched or inspected. The traffic between the scanner pods and the **ResultServer** is protected by mutual TLS protocols.

Finally, the scanner pods are launched in this phase; one scanner pod for a **Platform** scan instance and one scanner pod per matching node for a **node** scan instance. The per-node pods are labeled with the node name. Each pod is always labeled with the **ComplianceScan** name:

```
$ oc get pods -lcompliance.openshift.io/scan-name=rhcos4-e8-worker,workload=scanner --show-
labels
```

Example output

```
NAME                                                   READY   STATUS      RESTARTS   AGE   LABELS
rhcos4-e8-worker-ip-10-0-169-90.eu-north-1.compute.internal-pod  0/2    Completed   0         39m
compliance.openshift.io/scan-name=rhcos4-e8-worker,targetNode=ip-10-0-169-90.eu-north-
1.compute.internal,workload=scanner
At this point, the scan proceeds to the Running phase.
```

5.10.1.4.3. Running phase

The running phase waits until the scanner pods finish. The following terms and processes are in use in the running phase:

- **init container**: There is one init container called **content-container**. It runs the **contentImage** container and executes a single command that copies the **contentFile** to the **/content** directory shared with the other containers in this pod.
- **scanner**: This container runs the scan. For node scans, the container mounts the node filesystem as **/host** and mounts the content delivered by the init container. The container also mounts the **entrypoint ConfigMap** created in the Launching phase and executes it. The default script in the entrypoint **ConfigMap** executes OpenSCAP and stores the result files in the **/results** directory shared between the pod's containers. Logs from this pod can be viewed to determine what the OpenSCAP scanner checked. More verbose output can be viewed with the **debug** flag.
- **logcollector**: The logcollector container waits until the scanner container finishes. Then, it uploads the full ARF results to the **ResultServer** and separately uploads the XCCDF results along with scan result and OpenSCAP result code as a **ConfigMap.** These result config maps are labeled with the scan name (**compliance.openshift.io/scan-name=<scan_name>**):

  ```
  $ oc describe cm/rhcos4-e8-worker-ip-10-0-169-90.eu-north-1.compute.internal-pod
  ```

  Example output

  ```
      Name:         rhcos4-e8-worker-ip-10-0-169-90.eu-north-1.compute.internal-pod
      Namespace:    openshift-compliance
      Labels:       compliance.openshift.io/scan-name-scan=rhcos4-e8-worker
                    complianceoperator.openshift.io/scan-result=
      Annotations:  compliance-remediations/processed:
                    compliance.openshift.io/scan-error-msg:
                    compliance.openshift.io/scan-result: NON-COMPLIANT
                    OpenSCAP-scan-result/node: ip-10-0-169-90.eu-north-1.compute.internal

      Data
      ====
      exit-code:
      ----
      2
      results:
      ----
      <?xml version="1.0" encoding="UTF-8"?>
      ...
  ```

Scanner pods for **Platform** scans are similar, except:

- There is one extra init container called **api-resource-collector** that reads the OpenSCAP content provided by the content-container init, container, figures out which API resources the content needs to examine and stores those API resources to a shared directory where the **scanner** container would read them from.

- The **scanner** container does not need to mount the host file system.

When the scanner pods are done, the scans move on to the Aggregating phase.

5.10.1.4.4. Aggregating phase

In the aggregating phase, the scan controller spawns yet another pod called the aggregator pod. Its purpose it to take the result **ConfigMap** objects, read the results and for each check result create the corresponding Kubernetes object. If the check failure can be automatically remediated, a **ComplianceRemediation** object is created. To provide human-readable metadata for the checks and remediations, the aggregator pod also mounts the OpenSCAP content using an init container.

When a config map is processed by an aggregator pod, it is labeled the **compliance-remediations/processed** label. The result of this phase are **ComplianceCheckResult** objects:

```
$ oc get compliancecheckresults -lcompliance.openshift.io/scan-name=rhcos4-e8-worker
```

Example output

```
NAME                                                   STATUS   SEVERITY
rhcos4-e8-worker-accounts-no-uid-except-zero           PASS     high
rhcos4-e8-worker-audit-rules-dac-modification-chmod    FAIL     medium
```

and **ComplianceRemediation** objects:

```
$ oc get complianceremediations -lcompliance.openshift.io/scan-name=rhcos4-e8-worker
```

Example output

```
NAME                                                   STATE
rhcos4-e8-worker-audit-rules-dac-modification-chmod    NotApplied
rhcos4-e8-worker-audit-rules-dac-modification-chown    NotApplied
rhcos4-e8-worker-audit-rules-execution-chcon           NotApplied
rhcos4-e8-worker-audit-rules-execution-restorecon      NotApplied
rhcos4-e8-worker-audit-rules-execution-semanage        NotApplied
rhcos4-e8-worker-audit-rules-execution-setfiles        NotApplied
```

After these CRs are created, the aggregator pod exits and the scan moves on to the Done phase.

5.10.1.4.5. Done phase

In the final scan phase, the scan resources are cleaned up if needed and the **ResultServer** deployment is either scaled down (if the scan was one-time) or deleted if the scan is continuous; the next scan instance would then recreate the deployment again.

It is also possible to trigger a re-run of a scan in the Done phase by annotating it:

```
$ oc annotate compliancescans/<scan_name> compliance.openshift.io/rescan=
```

After the scan reaches the Done phase, nothing else happens on its own unless the remediations are set to be applied automatically with **autoApplyRemediations: true**. The OpenShift Container Platform administrator would now review the remediations and apply them as needed. If the remediations are set to be applied automatically, the **ComplianceSuite** controller takes over in the Done phase, pauses the machine config pool to which the scan maps to and applies all the remediations in one go. If a remediation is applied, the **ComplianceRemediation** controller takes over.

5.10.1.5. ComplianceRemediation controller lifecycle and debugging

The example scan has reported some findings. One of the remediations can be enabled by toggling its **apply** attribute to **true**:

```
$ oc patch complianceremediations/rhcos4-e8-worker-audit-rules-dac-modification-chmod --patch
'{"spec":{"apply":true}}' --type=merge
```

The **ComplianceRemediation** controller (**logger=remediationctrl**) reconciles the modified object. The result of the reconciliation is change of status of the remediation object that is reconciled, but also a change of the rendered per-suite **MachineConfig** object that contains all the applied remediations.

The **MachineConfig** object always begins with **75-** and is named after the scan and the suite:

```
$ oc get mc | grep 75-
```

Example output

```
75-rhcos4-e8-worker-my-companys-compliance-requirements                                    3.2.0
2m46s
```

The remediations the **mc** currently consists of are listed in the machine config’s annotations:

```
$ oc describe mc/75-rhcos4-e8-worker-my-companys-compliance-requirements
```

Example output

```
Name:        75-rhcos4-e8-worker-my-companys-compliance-requirements
Labels:      machineconfiguration.openshift.io/role=worker
Annotations:  remediation/rhcos4-e8-worker-audit-rules-dac-modification-chmod:
```

The **ComplianceRemediation** controller’s algorithm works like this:

- All currently applied remediations are read into an initial remediation set.
- If the reconciled remediation is supposed to be applied, it is added to the set.
- A **MachineConfig** object is rendered from the set and annotated with names of remediations in the set. If the set is empty (the last remediation was unapplied), the rendered **MachineConfig** object is removed.
- If and only if the rendered machine config is different from the one already applied in the cluster, the applied MC is updated (or created, or deleted).

[illegible]

- Creating or modifying a **MachineConfig** object triggers a reboot of nodes that match the **machineconfiguration.openshift.io/role** label - see the Machine Config Operator documentation for more details.

The remediation loop ends once the rendered machine config is updated, if needed, and the reconciled remediation object status is updated. In our case, applying the remediation would trigger a reboot. After the reboot, annotate the scan to re-run it:

```
$ oc annotate compliancescans/<scan_name> compliance.openshift.io/rescan=
```

The scan will run and finish. Check for the remediation to pass:

```
$ oc get compliancecheckresults/rhcos4-e8-worker-audit-rules-dac-modification-chmod
```

Example output

```
NAME                                             STATUS   SEVERITY
rhcos4-e8-worker-audit-rules-dac-modification-chmod   PASS     medium
```

5.10.1.6. Useful labels

Each pod that is spawned by the Compliance Operator is labeled specifically with the scan it belongs to and the work it does. The scan identifier is labeled with the **compliance.openshift.io/scan-name** label. The workload identifier is labeled with the **workload** label.

The Compliance Operator schedules the following workloads:

- **scanner**: Performs the compliance scan.
- **resultserver**: Stores the raw results for the compliance scan.
- **aggregator**: Aggregates the results, detects inconsistencies and outputs result objects (checkresults and remediations).
- **suitererunner**: Will tag a suite to be re-run (when a schedule is set).
- **profileparser**: Parses a datastream and creates the appropriate profiles, rules and variables.

When debugging and logs are required for a certain workload, run:

```
$ oc logs -l workload=<workload_name> -c <container_name>
```

5.10.2. Getting support

If you experience difficulty with a procedure described in this documentation, or with OpenShift Container Platform in general, visit the Red Hat Customer Portal . From the Customer Portal, you can:

- Search or browse through the Red Hat Knowledgebase of articles and solutions relating to Red Hat products.
- Submit a support case to Red Hat Support.
- Access other product documentation.

To identify issues with your cluster, you can use Insights in Red Hat OpenShift Cluster Manager. Insights provides details about issues and, if available, information on how to solve a problem.

If you have a suggestion for improving this documentation or have found an error, submit a Bugzilla report against the **OpenShift Container Platform** product for the **Documentation** component. Please provide specific details, such as the section name and OpenShift Container Platform version.

5.11. UNINSTALLING THE COMPLIANCE OPERATOR

You can remove the OpenShift Compliance Operator from your cluster by using the OpenShift Container Platform web console.

5.11.1. Uninstalling the OpenShift Compliance Operator from OpenShift Container Platform

To remove the Compliance Operator, you must first delete the Compliance Operator custom resource definitions (CRDs). After the CRDs are removed, you can then remove the Operator and its namespace by deleting the **openshift-compliance** project.

Prerequisites

- Access to an OpenShift Container Platform cluster using an account with **cluster-admin** permissions.
- The OpenShift Compliance Operator must be installed.

Procedure

To remove the Compliance Operator by using the OpenShift Container Platform web console:

1. Remove CRDs that were installed by the Compliance Operator:
   a. Switch to the **Administration** → **CustomResourceDefinitions** page.
   b. Search for **compliance.openshift.io** in the **Name** field.
   c. Click the Options menu ⋮ next to each of the following CRDs, and select **Delete Custom Resource Definition**:
      - **ComplianceCheckResult**
      - **ComplianceRemediation**
      - **ComplianceScan**
      - **ComplianceSuite**
      - **ProfileBundle**
      - **Profile**
      - **Rule**
      - **ScanSettingBinding**

- **ScanSetting**
- **TailoredProfile**
- **Variable**

2. Remove the OpenShift Compliance project:

   a. Switch to the **Home** → **Projects** page.

   b. Click the Options menu ⋮ next to the **openshift-compliance** project, and select **Delete Project**.

   c. Confirm the deletion by typing **openshift-compliance** in the dialog box, and click **Delete**.

5.12. USING THE OC-COMPLIANCE PLUG-IN

Although the Compliance Operator automates many of the checks and remediations for the cluster, the full process of bringing a cluster into compliance often requires administrator interaction with the Compliance Operator API and other components. The **oc-compliance** plug-in makes the process easier.

5.12.1. Installing the oc-compliance plug-in

Procedure

1. Extract the **oc-compliance** image to get the **oc-compliance** binary:

```
$ podman run --rm --entrypoint /bin/cat registry.redhat.io/compliance/oc-compliance-rhel8
/usr/bin/oc-compliance > ~/.local/bin/oc-compliance
```

Example output

```
W0611 20:35:46.486903   11354 manifest.go:440] Chose linux/amd64 manifest from the
manifest list.
```

You can now run **oc-compliance**.

5.12.2. Fetching raw results

When a compliance scan finishes, the results of the individual checks are listed in the resulting **ComplianceCheckResult** custom resource (CR). However, an administrator or auditor might require the complete details of the scan. The OpenSCAP tool creates an Advanced Recording Format (ARF) formatted file with the detailed results. This ARF file is too large to store in a config map or other standard Kubernetes resource, so a persistent volume (PV) is created to contain it.

Procedure

- Fetching the results from the PV with the Compliance Operator is a four-step process. However, with the **oc-compliance** plug-in, you can use a single command:

```
$ oc compliance fetch-raw <object-type> <object-name> -o <output-path>
```

- **<object-type>** can be either **scansettingbinding**, **compliancescan** or **compliancesuite**, depending on which of these objects the scans were launched with.
- **<object-name>** is the name of the binding, suite, or scan object to gather the ARF file for, and **<output-path>** is the local directory to place the results.
  For example:

  ```
  $ oc compliance fetch-raw scansettingbindings my-binding -o /tmp/
  ```

  Example output

  ```
  Fetching results for my-binding scans: ocp4-cis, ocp4-cis-node-worker, ocp4-cis-node-master
  Fetching raw compliance results for scan 'ocp4-cis'.......
  The raw compliance results are avaliable in the following directory: /tmp/ocp4-cis
  Fetching raw compliance results for scan 'ocp4-cis-node-worker'...........
  The raw compliance results are avaliable in the following directory: /tmp/ocp4-cis-node-worker
  Fetching raw compliance results for scan 'ocp4-cis-node-master'......
  The raw compliance results are avaliable in the following directory: /tmp/ocp4-cis-node-master
  ```

View the list of files in the directory:

```
$ ls /tmp/ocp4-cis-node-master/
```

Example output

```
ocp4-cis-node-master-ip-10-0-128-89.ec2.internal-pod.xml.bzip2  ocp4-cis-node-master-ip-10-0-150-5.ec2.internal-pod.xml.bzip2  ocp4-cis-node-master-ip-10-0-163-32.ec2.internal-pod.xml.bzip2
```

Extract the results:

```
$ bunzip2 -c resultsdir/worker-scan/worker-scan-stage-459-tqkg7-compute-0-pod.xml.bzip2 > resultsdir/worker-scan/worker-scan-ip-10-0-170-231.us-east-2.compute.internal-pod.xml
```

View the results:

```
$ ls resultsdir/worker-scan/
```

Example output

```
worker-scan-ip-10-0-170-231.us-east-2.compute.internal-pod.xml
worker-scan-stage-459-tqkg7-compute-0-pod.xml.bzip2
worker-scan-stage-459-tqkg7-compute-1-pod.xml.bzip2
```

5.12.3. Re-running scans

Although it is possible to run scans as scheduled jobs, you must often re-run a scan on demand, particularly after remediations are applied or when other changes to the cluster are made.

Procedure

- Triggering a re-scan with the Compliance Operator requires use of an annotation on the scan object. However, with the **oc-compliance** plug-in you can re-scan with a single command:

  ```
  $ oc compliance rerun-now <scan-object> <object-name>
  ```

- **<scan-object>** can be **compliancescan**, **compliancesuite**, or **scansettingbinding**.
- **<object-name>** is the name of the given **scan-object**.
  For example, to re-run the scans for the **ScanSettingBinding** object named **my-binding**:

  ```
  $ oc compliance rerun-now scansettingbindings my-binding
  ```

  Example output

  ```
  Rerunning scans from 'my-binding': ocp4-cis
  Re-running scan 'openshift-compliance/ocp4-cis'
  ```

5.12.4. Using ScanSettingBinding custom resources

When using the **ScanSetting** and **ScanSettingBinding** custom resources (CRs) that the Compliance Operator provides, it is possible to run scans for multiple profiles while using a common set of scan options, such as **schedule**, **machine roles**, **tolerations**, and so on. While that is easier than working with multiple **ComplianceSuite** or **ComplianceScan** objects, it can confuse new users.

The **oc compliance bind** subcommand helps you create a **ScanSettingBinding** CR.

Procedure

1. Run:

   ```
   $ oc compliance bind [--dry-run] -N <binding name> [-S <scansetting name>]
   <objtype/objname> [..<objtype/objname>]
   ```

   - If you omit the **-S** flag, the **default** scan setting provided by the Compliance Operator is used.
   - The object type is the Kubernetes object type, which can be **profile** or **tailoredprofile**. More than one object can be provided.
   - The object name is the name of the Kubernetes resource, such as **.metadata.name**.
   - Add the **--dry-run** option to display the YAML file of the objects that are created.
     For example, given the following profiles and scan settings:

     ```
     $ oc get profile.compliance -n openshift-compliance
     ```

     Example output

     ```
     NAME              AGE
     ocp4-cis          9m54s
     ocp4-cis-node     9m54s
     ocp4-e8           9m54s
     ocp4-moderate     9m54s
     ```

```
ocp4-ncp         9m54s
rhcos4-e8        9m54s
rhcos4-moderate   9m54s
rhcos4-ncp       9m54s
rhcos4-ospp      9m54s
rhcos4-stig      9m54s
```

```
$ oc get scansettings -n openshift-compliance
```

Example output

```
NAME                 AGE
default              10m
default-auto-apply   10m
```

2. To apply the **default** settings to the **ocp4-cis** and **ocp4-cis-node** profiles, run:

```
$ oc compliance bind -N my-binding profile/ocp4-cis profile/ocp4-cis-node
```

Example output

```
Creating ScanSettingBinding my-binding
```

Once the **ScanSettingBinding** CR is created, the bound profile begins scanning for both profiles with the related settings. Overall, this is the fastest way to begin scanning with the Compliance Operator.

5.12.5. Printing controls

Compliance standards are generally organized into a hierarchy as follows:

- A benchmark is the top-level definition of a set of controls for a particular standard. For example, FedRAMP Moderate or Center for Internet Security (CIS) v.1.6.0.
- A control describes a family of requirements that must be met in order to be in compliance with the benchmark. For example, FedRAMP AC-01 (access control policy and procedures).
- A rule is a single check that is specific for the system being brought into compliance, and one or more of these rules map to a control.
- The Compliance Operator handles the grouping of rules into a profile for a single benchmark. It can be difficult to determine which controls that the set of rules in a profile satisfy.

Procedure

- The **oc compliance controls** subcommand provides a report of the standards and controls that a given profile satisfies:

```
$ oc compliance controls profile ocp4-cis-node
```

Example output

```
+-----------+----------+
| FRAMEWORK | CONTROLS |
+-----------+----------+
| CIS-OCP   | 1.1.1    |
+           +----------+
|           | 1.1.10   |
+           +----------+
|           | 1.1.11   |
+           +----------+
...
```

5.12.6. Fetching compliance remediation details

The Compliance Operator provides remediation objects that are used to automate the changes required to make the cluster compliant. The **fetch-fixes** subcommand can help you understand exactly which configuration remediations are used. Use the **fetch-fixes** subcommand to extract the remediation objects from a profile, rule, or **ComplianceRemediation** object into a directory to inspect.

Procedure

1. View the remediations for a profile:

   ```
   $ oc compliance fetch-fixes profile ocp4-cis -o /tmp
   ```

   Example output

   ```
   No fixes to persist for rule 'ocp4-api-server-api-priority-flowschema-catch-all' (1)
   No fixes to persist for rule 'ocp4-api-server-api-priority-gate-enabled'
   No fixes to persist for rule 'ocp4-api-server-audit-log-maxbackup'
   Persisted rule fix to /tmp/ocp4-api-server-audit-log-maxsize.yaml
   No fixes to persist for rule 'ocp4-api-server-audit-log-path'
   No fixes to persist for rule 'ocp4-api-server-auth-mode-no-aa'
   No fixes to persist for rule 'ocp4-api-server-auth-mode-node'
   No fixes to persist for rule 'ocp4-api-server-auth-mode-rbac'
   No fixes to persist for rule 'ocp4-api-server-basic-auth'
   No fixes to persist for rule 'ocp4-api-server-bind-address'
   No fixes to persist for rule 'ocp4-api-server-client-ca'
   Persisted rule fix to /tmp/ocp4-api-server-encryption-provider-cipher.yaml
   Persisted rule fix to /tmp/ocp4-api-server-encryption-provider-config.yaml
   ```

   (1) The **No fixes to persist** warning is expected whenever there are rules in a profile that do not have a corresponding remediation, because either the rule cannot be remediated automatically or a remediation was not provided.

2. You can view a sample of the YAML file. The **head** command will show you the first 10 lines:

   ```
   $ head /tmp/ocp4-api-server-audit-log-maxsize.yaml
   ```

   Example output

   ```
   apiVersion: config.openshift.io/v1
   kind: APIServer
   ```

```
metadata:
  name: cluster
spec:
  maximumFileSizeMegabytes: 100
```

3. View the remediation from a **ComplianceRemediation** object created after a scan:

```
$ oc get complianceremediations -n openshift-compliance
```

Example output

```
NAME                                             STATE
ocp4-cis-api-server-encryption-provider-cipher   NotApplied
ocp4-cis-api-server-encryption-provider-config   NotApplied
```

```
$ oc compliance fetch-fixes complianceremediations ocp4-cis-api-server-encryption-provider-
cipher -o /tmp
```

Example output

```
Persisted compliance remediation fix to /tmp/ocp4-cis-api-server-encryption-provider-
cipher.yaml
```

4. You can view a sample of the YAML file. The **head** command will show you the first 10 lines:

```
$ head /tmp/ocp4-cis-api-server-encryption-provider-cipher.yaml
```

Example output

```
apiVersion: config.openshift.io/v1
kind: APIServer
metadata:
  name: cluster
spec:
  encryption:
    type: aescbc
```

WARNING

Use caution before applying remediations directly. Some remediations might not be applicable in bulk, such as the usbguard rules in the moderate profile. In these cases, allow the Compliance Operator to apply the rules because it addresses the dependencies and ensures that the cluster remains in a good state.

5.12.7. Viewing ComplianceCheckResult object details

When scans are finished running, **ComplianceCheckResult** objects are created for the individual scan rules. The **view-result** subcommand provides a human-readable output of the **ComplianceCheckResult** object details.

Procedure

- Run:

```
$ oc compliance view-result ocp4-cis-scheduler-no-bind-address
```

CHAPTER 6. FILE INTEGRITY OPERATOR

6.1. INSTALLING THE FILE INTEGRITY OPERATOR

6.1.1. Installing the File Integrity Operator using the web console

Prerequisites

- You must have **admin** privileges.

Procedure

1. In the OpenShift Container Platform web console, navigate to **Operators → OperatorHub**.
2. Search for the File Integrity Operator, then click **Install**.
3. Keep the default selection of **Installation mode** and **namespace** to ensure that the Operator will be installed to the **openshift-file-integrity** namespace.
4. Click **Install**.

Verification

To confirm that the installation is successful:

1. Navigate to the **Operators → Installed Operators** page.
2. Check that the Operator is installed in the **openshift-file-integrity** namespace and its status is **Succeeded**.

If the Operator is not installed successfully:

1. Navigate to the **Operators → Installed Operators** page and inspect the **Status** column for any errors or failures.
2. Navigate to the **Workloads → Pods** page and check the logs in any pods in the **openshift-file-integrity** project that are reporting issues.

6.1.2. Installing the File Integrity Operator using the CLI

Prerequisites

- You must have **admin** privileges.

Procedure

1. Create a **Namespace** object YAML file by running:

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

Example output

```
apiVersion: v1
```

```
kind: Namespace
metadata:
  name: openshift-file-integrity
```

2. Create the **OperatorGroup** object YAML file:

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

Example output

```
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: file-integrity-operator
  namespace: openshift-file-integrity
spec:
  targetNamespaces:
  - openshift-file-integrity
```

3. Create the **Subscription** object YAML file:

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

Example output

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: file-integrity-operator
  namespace: openshift-file-integrity
spec:
  channel: "release-0.1"
  installPlanApproval: Automatic
  name: file-integrity-operator
  source: redhat-operators
  sourceNamespace: openshift-marketplace
```

Verification

1. Verify the installation succeeded by inspecting the CSV file:

```
$ oc get csv -n openshift-file-integrity
```

2. Verify that the File Integrity Operator is up and running:

```
$ oc get deploy -n openshift-file-integrity
```

6.1.3. Additional resources

- The File Integrity Operator is supported in a restricted network environment. For more information, see Using Operator Lifecycle Manager on restricted networks .

6.2. UNDERSTANDING THE FILE INTEGRITY OPERATOR

The File Integrity Operator is an OpenShift Container Platform Operator that continually runs file integrity checks on the cluster nodes. It deploys a daemon set that initializes and runs privileged advanced intrusion detection environment (AIDE) containers on each node, providing a status object with a log of files that are modified during the initial run of the daemon set pods.

IMPORTANT

Currently, only Red Hat Enterprise Linux CoreOS (RHCOS) nodes are supported.

6.2.1. Understanding the FileIntegrity custom resource

An instance of a **FileIntegrity** custom resource (CR) represents a set of continuous file integrity scans for one or more nodes.

Each **FileIntegrity** CR is backed by a daemon set running AIDE on the nodes matching the **FileIntegrity** CR specification.

The following example **FileIntegrity** CR enables scans on only the worker nodes, but otherwise uses the defaults.

Example FileIntegrity CR

```
apiVersion: fileintegrity.openshift.io/v1alpha1
kind: FileIntegrity
metadata:
  name: worker-fileintegrity
  namespace: openshift-file-integrity
spec:
  nodeSelector:
      node-role.kubernetes.io/worker: ""
  config: {}
```

6.2.2. Checking the FileIntegrity custom resource status

The **FileIntegrity** custom resource (CR) reports its status through the . **status.phase** subresource.

Procedure

- To query the **FileIntegrity** CR status, run:

  ```
  $ oc get fileintegrities/worker-fileintegrity  -o jsonpath="{ .status.phase }"
  ```

  #### Example output

  ```
  Active
  ```

6.2.3. FileIntegrity custom resource phases

- **Pending** - The phase after the custom resource (CR) is created.
- **Active** - The phase when the backing daemon set is up and running.

- **Initializing** - The phase when the AIDE database is being reinitialized.

6.2.4. Understanding the FileIntegrityNodeStatuses object

The scan results of the **FileIntegrity** CR are reported in another object called **FileIntegrityNodeStatuses**.

```
$ oc get fileintegritynodestatuses
```

Example output

```
NAME                                              AGE
worker-fileintegrity-ip-10-0-130-192.ec2.internal   101s
worker-fileintegrity-ip-10-0-147-133.ec2.internal   109s
worker-fileintegrity-ip-10-0-165-160.ec2.internal   102s
```

NOTE

The **FileIntegrityNodeStatus** object might not be created until the second run of the scanner is finished. The period is configurable.

There is one result object per node. The **nodeName** attribute of each **FileIntegrityNodeStatus** object corresponds to the node being scanned. The status of the file integrity scan is represented in the **results** array, which holds scan conditions.

```
$ oc get fileintegritynodestatuses.fileintegrity.openshift.io -ojsonpath='{.items[*].results}' | jq
```

The **fileintegritynodestatus** object reports the latest status of an AIDE run and exposes the status as **Failed**, **Succeeded**, or **Errored** in a **status** field.

```
$ oc get fileintegritynodestatuses -w
```

Example output

```
NAME                                                            NODE                                 STATUS
example-fileintegrity-ip-10-0-134-186.us-east-2.compute.internal   ip-10-0-134-186.us-east-
2.compute.internal   Succeeded
example-fileintegrity-ip-10-0-150-230.us-east-2.compute.internal   ip-10-0-150-230.us-east-
2.compute.internal   Succeeded
example-fileintegrity-ip-10-0-169-137.us-east-2.compute.internal   ip-10-0-169-137.us-east-
2.compute.internal   Succeeded
example-fileintegrity-ip-10-0-180-200.us-east-2.compute.internal   ip-10-0-180-200.us-east-
2.compute.internal   Succeeded
example-fileintegrity-ip-10-0-194-66.us-east-2.compute.internal    ip-10-0-194-66.us-east-
2.compute.internal    Failed
example-fileintegrity-ip-10-0-222-188.us-east-2.compute.internal   ip-10-0-222-188.us-east-
2.compute.internal   Succeeded
example-fileintegrity-ip-10-0-134-186.us-east-2.compute.internal   ip-10-0-134-186.us-east-
2.compute.internal   Succeeded
example-fileintegrity-ip-10-0-222-188.us-east-2.compute.internal   ip-10-0-222-188.us-east-
2.compute.internal   Succeeded
example-fileintegrity-ip-10-0-194-66.us-east-2.compute.internal    ip-10-0-194-66.us-east-
```

```
2.compute.internal    Failed
example-fileintegrity-ip-10-0-150-230.us-east-2.compute.internal   ip-10-0-150-230.us-east-
2.compute.internal   Succeeded
example-fileintegrity-ip-10-0-180-200.us-east-2.compute.internal   ip-10-0-180-200.us-east-
2.compute.internal   Succeeded
```

6.2.5. FileIntegrityNodeStatus CR status types

These conditions are reported in the results array of the corresponding **FileIntegrityNodeStatus** CR status:

- **Succeeded** - The integrity check passed; the files and directories covered by the AIDE check have not been modified since the database was last initialized.
- **Failed** - The integrity check failed; some files or directories covered by the AIDE check have been modified since the database was last initialized.
- **Errored** - The AIDE scanner encountered an internal error.

6.2.5.1. FileIntegrityNodeStatus CR success example

Example output of a condition with a success status

```
[
  {
    "condition": "Succeeded",
    "lastProbeTime": "2020-09-15T12:45:57Z"
  }
]
[
  {
    "condition": "Succeeded",
    "lastProbeTime": "2020-09-15T12:46:03Z"
  }
]
[
  {
    "condition": "Succeeded",
    "lastProbeTime": "2020-09-15T12:45:48Z"
  }
]
```

In this case, all three scans succeeded and so far there are no other conditions.

6.2.5.2. FileIntegrityNodeStatus CR failure status example

To simulate a failure condition, modify one of the files AIDE tracks. For example, modify **/etc/resolv.conf** on one of the worker nodes:

```
$ oc debug node/ip-10-0-130-192.ec2.internal
```

Example output

```
Creating debug namespace/openshift-debug-node-ldfbj ...
Starting pod/ip-10-0-130-192ec2internal-debug ...
To use host binaries, run `chroot /host`
Pod IP: 10.0.130.192
If you don't see a command prompt, try pressing enter.
sh-4.2# echo "# integrity test" >> /host/etc/resolv.conf
sh-4.2# exit

Removing debug pod ...
Removing debug namespace/openshift-debug-node-ldfbj ...
```

After some time, the **Failed** condition is reported in the results array of the corresponding **FileIntegrityNodeStatus** object. The previous **Succeeded** condition is retained, which allows you to pinpoint the time the check failed.

```
$ oc get fileintegritynodestatuses.fileintegrity.openshift.io/worker-fileintegrity-ip-10-0-130-
192.ec2.internal -ojsonpath='{.results}' | jq -r
```

Alternatively, if you are not mentioning the object name, run:

```
$ oc get fileintegritynodestatuses.fileintegrity.openshift.io -ojsonpath='{.items[*].results}' | jq
```

Example output

```
[
  {
    "condition": "Succeeded",
    "lastProbeTime": "2020-09-15T12:54:14Z"
  },
  {
    "condition": "Failed",
    "filesChanged": 1,
    "lastProbeTime": "2020-09-15T12:57:20Z",
    "resultConfigMapName": "aide-ds-worker-fileintegrity-ip-10-0-130-192.ec2.internal-failed",
    "resultConfigMapNamespace": "openshift-file-integrity"
  }
]
```

The **Failed** condition points to a config map that gives more details about what exactly failed and why:

```
$ oc describe cm aide-ds-worker-fileintegrity-ip-10-0-130-192.ec2.internal-failed
```

Example output

```
Name:         aide-ds-worker-fileintegrity-ip-10-0-130-192.ec2.internal-failed
Namespace:    openshift-file-integrity
Labels:       file-integrity.openshift.io/node=ip-10-0-130-192.ec2.internal
              file-integrity.openshift.io/owner=worker-fileintegrity
              file-integrity.openshift.io/result-log=
Annotations:  file-integrity.openshift.io/files-added: 0
              file-integrity.openshift.io/files-changed: 1
              file-integrity.openshift.io/files-removed: 0
```

```
Data

integritylog:
------
AIDE 0.15.1 found differences between database and filesystem!!
Start timestamp: 2020-09-15 12:58:15

Summary:
  Total number of files:  31553
  Added files:            0
  Removed files:          0
  Changed files:          1


---------------------------------------------------
Changed files:
---------------------------------------------------

changed: /hostroot/etc/resolv.conf

---------------------------------------------------
Detailed information about changes:
---------------------------------------------------


File: /hostroot/etc/resolv.conf
 SHA512    : sTQYpB/AL7FeoGtu/1g7opv6C+KT1CBJ , qAeM+a8yTgHPnIHMaRlS+so61EN8VOpg

Events:  <none>
```

Due to the config map data size limit, AIDE logs over 1 MB are added to the failure config map as a base64-encoded gzip archive. In this case, you want to pipe the output of the above command to **base64 --decode | gunzip**. Compressed logs are indicated by the presence of a **file-integrity.openshift.io/compressed** annotation key in the config map.

6.2.6. Understanding events

Transitions in the status of the **FileIntegrity** and **FileIntegrityNodeStatus** objects are logged by *events*. The creation time of the event reflects the latest transition, such as **Initializing** to **Active**, and not necessarily the latest scan result. However, the newest event always reflects the most recent status.

```
$ oc get events --field-selector reason=FileIntegrityStatus
```

Example output

```
LAST SEEN   TYPE     REASON              OBJECT                             MESSAGE
97s         Normal   FileIntegrityStatus   fileintegrity/example-fileintegrity   Pending
67s         Normal   FileIntegrityStatus   fileintegrity/example-fileintegrity   Initializing
37s         Normal   FileIntegrityStatus   fileintegrity/example-fileintegrity   Active
```

When a node scan fails, an event is created with the **add/changed/removed** and config map information.

```
$ oc get events --field-selector reason=NodeIntegrityStatus
```

Example output

```
LAST SEEN   TYPE      REASON               OBJECT                               MESSAGE
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-134-173.ec2.internal
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-168-238.ec2.internal
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-169-175.ec2.internal
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-152-92.ec2.internal
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-158-144.ec2.internal
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-131-30.ec2.internal
87m         Warning   NodeIntegrityStatus   fileintegrity/example-fileintegrity   node ip-10-0-152-92.ec2.internal has changed! a:1,c:1,r:0 \ log:openshift-file-integrity/aide-ds-example-fileintegrity-ip-10-0-152-92.ec2.internal-failed
```

Changes to the number of added, changed, or removed files results in a new event, even if the status of the node has not transitioned.

```
$ oc get events --field-selector reason=NodeIntegrityStatus
```

Example output

```
LAST SEEN   TYPE      REASON               OBJECT                               MESSAGE
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-134-173.ec2.internal
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-168-238.ec2.internal
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-169-175.ec2.internal
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-152-92.ec2.internal
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-158-144.ec2.internal
114m        Normal    NodeIntegrityStatus   fileintegrity/example-fileintegrity   no changes to node ip-10-0-131-30.ec2.internal
87m         Warning   NodeIntegrityStatus   fileintegrity/example-fileintegrity   node ip-10-0-152-92.ec2.internal has changed! a:1,c:1,r:0 \ log:openshift-file-integrity/aide-ds-example-fileintegrity-ip-10-0-152-92.ec2.internal-failed
40m         Warning   NodeIntegrityStatus   fileintegrity/example-fileintegrity   node ip-10-0-152-92.ec2.internal has changed! a:3,c:1,r:0 \ log:openshift-file-integrity/aide-ds-example-fileintegrity-ip-10-0-152-92.ec2.internal-failed
```

6.3. CONFIGURING THE CUSTOM FILE INTEGRITY OPERATOR

6.3.1. Viewing FileIntegrity object attributes

As with any Kubernetes custom resources (CRs), you can run **oc explain fileintegrity**, and then look at the individual attributes using:

```
$ oc explain fileintegrity.spec
```

```
$ oc explain fileintegrity.spec.config
```

6.3.2. Important attributes

Table 6.1. Important **spec** and **spec.config** attributes

Attribute	Description
spec.nodeSelector	A map of key-values pairs that must match with node's labels in order for the AIDE pods to be schedulable on that node. The typical use is to set only a single key-value pair where **node-role.kubernetes.io/worker: ""** schedules AIDE on all worker nodes, **node.openshift.io/os_id: "rhcos"** schedules on all Red Hat Enterprise Linux CoreOS (RHCOS) nodes.
spec.debug	A boolean attribute. If set to **true**, the daemon running in the AIDE deamon set's pods would output extra information.
spec.tolerations	Specify tolerations to schedule on nodes with custom taints. When not specified, a default toleration is applied, which allows tolerations to run on control plane nodes.
spec.config.gracePeriod	The number of seconds to pause in between AIDE integrity checks. Frequent AIDE checks on a node can be resource intensive, so it can be useful to specify a longer interval. Defaults to **900**, or 15 minutes.
spec.config.name, **spec.config.namespace**, **spec.config.key**	These three attributes allow you to set a custom AIDE configuration. When the name or namespace are unset, the File Integrity Operator generates a configuration suitable for RHCOS systems. The name and namespace attributes point to the config map; the key points to a key inside that config map. Use the key attribute to specify a custom key that contains the actual config and defaults to **aide.conf**.

6.3.3. Examine the default configuration

The default File Integrity Operator configuration is stored in a config map with the same name as the **FileIntegrity** CR.

Procedure

- To examine the default config, run:

```
$ oc describe cm/worker-fileintegrity
```

6.3.4. Understanding the default File Integrity Operator configuration

Below is an excerpt from the **aide.conf** key of the config map:

```
@@define DBDIR /hostroot/etc/kubernetes
@@define LOGDIR /hostroot/etc/kubernetes
database=file:@@{DBDIR}/aide.db.gz
database_out=file:@@{DBDIR}/aide.db.gz
gzip_dbout=yes
verbose=5
report_url=file:@@{LOGDIR}/aide.log
report_url=stdout
PERMS = p+u+g+acl+selinux+xattrs
CONTENT_EX = sha512+ftype+p+u+g+n+acl+selinux+xattrs

/hostroot/boot/     CONTENT_EX
/hostroot/root/\..* PERMS
/hostroot/root/   CONTENT_EX
```

The default configuration for a **FileIntegrity** instance provides coverage for files under the following directories:

- **/root**
- **/boot**
- **/usr**
- **/etc**

The following directories are not covered:

- **/var**
- **/opt**
- Some OpenShift Container Platform-specific excludes under **/etc/**

6.3.5. Supplying a custom AIDE configuration

Any entries that configure AIDE internal behavior such as **DBDIR**, **LOGDIR**, **database**, and **database_out** are overwritten by the Operator. The Operator would add a prefix to **/hostroot/** before all paths to be watched for integrity changes. This makes reusing existing AIDE configs that might often not be tailored for a containerized environment and start from the root directory easier.

NOTE

/hostroot is the directory where the pods running AIDE mount the host's file system. Changing the configuration triggers a reinitializing of the database.

6.3.6. Defining a custom File Integrity Operator configuration

This example focuses on defining a custom configuration for a scanner that runs on the control plane nodes based on the default configuration provided for the **worker-fileintegrity** CR. This workflow might be useful if you are planning to deploy a custom software running as a daemon set and storing its data under **/opt/mydaemon** on the control plane nodes.

Procedure

1. Make a copy of the default configuration.
2. Edit the default configuration with the files that must be watched or excluded.
3. Store the edited contents in a new config map.
4. Point the **FileIntegrity** object to the new config map through the attributes in **spec.config**.
5. Extract the default configuration:

   ```
   $ oc extract cm/worker-fileintegrity --keys=aide.conf
   ```

   This creates a file named **aide.conf** that you can edit. To illustrate how the Operator post-processes the paths, this example adds an exclude directory without the prefix:

   ```
   $ vim aide.conf
   ```

   #### Example output

   ```
   /hostroot/etc/kubernetes/static-pod-resources
   !/hostroot/etc/kubernetes/aide.*
   !/hostroot/etc/kubernetes/manifests
   !/hostroot/etc/docker/certs.d
   !/hostroot/etc/selinux/targeted
   !/hostroot/etc/openvswitch/conf.db
   ```

   Exclude a path specific to control plane nodes:

   ```
   !/opt/mydaemon/
   ```

   Store the other content in **/etc**:

   ```
   /hostroot/etc/ CONTENT_EX
   ```

6. Create a config map based on this file:

   ```
   $ oc create cm master-aide-conf --from-file=aide.conf
   ```

7. Define a **FileIntegrity** CR manifest that references the config map:

   ```
   apiVersion: fileintegrity.openshift.io/v1alpha1
   kind: FileIntegrity
   metadata:
     name: master-fileintegrity
     namespace: openshift-file-integrity
   spec:
   ```

```
  nodeSelector:
      node-role.kubernetes.io/master: ""
  config:
      name: master-aide-conf
      namespace: openshift-file-integrity
```

The Operator processes the provided config map file and stores the result in a config map with the same name as the **FileIntegrity** object:

```
$ oc describe cm/master-fileintegrity | grep /opt/mydaemon
```

Example output

```
!/hostroot/opt/mydaemon
```

6.3.7. Changing the custom File Integrity configuration

To change the File Integrity configuration, never change the generated config map. Instead, change the config map that is linked to the **FileIntegrity** object through the **spec.name**, **namespace**, and **key** attributes.

6.4. PERFORMING ADVANCED CUSTOM FILE INTEGRITY OPERATOR TASKS

6.4.1. Reinitializing the database

If the File Integrity Operator detects a change that was planned, it might be required to reinitialize the database.

Procedure

- Annotate the **FileIntegrity** custom resource (CR) with **file-integrity.openshift.io/re-init**:

  ```
  $ oc annotate fileintegrities/worker-fileintegrity file-integrity.openshift.io/re-init=
  ```

  The old database and log files are backed up and a new database is initialized. The old database and logs are retained on the nodes under **/etc/kubernetes**, as seen in the following output from a pod spawned using **oc debug**:

  Example output

  ```
   ls -lR /host/etc/kubernetes/aide.*
  -rw-------. 1 root root 1839782 Sep 17 15:08 /host/etc/kubernetes/aide.db.gz
  -rw-------. 1 root root 1839783 Sep 17 14:30 /host/etc/kubernetes/aide.db.gz.backup-
  20200917T15_07_38
  -rw-------. 1 root root   73728 Sep 17 15:07 /host/etc/kubernetes/aide.db.gz.backup-
  20200917T15_07_55
  -rw-r--r--. 1 root root       0 Sep 17 15:08 /host/etc/kubernetes/aide.log
  -rw-------. 1 root root     613 Sep 17 15:07 /host/etc/kubernetes/aide.log.backup-
  20200917T15_07_38
  -rw-r--r--. 1 root root       0 Sep 17 15:07 /host/etc/kubernetes/aide.log.backup-
  20200917T15_07_55
  ```

To provide some permanence of record, the resulting config maps are not owned by the **FileIntegrity** object, so manual cleanup is necessary. As a result, any previous integrity failures would still be visible in the **FileIntegrityNodeStatus** object.

6.4.2. Machine config integration

In OpenShift Container Platform 4, the cluster node configuration is delivered through **MachineConfig** objects. You can assume that the changes to files that are caused by a **MachineConfig** object are expected and should not cause the file integrity scan to fail. To suppress changes to files caused by **MachineConfig** object updates, the File Integrity Operator watches the node objects; when a node is being updated, the AIDE scans are suspended for the duration of the update. When the update finishes, the database is reinitialized and the scans resume.

This pause and resume logic only applies to updates through the **MachineConfig** API, as they are reflected in the node object annotations.

6.4.3. Exploring the daemon sets

Each **FileIntegrity** object represents a scan on a number of nodes. The scan itself is performed by pods managed by a daemon set.

To find the daemon set that represents a **FileIntegrity** object, run:

```
$ oc get ds/aide-ds-$file-integrity-object-name
```

To list the pods in that daemon set, run:

```
$ oc get pods -lapp=$ds-name
```

To view logs of a single AIDE pod, call **oc logs** on one of the pods.

Example output

```
debug: aide files locked by aideLoop
running aide check
aide check returned status 0
debug: aide files unlocked by aideLoop
debug: Getting FileIntegrity openshift-file-integrity/worker-fileintegrity
Created OK configMap 'aide-ds-worker-fileintegrity-ip-10-0-128-73.eu-north-1.compute.internal'
```

The config maps created by the AIDE daemon are not retained and are deleted after the File Integrity Operator processes them. However, on failure and error, the contents of these config maps are copied to the config map that the **FileIntegrityNodeStatus** object points to.

6.5. TROUBLESHOOTING THE FILE INTEGRITY OPERATOR

6.5.1. General troubleshooting

Issue

You want to generally troubleshoot issues with the File Integrity Operator.

Resolution

Enable the debug flag in the **FileIntegrity** object. The **debug** flag increases the verbosity of the daemons that run in the **DaemonSet** pods and run the AIDE checks.

6.5.2. Checking the AIDE configuration

Issue

You want to check the AIDE configuration.

Resolution

The AIDE configuration is stored in a config map with the same name as the **FileIntegrity** object. All AIDE configuration config maps are labeled with **file-integrity.openshift.io/aide-conf**.

6.5.3. Determining the FileIntegrity object's phase

Issue

You want to determine if the **FileIntegrity** object exists and see its current status.

Resolution

To see the **FileIntegrity** object's current status, run:

```
$ oc get fileintegrities/worker-fileintegrity  -o jsonpath="{ .status }"
```

Once the **FileIntegrity** object and the backing daemon set are created, the status should switch to **Active**. If it does not, check the Operator pod logs.

6.5.4. Determining that the daemon set's pods are running on the expected nodes

Issue

You want to confirm that the daemon set exists and that its pods are running on the nodes you expect them to run on.

Resolution

Run:

```
$ oc get pods -lapp=aide-ds-$(<FIO_NAME>)
```

- **FIO_NAME** is the name of the **FileIntegrity** object to get a list of the pods.
- Adding **-owide** adds the IP address of the node the pod is running on.

To check the logs of the daemon pods, run **oc logs**

Check the return value of the AIDE command to see if the check passed or failed.

CHAPTER 7. VIEWING AUDIT LOGS

OpenShift Container Platform auditing provides a security-relevant chronological set of records documenting the sequence of activities that have affected the system by individual users, administrators, or other components of the system.

7.1. ABOUT THE API AUDIT LOG

Audit works at the API server level, logging all requests coming to the server. Each audit log contains the following information:

Table 7.1. Audit log fields

Field	Description
level	The audit level at which the event was generated.
auditID	A unique audit ID, generated for each request.
stage	The stage of the request handling when this event instance was generated.
requestURI	The request URI as sent by the client to a server.
verb	The Kubernetes verb associated with the request. For non-resource requests, this is the lowercase HTTP method.
user	The authenticated user information.
impersonatedUser	Optional. The impersonated user information, if the request is impersonating another user.
sourceIPs	Optional. The source IPs, from where the request originated and any intermediate proxies.
userAgent	Optional. The user agent string reported by the client. Note that the user agent is provided by the client, and must not be trusted.
objectRef	Optional. The object reference this request is targeted at. This does not apply for **List**-type requests, or non-resource requests.
responseStatus	Optional. The response status, populated even when the **ResponseObject** is not a **Status** type. For successful responses, this will only include the code. For non-status type error responses, this will be auto-populated with the error message.

Field	Description
requestObject	Optional. The API object from the request, in JSON format. The **RequestObject** is recorded as is in the request (possibly re-encoded as JSON), prior to version conversion, defaulting, admission or merging. It is an external versioned object type, and might not be a valid object on its own. This is omitted for non-resource requests and is only logged at request level and higher.
responseObject	Optional. The API object returned in the response, in JSON format. The **ResponseObject** is recorded after conversion to the external type, and serialized as JSON. This is omitted for non-resource requests and is only logged at response level.
requestReceivedTimestamp	The time that the request reached the API server.
stageTimestamp	The time that the request reached the current audit stage.
annotations	Optional. An unstructured key value map stored with an audit event that may be set by plug-ins invoked in the request serving chain, including authentication, authorization and admission plug-ins. Note that these annotations are for the audit event, and do not correspond to the **metadata.annotations** of the submitted object. Keys should uniquely identify the informing component to avoid name collisions, for example **podsecuritypolicy.admission.k8s.io/policy**. Values should be short. Annotations are included in the metadata level.

Example output for the Kubernetes API server:

```
{"kind":"Event","apiVersion":"audit.k8s.io/v1","level":"Metadata","auditID":"ad209ce1-fec7-4130-8192-c4cc63f1d8cd","stage":"ResponseComplete","requestURI":"/api/v1/namespaces/openshift-kube-controller-manager/configmaps/cert-recovery-controller-lock?timeout=35s","verb":"update","user":{"username":"system:serviceaccount:openshift-kube-controller-manager:localhost-recovery-client","uid":"dd4997e3-d565-4e37-80f8-7fc122ccd785","groups":["system:serviceaccounts","system:serviceaccounts:openshift-kube-controller-manager","system:authenticated"]},"sourceIPs":["::1"],"userAgent":"cluster-kube-controller-manager-operator/v0.0.0 (linux/amd64) kubernetes/$Format","objectRef":{"resource":"configmaps","namespace":"openshift-kube-controller-manager","name":"cert-recovery-controller-lock","uid":"5c57190b-6993-425d-8101-8337e48c7548","apiVersion":"v1","resourceVersion":"574307"},"responseStatus":{"metadata":{},"code":200},"requestReceivedTimestamp":"2020-04-02T08:27:20.200962Z","stageTimestamp":"2020-04-02T08:27:20.206710Z","annotations":{"authorization.k8s.io/decision":"allow","authorization.k8s.io/reason":"RBAC: allowed by ClusterRoleBinding \"system:openshift:operator:kube-controller-manager-recovery\" of ClusterRole \"cluster-admin\" to ServiceAccount \"localhost-recovery-client/openshift-kube-controller-manager\""}}
```

7.2. VIEWING THE AUDIT LOGS

You can view the logs for the OpenShift API server, Kubernetes API server, and OpenShift OAuth API server for each control plane node.

Procedure

To view the audit logs:

- View the OpenShift API server logs:

  a. List the OpenShift API server logs that are available for each control plane node:

  ```
  $ oc adm node-logs --role=master --path=openshift-apiserver/
  ```

  Example output

  ```
  ci-ln-m0wpfjb-f76d1-vnb5x-master-0 audit-2021-03-09T00-12-19.834.log
  ci-ln-m0wpfjb-f76d1-vnb5x-master-0 audit.log
  ci-ln-m0wpfjb-f76d1-vnb5x-master-1 audit-2021-03-09T00-11-49.835.log
  ci-ln-m0wpfjb-f76d1-vnb5x-master-1 audit.log
  ci-ln-m0wpfjb-f76d1-vnb5x-master-2 audit-2021-03-09T00-13-00.128.log
  ci-ln-m0wpfjb-f76d1-vnb5x-master-2 audit.log
  ```

  b. View a specific OpenShift API server log by providing the node name and the log name:

  ```
  $ oc adm node-logs <node_name> --path=openshift-apiserver/<log_name>
  ```

  For example:

  ```
  $ oc adm node-logs ci-ln-m0wpfjb-f76d1-vnb5x-master-0 --path=openshift-
  apiserver/audit-2021-03-09T00-12-19.834.log
  ```

  Example output

  ```
  {"kind":"Event","apiVersion":"audit.k8s.io/v1","level":"Metadata","auditID":"381acf6d-5f30-
  4c7d-8175-
  c9c317ae5893","stage":"ResponseComplete","requestURI":"/metrics","verb":"get","user":
  {"username":"system:serviceaccount:openshift-monitoring:prometheus-
  k8s","uid":"825b60a0-3976-4861-a342-3b2b561e8f82","groups":
  ["system:serviceaccounts","system:serviceaccounts:openshift-
  monitoring","system:authenticated"]},"sourceIPs":
  ["10.129.2.6"],"userAgent":"Prometheus/2.23.0","responseStatus":{"metadata":
  {},"code":200},"requestReceivedTimestamp":"2021-03-
  08T18:02:04.086545Z","stageTimestamp":"2021-03-
  08T18:02:04.107102Z","annotations":
  {"authorization.k8s.io/decision":"allow","authorization.k8s.io/reason":"RBAC: allowed by
  ClusterRoleBinding \"prometheus-k8s\" of ClusterRole \"prometheus-k8s\" to
  ServiceAccount \"prometheus-k8s/openshift-monitoring\""}}
  ```

- View the Kubernetes API server logs:

  a. List the Kubernetes API server logs that are available for each control plane node:

  ```
  $ oc adm node-logs --role=master --path=kube-apiserver/
  ```

Example output

```
ci-ln-m0wpfjb-f76d1-vnb5x-master-0 audit-2021-03-09T14-07-27.129.log
ci-ln-m0wpfjb-f76d1-vnb5x-master-0 audit.log
ci-ln-m0wpfjb-f76d1-vnb5x-master-1 audit-2021-03-09T19-24-22.620.log
ci-ln-m0wpfjb-f76d1-vnb5x-master-1 audit.log
ci-ln-m0wpfjb-f76d1-vnb5x-master-2 audit-2021-03-09T18-37-07.511.log
ci-ln-m0wpfjb-f76d1-vnb5x-master-2 audit.log
```

b. View a specific Kubernetes API server log by providing the node name and the log name:

```
$ oc adm node-logs <node_name> --path=kube-apiserver/<log_name>
```

For example:

```
$ oc adm node-logs ci-ln-m0wpfjb-f76d1-vnb5x-master-0 --path=kube-apiserver/audit-
2021-03-09T14-07-27.129.log
```

Example output

```
{"kind":"Event","apiVersion":"audit.k8s.io/v1","level":"Metadata","auditID":"cfce8a0b-b5f5-
4365-8c9f-
79c1227d10f9","stage":"ResponseComplete","requestURI":"/api/v1/namespaces/openshift-
kube-scheduler/serviceaccounts/openshift-kube-scheduler-sa","verb":"get","user":
{"username":"system:serviceaccount:openshift-kube-scheduler-operator:openshift-kube-
scheduler-operator","uid":"2574b041-f3c8-44e6-a057-baef7aa81516","groups":
["system:serviceaccounts","system:serviceaccounts:openshift-kube-scheduler-
operator","system:authenticated"]},"sourceIPs":["10.128.0.8"],"userAgent":"cluster-kube-
scheduler-operator/v0.0.0 (linux/amd64) kubernetes/$Format","objectRef":
{"resource":"serviceaccounts","namespace":"openshift-kube-
scheduler","name":"openshift-kube-scheduler-sa","apiVersion":"v1"},"responseStatus":
{"metadata":{},"code":200},"requestReceivedTimestamp":"2021-03-
08T18:06:42.512619Z","stageTimestamp":"2021-03-
08T18:06:42.516145Z","annotations":{"authentication.k8s.io/legacy-
token":"system:serviceaccount:openshift-kube-scheduler-operator:openshift-kube-
scheduler-
operator","authorization.k8s.io/decision":"allow","authorization.k8s.io/reason":"RBAC:
allowed by ClusterRoleBinding \"system:openshift:operator:cluster-kube-scheduler-
operator\" of ClusterRole \"cluster-admin\" to ServiceAccount \"openshift-kube-scheduler-
operator/openshift-kube-scheduler-operator\""}}
```

- View the OpenShift OAuth API server logs:

a. List the OpenShift OAuth API server logs that are available for each control plane node:

```
$ oc adm node-logs --role=master --path=oauth-apiserver/
```

Example output

```
ci-ln-m0wpfjb-f76d1-vnb5x-master-0 audit-2021-03-09T13-06-26.128.log
ci-ln-m0wpfjb-f76d1-vnb5x-master-0 audit.log
ci-ln-m0wpfjb-f76d1-vnb5x-master-1 audit-2021-03-09T18-23-21.619.log
```

```
ci-ln-m0wpfjb-f76d1-vnb5x-master-1 audit.log
ci-ln-m0wpfjb-f76d1-vnb5x-master-2 audit-2021-03-09T17-36-06.510.log
ci-ln-m0wpfjb-f76d1-vnb5x-master-2 audit.log
```

b. View a specific OpenShift OAuth API server log by providing the node name and the log name:

```
$ oc adm node-logs <node_name> --path=oauth-apiserver/<log_name>
```

For example:

```
$ oc adm node-logs ci-ln-m0wpfjb-f76d1-vnb5x-master-0 --path=oauth-apiserver/audit-
2021-03-09T13-06-26.128.log
```

Example output

```
{"kind":"Event","apiVersion":"audit.k8s.io/v1","level":"Metadata","auditID":"dd4c44e2-
3ea1-4830-9ab7-
c91a5f1388d6","stage":"ResponseComplete","requestURI":"/apis/user.openshift.io/v1/users
/~","verb":"get","user":{"username":"system:serviceaccount:openshift-
monitoring:prometheus-k8s","groups":
["system:serviceaccounts","system:serviceaccounts:openshift-
monitoring","system:authenticated"]},"sourceIPs":
["10.0.32.4","10.128.0.1"],"userAgent":"dockerregistry/v0.0.0 (linux/amd64)
kubernetes/$Format","objectRef":
{"resource":"users","name":"~","apiGroup":"user.openshift.io","apiVersion":"v1"},"response
Status":{"metadata":{},"code":200},"requestReceivedTimestamp":"2021-03-
08T17:47:43.653187Z","stageTimestamp":"2021-03-
08T17:47:43.660187Z","annotations":
{"authorization.k8s.io/decision":"allow","authorization.k8s.io/reason":"RBAC: allowed by
ClusterRoleBinding \"basic-users\" of ClusterRole \"basic-user\" to Group
\"system:authenticated\""}}
```

7.3. FILTERING AUDIT LOGS

You can use **jq** or another JSON parsing tool to filter the API server audit logs.

NOTE

The amount of information logged to the API server audit logs is controlled by the audit log policy that is set.

The following procedure provides examples of using **jq** to filter audit logs on control plane node **node-1.example.com**. See the jq Manual for detailed information on using **jq**.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.
- You have installed **jq**.

Procedure

- Filter OpenShift API server audit logs by user:

```
$ oc adm node-logs node-1.example.com  \
  --path=openshift-apiserver/audit.log \
  | jq 'select(.user.username == "myusername")'
```

- Filter OpenShift API server audit logs by user agent:

```
$ oc adm node-logs node-1.example.com  \
  --path=openshift-apiserver/audit.log \
  | jq 'select(.userAgent == "cluster-version-operator/v0.0.0 (linux/amd64)
kubernetes/$Format")'
```

- Filter Kubernetes API server audit logs by a certain API version and only output the user agent:

```
$ oc adm node-logs node-1.example.com  \
  --path=kube-apiserver/audit.log \
  | jq 'select(.requestURI | startswith("/apis/apiextensions.k8s.io/v1beta1")) | .userAgent'
```

- Filter OpenShift OAuth API server audit logs by excluding a verb:

```
$ oc adm node-logs node-1.example.com  \
  --path=oauth-apiserver/audit.log \
  | jq 'select(.verb != "get")'
```

7.4. ADDITIONAL RESOURCES

- API audit log event structure
- Configuring the audit log policy
- Forwarding logs to third party systems

CHAPTER 8. CONFIGURING THE AUDIT LOG POLICY

You can control the amount of information that is logged to the API server audit logs by choosing the audit log policy profile to use.

8.1. ABOUT AUDIT LOG POLICY PROFILES

Audit log profiles define how to log requests that come to the OpenShift API server, the Kubernetes API server, and the OAuth API server.

OpenShift Container Platform provides the following predefined audit policy profiles:

Profile	Description
Default	Logs only metadata for read and write requests; does not log request bodies except for OAuth access token requests. This is the default policy.
WriteRequestBodies	In addition to logging metadata for all requests, logs request bodies for every write request to the API servers (**create**, **update**, **patch**). This profile has more resource overhead than the **Default** profile. [1]
AllRequestBodies	In addition to logging metadata for all requests, logs request bodies for every read and write request to the API servers (**get**, **list**, **create**, **update**, **patch**). This profile has the most resource overhead.[1]
None	No requests are logged; even OAuth access token requests and OAuth authorize token requests are not logged. WARNING: It is not recommended to disable audit logging by using the **None** profile unless you are fully aware of the risks of not logging data that can be beneficial when troubleshooting issues. If you disable audit logging and a support situation arises, you might need to enable audit logging and reproduce the issue in order to troubleshoot properly.

1. Sensitive resources, such as **Secret**, **Route**, and **OAuthClient** objects, are never logged past the metadata level.

By default, OpenShift Container Platform uses the **Default** audit log profile. You can use another audit policy profile that also logs request bodies, but be aware of the increased resource usage (CPU, memory, and I/O).

8.2. CONFIGURING THE AUDIT LOG POLICY

You can configure the audit log policy to use when logging requests that come to the API servers.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

1. Edit the **APIServer** resource:

```
$ oc edit apiserver cluster
```

2. Update the **spec.audit.profile** field:

```
apiVersion: config.openshift.io/v1
kind: APIServer
metadata:
...
spec:
  audit:
    profile: WriteRequestBodies 1
```

1 Set to **Default**, **WriteRequestBodies**, **AllRequestBodies**, or **None**. The default profile is **Default**.

WARNING

It is not recommended to disable audit logging by using the **None** profile unless you are fully aware of the risks of not logging data that can be beneficial when troubleshooting issues. If you disable audit logging and a support situation arises, you might need to enable audit logging and reproduce the issue in order to troubleshoot properly.

3. Save the file to apply the changes.

Verification

- Verify that a new revision of the Kubernetes API server pods is rolled out. It can take several minutes for all nodes to update to the new revision.

```
$ oc get kubeapiserver -o=jsonpath='{range .items[0].status.conditions[?
(@.type=="NodeInstallerProgressing")]}{.reason}{"\n"}{.message}{"\n"}'
```

Review the **NodeInstallerProgressing** status condition for the Kubernetes API server to verify that all nodes are at the latest revision. The output shows **AllNodesAtLatestRevision** upon successful update:

```
AllNodesAtLatestRevision
3 nodes are at revision 12 (1)
```

(1) In this example, the latest revision number is **12**.

If the output shows a message similar to one of the following messages, the update is still in progress. Wait a few minutes and try again.

- **3 nodes are at revision 11; 0 nodes have achieved new revision 12**
- **2 nodes are at revision 11; 1 nodes are at revision 12**

8.3. CONFIGURING THE AUDIT LOG POLICY WITH CUSTOM RULES

You can configure an audit log policy that defines custom rules. You can specify multiple groups and define which profile to use for that group.

These custom rules take precedence over the top-level profile field. The custom rules are evaluated from top to bottom, and the first that matches is applied.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

1. Edit the **APIServer** resource:

```
$ oc edit apiserver cluster
```

2. Add the **spec.audit.customRules** field:

```
apiVersion: config.openshift.io/v1
kind: APIServer
metadata:
...
spec:
  audit:
    customRules:                    (1)
    - group: system:authenticated:oauth
      profile: WriteRequestBodies
    - group: system:authenticated
      profile: AllRequestBodies
    profile: Default                (2)
```

(1) Add one or more groups and specify the profile to use for that group. These custom rules take precedence over the top-level profile field. The custom rules are evaluated from top to bottom, and the first that matches is applied.

(2) Set to **Default**, **WriteRequestBodies**, **AllRequestBodies**, or **None**. If you do not set this top-level **audit.profile** field, it defaults to the **Default** profile.

WARNING

It is not recommended to disable audit logging by using the **None** profile unless you are fully aware of the risks of not logging data that can be beneficial when troubleshooting issues. If you disable audit logging and a support situation arises, you might need to enable audit logging and reproduce the issue in order to troubleshoot properly.

3. Save the file to apply the changes.

Verification

- Verify that a new revision of the Kubernetes API server pods is rolled out. It can take several minutes for all nodes to update to the new revision.

```
$ oc get kubeapiserver -o=jsonpath='{range .items[0].status.conditions[?(@.type=="NodeInstallerProgressing")]}{.reason}{"\n"}{.message}{"\n"}'
```

  Review the **NodeInstallerProgressing** status condition for the Kubernetes API server to verify that all nodes are at the latest revision. The output shows **AllNodesAtLatestRevision** upon successful update:

```
AllNodesAtLatestRevision
3 nodes are at revision 12 (1)
```

  (1) In this example, the latest revision number is **12**.

  If the output shows a message similar to one of the following messages, the update is still in progress. Wait a few minutes and try again.

  - **3 nodes are at revision 11; 0 nodes have achieved new revision 12**
  - **2 nodes are at revision 11; 1 nodes are at revision 12**

8.4. DISABLING AUDIT LOGGING

You can disable audit logging for OpenShift Container Platform. When you disable audit logging, even OAuth access token requests and OAuth authorize token requests are not logged.

WARNING

It is not recommended to disable audit logging by using the **None** profile unless you are fully aware of the risks of not logging data that can be beneficial when troubleshooting issues. If you disable audit logging and a support situation arises, you might need to enable audit logging and reproduce the issue in order to troubleshoot properly.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

1. Edit the **APIServer** resource:

```
$ oc edit apiserver cluster
```

2. Set the **spec.audit.profile** field to **None**:

```
apiVersion: config.openshift.io/v1
kind: APIServer
metadata:
...
spec:
  audit:
    profile: None
```

NOTE

You can also disable audit logging only for specific groups by specifying custom rules in the **spec.audit.customRules** field.

3. Save the file to apply the changes.

Verification

- Verify that a new revision of the Kubernetes API server pods is rolled out. It can take several minutes for all nodes to update to the new revision.

```
$ oc get kubeapiserver -o=jsonpath='{range .items[0].status.conditions[?
(@.type=="NodeInstallerProgressing")]}{.reason}{"\n"}{.message}{"\n"}'
```

Review the **NodeInstallerProgressing** status condition for the Kubernetes API server to verify that all nodes are at the latest revision. The output shows **AllNodesAtLatestRevision** upon successful update:

```
AllNodesAtLatestRevision
3 nodes are at revision 12 (1)
```

1 In this example, the latest revision number is **12**.

If the output shows a message similar to one of the following messages, the update is still in progress. Wait a few minutes and try again.

- **3 nodes are at revision 11; 0 nodes have achieved new revision 12**
- **2 nodes are at revision 11; 1 nodes are at revision 12**

CHAPTER 9. CONFIGURING TLS SECURITY PROFILES

TLS security profiles provide a way for servers to regulate which ciphers a client can use when connecting to the server. This ensures that OpenShift Container Platform components use cryptographic libraries that do not allow known insecure protocols, ciphers, or algorithms.

Cluster administrators can choose which TLS security profile to use for each of the following components:

- the Ingress Controller
- the control plane
  This includes the Kubernetes API server, Kubernetes controller manager, Kubernetes scheduler, OpenShift API server, OpenShift OAuth API server, OpenShift OAuth server, and etcd.
- the kubelet, when it acts as an HTTP server for the Kubernetes API server

9.1. UNDERSTANDING TLS SECURITY PROFILES

You can use a TLS (Transport Layer Security) security profile to define which TLS ciphers are required by various OpenShift Container Platform components. The OpenShift Container Platform TLS security profiles are based on Mozilla recommended configurations.

You can specify one of the following TLS security profiles for each component:

Table 9.1. TLS security profiles

Profile	Description
Old	This profile is intended for use with legacy clients or libraries. The profile is based on the Old backward compatibility recommended configuration. The **Old** profile requires a minimum TLS version of 1.0. NOTE For the Ingress Controller, the minimum TLS version is converted from 1.0 to 1.1.
Intermediate	This profile is the recommended configuration for the majority of clients. It is the default TLS security profile for the Ingress Controller, kubelet, and control plane. The profile is based on the Intermediate compatibility recommended configuration. The **Intermediate** profile requires a minimum TLS version of 1.2.
Modern	This profile is intended for use with modern clients that have no need for backwards compatibility. This profile is based on the Modern compatibility recommended configuration. The **Modern** profile requires a minimum TLS version of 1.3.

Profile	Description
Custom	This profile allows you to define the TLS version and ciphers to use. **WARNING** Use caution when using a **Custom** profile, because invalid configurations can cause problems.

NOTE

When using one of the predefined profile types, the effective profile configuration is subject to change between releases. For example, given a specification to use the Intermediate profile deployed on release X.Y.Z, an upgrade to release X.Y.Z+1 might cause a new profile configuration to be applied, resulting in a rollout.

9.2. VIEWING TLS SECURITY PROFILE DETAILS

You can view the minimum TLS version and ciphers for the predefined TLS security profiles for each of the following components: Ingress Controller, control plane, and kubelet.

IMPORTANT

The effective configuration of minimum TLS version and list of ciphers for a profile might differ between components.

Procedure

- View details for a specific TLS security profile:

```
$ oc explain <component>.spec.tlsSecurityProfile.<profile> (1)
```

(1) For **<component>**, specify **ingresscontroller**, **apiserver**, or **kubeletconfig**. For **<profile>**, specify **old**, **intermediate**, or **custom**.

For example, to check the ciphers included for the **intermediate** profile for the control plane:

```
$ oc explain apiserver.spec.tlsSecurityProfile.intermediate
```

Example output

```
KIND:     APIServer
VERSION:  config.openshift.io/v1

DESCRIPTION:
    intermediate is a TLS security profile based on:

https://wiki.mozilla.org/Security/Server_Side_TLS#Intermediate_compatibility_.28recommended
.29
    and looks like this (yaml):
    ciphers: - TLS_AES_128_GCM_SHA256 - TLS_AES_256_GCM_SHA384 -
    TLS_CHACHA20_POLY1305_SHA256 - ECDHE-ECDSA-AES128-GCM-SHA256 -
    ECDHE-RSA-AES128-GCM-SHA256 - ECDHE-ECDSA-AES256-GCM-SHA384 -
    ECDHE-RSA-AES256-GCM-SHA384 - ECDHE-ECDSA-CHACHA20-POLY1305 -
    ECDHE-RSA-CHACHA20-POLY1305 - DHE-RSA-AES128-GCM-SHA256 -
    DHE-RSA-AES256-GCM-SHA384 minTLSVersion: TLSv1.2
```

- View all details for the **tlsSecurityProfile** field of a component:

```
$ oc explain <component>.spec.tlsSecurityProfile (1)
```

(1) For **<component>**, specify **ingresscontroller**, **apiserver**, or **kubeletconfig**.

For example, to check all details for the **tlsSecurityProfile** field for the Ingress Controller:

```
$ oc explain ingresscontroller.spec.tlsSecurityProfile
```

Example output

```
KIND:     IngressController
VERSION:  operator.openshift.io/v1

RESOURCE: tlsSecurityProfile <Object>

DESCRIPTION:
    ...

FIELDS:
  custom <>
    custom is a user-defined TLS security profile. Be extremely careful using a
    custom profile as invalid configurations can be catastrophic. An example
    custom profile looks like this:
    ciphers: - ECDHE-ECDSA-CHACHA20-POLY1305 - ECDHE-RSA-CHACHA20-
POLY1305 -
    ECDHE-RSA-AES128-GCM-SHA256 - ECDHE-ECDSA-AES128-GCM-SHA256
minTLSVersion:
    TLSv1.1

  intermediate <>
    intermediate is a TLS security profile based on:

https://wiki.mozilla.org/Security/Server_Side_TLS#Intermediate_compatibility_.28recommended
.29
    and looks like this (yaml):
    ... (1)

  modern <>
    modern is a TLS security profile based on:
    https://wiki.mozilla.org/Security/Server_Side_TLS#Modern_compatibility and
    looks like this (yaml):
    ... (2)
    NOTE: Currently unsupported.

  old <>
    old is a TLS security profile based on:
    https://wiki.mozilla.org/Security/Server_Side_TLS#Old_backward_compatibility
    and looks like this (yaml):
    ... (3)

  type <string>
    ...
```

1. Lists ciphers and minimum version for the **intermediate** profile here.
2. Lists ciphers and minimum version for the **modern** profile here.
3. Lists ciphers and minimum version for the **old** profile here.

9.3. CONFIGURING THE TLS SECURITY PROFILE FOR THE INGRESS CONTROLLER

To configure a TLS security profile for an Ingress Controller, edit the **IngressController** custom resource (CR) to specify a predefined or custom TLS security profile. If a TLS security profile is not configured, the default value is based on the TLS security profile set for the API server.

Sample IngressController CR that configures the Old TLS security profile

```
apiVersion: config.openshift.io/v1
kind: IngressController
 ...
spec:
  tlsSecurityProfile:
    old: {}
    type: Old
 ...
```

The TLS security profile defines the minimum TLS version and the TLS ciphers for TLS connections for Ingress Controllers.

You can see the ciphers and the minimum TLS version of the configured TLS security profile in the **IngressController** custom resource (CR) under **Status.Tls Profile** and the configured TLS security profile under **Spec.Tls Security Profile**. For the **Custom** TLS security profile, the specific ciphers and minimum TLS version are listed under both parameters.

NOTE

The HAProxy Ingress Controller image supports TLS **1.3** and the **Modern** profile.

The Ingress Operator also converts the TLS **1.0** of an **Old** or **Custom** profile to **1.1**.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

1. Edit the **IngressController** CR in the **openshift-ingress-operator** project to configure the TLS security profile:

```
$ oc edit IngressController default -n openshift-ingress-operator
```

2. Add the **spec.tlsSecurityProfile** field:

Sample IngressController CR for a Custom profile

```
apiVersion: operator.openshift.io/v1
kind: IngressController
 ...
spec:
  tlsSecurityProfile:
    type: Custom (1)
    custom: (2)
      ciphers: (3)
      - ECDHE-ECDSA-CHACHA20-POLY1305
      - ECDHE-RSA-CHACHA20-POLY1305
      - ECDHE-RSA-AES128-GCM-SHA256
      - ECDHE-ECDSA-AES128-GCM-SHA256
      minTLSVersion: VersionTLS11
 ...
```

(1) Specify the TLS security profile type (**Old**, **Intermediate**, or **Custom**). The default is **Intermediate**.

(2) Specify the appropriate field for the selected type:

- **old: {}**
- **intermediate: {}**
- **custom:**

(3) For the **custom** type, specify a list of TLS ciphers and minimum accepted TLS version.

3. Save the file to apply the changes.

Verification

- Verify that the profile is set in the **IngressController** CR:

```
$ oc describe IngressController default -n openshift-ingress-operator
```

Example output

```
Name:         default
Namespace:    openshift-ingress-operator
```

```
Labels:       <none>
Annotations:  <none>
API Version:  operator.openshift.io/v1
Kind:         IngressController
 ...
Spec:
 ...
  Tls Security Profile:
    Custom:
      Ciphers:
        ECDHE-ECDSA-CHACHA20-POLY1305
        ECDHE-RSA-CHACHA20-POLY1305
        ECDHE-RSA-AES128-GCM-SHA256
        ECDHE-ECDSA-AES128-GCM-SHA256
      Min TLS Version:  VersionTLS11
    Type:               Custom
 ...
```

9.4. CONFIGURING THE TLS SECURITY PROFILE FOR THE CONTROL PLANE

To configure a TLS security profile for the control plane, edit the **APIServer** custom resource (CR) to specify a predefined or custom TLS security profile. Setting the TLS security profile in the **APIServer** CR propagates the setting to the following control plane components:

- Kubernetes API server
- Kubernetes controller manager
- Kubernetes scheduler
- OpenShift API server
- OpenShift OAuth API server
- OpenShift OAuth server
- etcd

If a TLS security profile is not configured, the default TLS security profile is **Intermediate**.

NOTE

The default TLS security profile for the Ingress Controller is based on the TLS security profile set for the API server.

Sample **APIServer** CR that configures the **Old** TLS security profile

```
apiVersion: config.openshift.io/v1
kind: APIServer
 ...
spec:
  tlsSecurityProfile:
    old: {}
    type: Old
...
```

The TLS security profile defines the minimum TLS version and the TLS ciphers required to communicate with the control plane components.

You can see the configured TLS security profile in the **APIServer** custom resource (CR) under **Spec.Tls Security Profile**. For the **Custom** TLS security profile, the specific ciphers and minimum TLS version are listed.

NOTE

The control plane does not support TLS **1.3** as the minimum TLS version; the **Modern** profile is not supported because it requires TLS **1.3**.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

1. Edit the default **APIServer** CR to configure the TLS security profile:

   ```
   $ oc edit APIServer cluster
   ```

2. Add the **spec.tlsSecurityProfile** field:

   Sample APIServer CR for a Custom profile

   ```
   apiVersion: config.openshift.io/v1
   kind: APIServer
   metadata:
     name: cluster
   spec:
     tlsSecurityProfile:
       type: Custom (1)
       custom: (2)
         ciphers: (3)
         - ECDHE-ECDSA-CHACHA20-POLY1305
         - ECDHE-RSA-CHACHA20-POLY1305
         - ECDHE-RSA-AES128-GCM-SHA256
         - ECDHE-ECDSA-AES128-GCM-SHA256
         minTLSVersion: VersionTLS11
   ```

   (1) Specify the TLS security profile type (**Old**, **Intermediate**, or **Custom**). The default is **Intermediate**.

   (2) Specify the appropriate field for the selected type:

   - **old: {}**
   - **intermediate: {}**

- **custom:**

(3) For the **custom** type, specify a list of TLS ciphers and minimum accepted TLS version.

3. Save the file to apply the changes.

Verification

- Verify that the TLS security profile is set in the **APIServer** CR:

```
$ oc describe apiserver cluster
```

Example output

```
Name:         cluster
Namespace:
 ...
API Version:  config.openshift.io/v1
Kind:         APIServer
 ...
Spec:
  Audit:
    Profile:  Default
  Tls Security Profile:
    Custom:
      Ciphers:
        ECDHE-ECDSA-CHACHA20-POLY1305
        ECDHE-RSA-CHACHA20-POLY1305
        ECDHE-RSA-AES128-GCM-SHA256
        ECDHE-ECDSA-AES128-GCM-SHA256
      Min TLS Version:  VersionTLS11
    Type:               Custom
 ...
```

- Verify that the TLS security profile is set in the **etcd** CR:

```
$ oc describe etcd cluster
```

Example output

```
Name:         cluster
Namespace:
 ...
API Version:  operator.openshift.io/v1
Kind:         Etcd
 ...
Spec:
  Log Level:         Normal
  Management State:  Managed
  Observed Config:
    Serving Info:
      Cipher Suites:
        TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256
        TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256
        TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384
        TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384
        TLS_ECDHE_ECDSA_WITH_CHACHA20_POLY1305_SHA256
        TLS_ECDHE_RSA_WITH_CHACHA20_POLY1305_SHA256
      Min TLS Version:           VersionTLS12
...
```

9.5. CONFIGURING THE TLS SECURITY PROFILE FOR THE KUBELET

To configure a TLS security profile for the kubelet when it is acting as an HTTP server, create a **KubeletConfig** custom resource (CR) to specify a predefined or custom TLS security profile for specific nodes. If a TLS security profile is not configured, the default TLS security profile is **Intermediate**.

The kubelet uses its HTTP/GRPC server to communicate with the Kubernetes API server, which sends commands to pods, gathers logs, and run exec commands on pods through the kubelet.

Sample KubeletConfig CR that configures the Old TLS security profile on worker nodes

```
apiVersion: config.openshift.io/v1
kind: KubeletConfig
 ...
spec:
  tlsSecurityProfile:
    old: {}
    type: Old
  machineConfigPoolSelector:
    matchLabels:
      pools.operator.machineconfiguration.openshift.io/worker: ""
```

You can see the ciphers and the minimum TLS version of the configured TLS security profile in the **kubelet.conf** file on a configured node.

IMPORTANT

The kubelet does not support TLS **1.3** and because the **Modern** profile requires TLS **1.3**, it is not supported. The kubelet converts the **Modern** profile to **Intermediate**.

The kubelet also converts the TLS **1.0** of an **Old** or **Custom** profile to **1.1**, and TLS **1.3** of a **Custom** profile to **1.2**.

Prerequisites

- You have access to the cluster as a user with the **cluster-admin** role.

Procedure

1. Create a **KubeletConfig** CR to configure the TLS security profile:

   Sample KubeletConfig CR for a Custom profile

```
apiVersion: machineconfiguration.openshift.io/v1
kind: KubeletConfig
metadata:
  name: set-kubelet-tls-security-profile
spec:
  tlsSecurityProfile:
    type: Custom (1)
    custom: (2)
      ciphers: (3)
      - ECDHE-ECDSA-CHACHA20-POLY1305
      - ECDHE-RSA-CHACHA20-POLY1305
      - ECDHE-RSA-AES128-GCM-SHA256
      - ECDHE-ECDSA-AES128-GCM-SHA256
      minTLSVersion: VersionTLS11
  machineConfigPoolSelector:
    matchLabels:
      pools.operator.machineconfiguration.openshift.io/worker: "" (4)
```

(1) Specify the TLS security profile type (**Old**, **Intermediate**, or **Custom**). The default is **Intermediate**.

(2) Specify the appropriate field for the selected type:

- **old: {}**
- **intermediate: {}**
- **custom:**

(3) For the **custom** type, specify a list of TLS ciphers and minimum accepted TLS version.

(4) Optional: Specify the machine config pool label for the nodes you want to apply the TLS security profile.

2. Create the **KubeletConfig** object:

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

Depending on the number of worker nodes in the cluster, wait for the configured nodes to be rebooted one by one.

Verification

To verify that the profile is set, perform the following steps after the nodes are in the **Ready** state:

1. Start a debug session for a configured node:

```
$ oc debug node/<node_name>
```

2. Set /**host** as the root directory within the debug shell:

```
sh-4.4# chroot /host
```

3. View the **kubelet.conf** file:

```
sh-4.4# cat /etc/kubernetes/kubelet.conf
```

Example output

```
kind: KubeletConfiguration
apiVersion: kubelet.config.k8s.io/v1beta1
 ...
  "tlsCipherSuites": [
    "TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256",
    "TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256",
    "TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384",
    "TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384",
    "TLS_ECDHE_ECDSA_WITH_CHACHA20_POLY1305_SHA256",
    "TLS_ECDHE_RSA_WITH_CHACHA20_POLY1305_SHA256"
  ],
  "tlsMinVersion": "VersionTLS12",
```

CHAPTER 10. CONFIGURING SECCOMP PROFILES

An OpenShift Container Platform container or a pod runs a single application that performs one or more well-defined tasks. The application usually requires only a small subset of the underlying operating system kernel APIs. Seccomp, secure computing mode, is a Linux kernel feature that can be used to limit the process running in a container to only call a subset of the available system calls. These system calls can be configured by creating a profile that is applied to a container or pod. Seccomp profiles are stored as JSON files on the disk.

IMPORTANT

OpenShift workloads run unconfined by default, without any seccomp profile applied.

IMPORTANT

Seccomp profiles cannot be applied to privileged containers.

10.1. CONFIGURING THE DEFAULT SECCOMP PROFILE

OpenShift ships with a default seccomp profile that is referenced as **runtime/default**. You can enable the default seccomp profile for a pod or container workload by setting **RuntimeDefault** as following:

Example

```
spec:
  securityContext:
    seccompProfile:
      type: RuntimeDefault
```

Alternatively, you can use the pod annotations **seccomp.security.alpha.kubernetes.io/pod: runtime/default** and **container.seccomp.security.alpha.kubernetes.io/<container_name>: runtime/default**. However, this method is deprecated in OpenShift Container Platform 4.9.

10.2. CONFIGURING A CUSTOM SECCOMP PROFILE

You can configure a custom seccomp profile, which allows you to update the filters based on the application requirements. This allows cluster administrators to have greater control over the security of workloads running in OpenShift Container Platform.

10.2.1. Setting up the custom seccomp profile

Prerequisite

- You have cluster administrator permissions.
- You have created a custom security context constraints (SCC). For more information, see "Additional resources".
- You have created a custom seccomp profile.

Procedure

1. Upload your custom seccomp profile to **/var/lib/kubelet/seccomp/<custom-name>.json** by using the Machine Config. See "Additional resources" for detailed steps.

2. Update the custom SCC by providing reference to the created custom seccomp profile:

```
seccompProfiles:
- localhost/<custom-name>.json (1)
```

(1) Provide the name of your custom seccomp profile.

10.2.2. Applying the custom seccomp profile to the workload

Prerequisite

- The cluster administrator has set up the custom seccomp profile. For more details, see "Setting up the custom seccomp profile".

Procedure

- Apply the seccomp profile to the workload by setting the **securityContext.seccompProfile.type** field as following:

  Example

  ```
  spec:
    securityContext:
      seccompProfile:
        type: Localhost
        localhostProfile: <custom-name>.json (1)
  ```

  (1) Provide the name of your custom seccomp profile.

  Alternatively, you can use the pod annotations **seccomp.security.alpha.kubernetes.io/pod: localhost/<custom-name>.json**. However, this method is deprecated in OpenShift Container Platform 4.9.

During deployment, the admission controller validates the following:

- The annotations against the current SCCs allowed by the user role.

- The SCC, which includes the seccomp profile, is allowed for the pod.

If the SCC is allowed for the pod, the kubelet runs the pod with the specified seccomp profile.

IMPORTANT

Ensure that the seccomp profile is deployed to all worker nodes.

NOTE

The custom SCC must have the appropriate priority to be automatically assigned to the pod or meet other conditions required by the pod, such as allowing CAP_NET_ADMIN.

10.3. ADDITIONAL RESOURCES

- Managing security context constraints
- Post-installation machine configuration tasks

CHAPTER 11. ALLOWING JAVASCRIPT-BASED ACCESS TO THE API SERVER FROM ADDITIONAL HOSTS

11.1. ALLOWING JAVASCRIPT-BASED ACCESS TO THE API SERVER FROM ADDITIONAL HOSTS

The default OpenShift Container Platform configuration only allows the web console to send requests to the API server.

If you need to access the API server or OAuth server from a JavaScript application using a different hostname, you can configure additional hostnames to allow.

Prerequisites

- Access to the cluster as a user with the **cluster-admin** role.

Procedure

1. Edit the **APIServer** resource:

```
$ oc edit apiserver.config.openshift.io cluster
```

2. Add the **additionalCORSAllowedOrigins** field under the **spec** section and specify one or more additional hostnames:

```
apiVersion: config.openshift.io/v1
kind: APIServer
metadata:
  annotations:
    release.openshift.io/create-only: "true"
  creationTimestamp: "2019-07-11T17:35:37Z"
  generation: 1
  name: cluster
  resourceVersion: "907"
  selfLink: /apis/config.openshift.io/v1/apiservers/cluster
  uid: 4b45a8dd-a402-11e9-91ec-0219944e0696
spec:
  additionalCORSAllowedOrigins:
  - (?i)//my\.subdomain\.domain\.com(:|\z) 1
```

1 The hostname is specified as a Golang regular expression that matches against CORS headers from HTTP requests against the API server and OAuth server.

NOTE

This example uses the following syntax:

- The **(?i)** makes it case-insensitive.
- The // pins to the beginning of the domain and matches the double slash following **http:** or **https:**.
- The **\.** escapes dots in the domain name.
- The **(:|\z)** matches the end of the domain name **(\z)** or a port separator **(:)**.

3. Save the file to apply the changes.

CHAPTER 12. ENCRYPTING ETCD DATA

12.1. ABOUT ETCD ENCRYPTION

By default, etcd data is not encrypted in OpenShift Container Platform. You can enable etcd encryption for your cluster to provide an additional layer of data security. For example, it can help protect the loss of sensitive data if an etcd backup is exposed to the incorrect parties.

When you enable etcd encryption, the following OpenShift API server and Kubernetes API server resources are encrypted:

- Secrets
- Config maps
- Routes
- OAuth access tokens
- OAuth authorize tokens

When you enable etcd encryption, encryption keys are created. These keys are rotated on a weekly basis. You must have these keys to restore from an etcd backup.

NOTE

Keep in mind that etcd encryption only encrypts values, not keys. This means that resource types, namespaces, and object names are unencrypted.

12.2. ENABLING ETCD ENCRYPTION

You can enable etcd encryption to encrypt sensitive resources in your cluster.

WARNING

It is not recommended to take a backup of etcd until the initial encryption process is complete. If the encryption process has not completed, the backup might be only partially encrypted.

Prerequisites

- Access to the cluster as a user with the **cluster-admin** role.

Procedure

1. Modify the **APIServer** object:

```
$ oc edit apiserver
```

2. Set the **encryption** field type to **aescbc**:

```
spec:
  encryption:
    type: aescbc 1
```

1 The **aescbc** type means that AES-CBC with PKCS#7 padding and a 32 byte key is used to perform the encryption.

3. Save the file to apply the changes.
   The encryption process starts. It can take 20 minutes or longer for this process to complete, depending on the size of your cluster.

4. Verify that etcd encryption was successful.

   a. Review the **Encrypted** status condition for the OpenShift API server to verify that its resources were successfully encrypted:

   ```
   $ oc get openshiftapiserver -o=jsonpath='{range .items[0].status.conditions[?
   (@.type=="Encrypted")]}{.reason}{"\n"}{.message}{"\n"}'
   ```

   The output shows **EncryptionCompleted** upon successful encryption:

   ```
   EncryptionCompleted
   All resources encrypted: routes.route.openshift.io
   ```

   If the output shows **EncryptionInProgress**, encryption is still in progress. Wait a few minutes and try again.

   b. Review the **Encrypted** status condition for the Kubernetes API server to verify that its resources were successfully encrypted:

   ```
   $ oc get kubeapiserver -o=jsonpath='{range .items[0].status.conditions[?
   (@.type=="Encrypted")]}{.reason}{"\n"}{.message}{"\n"}'
   ```

   The output shows **EncryptionCompleted** upon successful encryption:

   ```
   EncryptionCompleted
   All resources encrypted: secrets, configmaps
   ```

   If the output shows **EncryptionInProgress**, encryption is still in progress. Wait a few minutes and try again.

   c. Review the **Encrypted** status condition for the OpenShift OAuth API server to verify that its resources were successfully encrypted:

   ```
   $ oc get authentication.operator.openshift.io -o=jsonpath='{range
   .items[0].status.conditions[?(@.type=="Encrypted")]}{.reason}{"\n"}{.message}{"\n"}'
   ```

   The output shows **EncryptionCompleted** upon successful encryption:

```
EncryptionCompleted
All resources encrypted: oauthaccesstokens.oauth.openshift.io,
oauthauthorizetokens.oauth.openshift.io
```

If the output shows **EncryptionInProgress**, encryption is still in progress. Wait a few minutes and try again.

12.3. DISABLING ETCD ENCRYPTION

You can disable encryption of etcd data in your cluster.

Prerequisites

- Access to the cluster as a user with the **cluster-admin** role.

Procedure

1. Modify the **APIServer** object:

```
$ oc edit apiserver
```

2. Set the **encryption** field type to **identity**:

```
spec:
  encryption:
    type: identity (1)
```

(1) The **identity** type is the default value and means that no encryption is performed.

3. Save the file to apply the changes.
   The decryption process starts. It can take 20 minutes or longer for this process to complete, depending on the size of your cluster.

4. Verify that etcd decryption was successful.

   a. Review the **Encrypted** status condition for the OpenShift API server to verify that its resources were successfully decrypted:

```
$ oc get openshiftapiserver -o=jsonpath='{range .items[0].status.conditions[?
(@.type=="Encrypted")]}{.reason}{"\n"}{.message}{"\n"}'
```

   The output shows **DecryptionCompleted** upon successful decryption:

```
DecryptionCompleted
Encryption mode set to identity and everything is decrypted
```

   If the output shows **DecryptionInProgress**, decryption is still in progress. Wait a few minutes and try again.

   b. Review the **Encrypted** status condition for the Kubernetes API server to verify that its resources were successfully decrypted:

```
$ oc get kubeapiserver -o=jsonpath='{range .items[0].status.conditions[?
(@.type=="Encrypted")]}{.reason}{"\n"}{.message}{"\n"}'
```

The output shows **DecryptionCompleted** upon successful decryption:

```
DecryptionCompleted
Encryption mode set to identity and everything is decrypted
```

If the output shows **DecryptionInProgress**, decryption is still in progress. Wait a few minutes and try again.

c. Review the **Encrypted** status condition for the OpenShift OAuth API server to verify that its resources were successfully decrypted:

```
$ oc get authentication.operator.openshift.io -o=jsonpath='{range
.items[0].status.conditions[?(@.type=="Encrypted")]}{.reason}{"\n"}{.message}{"\n"}'
```

The output shows **DecryptionCompleted** upon successful decryption:

```
DecryptionCompleted
Encryption mode set to identity and everything is decrypted
```

If the output shows **DecryptionInProgress**, decryption is still in progress. Wait a few minutes and try again.

CHAPTER 13. SCANNING PODS FOR VULNERABILITIES

Using the Container Security Operator (CSO), you can access vulnerability scan results from the OpenShift Container Platform web console for container images used in active pods on the cluster. The CSO:

- Watches containers associated with pods on all or specified namespaces
- Queries the container registry where the containers came from for vulnerability information, provided an image's registry is running image scanning (such as Quay.io or a Red Hat Quay registry with Clair scanning)
- Exposes vulnerabilities via the **ImageManifestVuln** object in the Kubernetes API

Using the instructions here, the CSO is installed in the **openshift-operators** namespace, so it is available to all namespaces on your OpenShift Container Platform cluster.

13.1. RUNNING THE CONTAINER SECURITY OPERATOR

You can start the Container Security Operator from the OpenShift Container Platform web console by selecting and installing that Operator from the Operator Hub, as described here.

Prerequisites

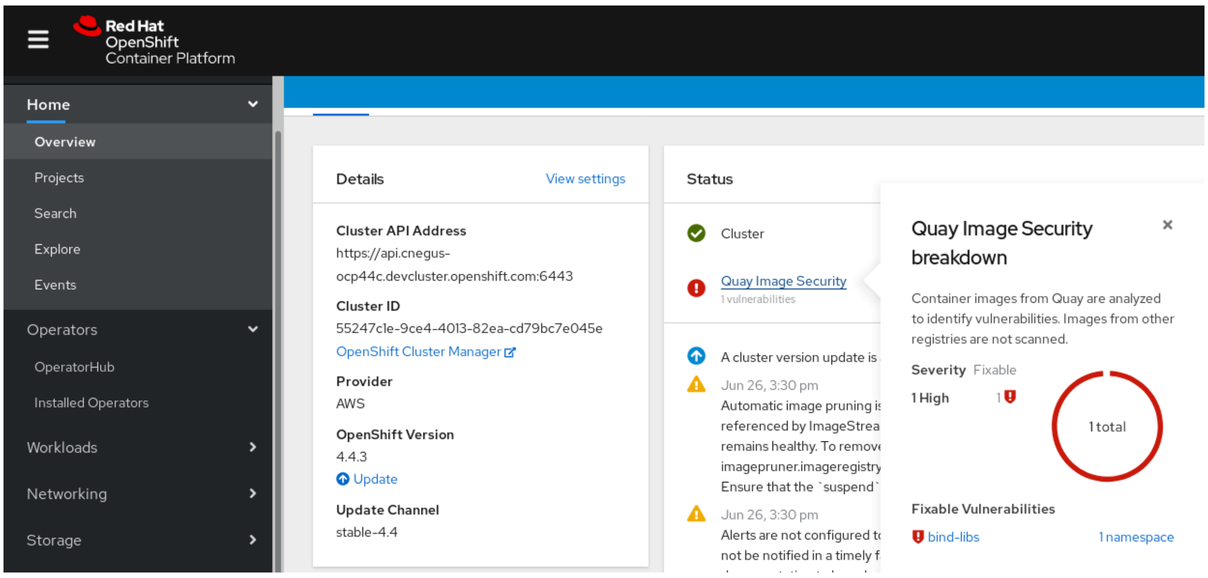
- Have administrator privileges to the OpenShift Container Platform cluster
- Have containers that come from a Red Hat Quay or Quay.io registry running on your cluster

Procedure

1. Navigate to **Operators → OperatorHub** and select **Security**.
2. Select the **Container Security** Operator, then select **Install** to go to the Create Operator Subscription page.
3. Check the settings. All namespaces and automatic approval strategy are selected, by default.
4. Select **Install**. The **Container Security** Operator appears after a few moments on the **Installed Operators** screen.
5. Optional: You can add custom certificates to the CSO. In this example, create a certificate named **quay.crt** in the current directory. Then run the following command to add the cert to the CSO:

```
$ oc create secret generic container-security-operator-extra-certs --from-file=quay.crt -n
openshift-operators
```

6. If you added a custom certificate, restart the Operator pod for the new certs to take effect.
7. Open the OpenShift Dashboard (**Home → Overview**). A link to **Quay Image Security** appears under the status section, with a listing of the number of vulnerabilities found so far. Select the link to see a **Quay Image Security breakdown**, as shown in the following figure:



Details View settings

Cluster API Address
https://api.cnegus-ocp44c.devcluster.openshift.com:6443
Cluster ID
55247c1e-9ce4-4013-82ea-cd79bc7e045e
OpenShift Cluster Manager
Provider
AWS
OpenShift Version
4.4.3
Update
Update Channel
stable-4.4

Status

Cluster
Quay Image Security
1 vulnerabilities

A cluster version update is
Jun 26, 3:30 pm
Automatic image pruning is
referenced by ImageStrea
remains healthy. To remove
imagepruner.imageregistry
Ensure that the `suspend`
Jun 26, 3:30 pm
Alerts are not configured t
not be notified in a timely f

Quay Image Security breakdown

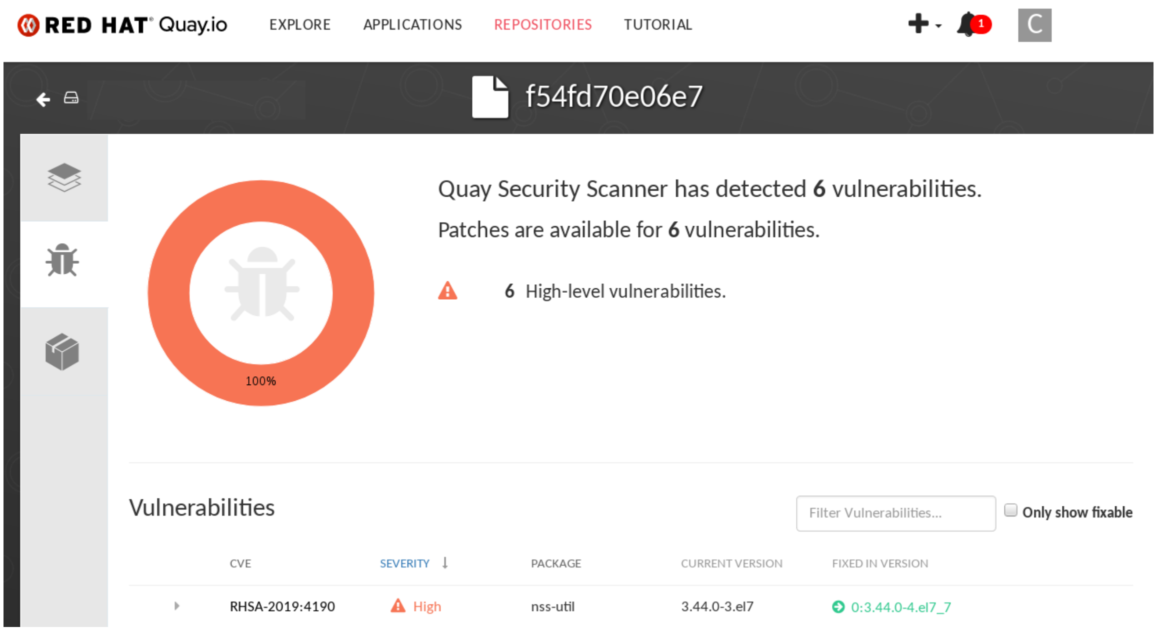
Container images from Quay are analyzed to identify vulnerabilities. Images from other registries are not scanned.

Severity Fixable
1 High 1
1 total

Fixable Vulnerabilities
bind-libs 1 namespace

8. You can do one of two things at this point to follow up on any detected vulnerabilities:

- Select the link to the vulnerability. You are taken to the container registry that the container came from, where you can see information about the vulnerability. The following figure shows an example of detected vulnerabilities from a Quay.io registry:



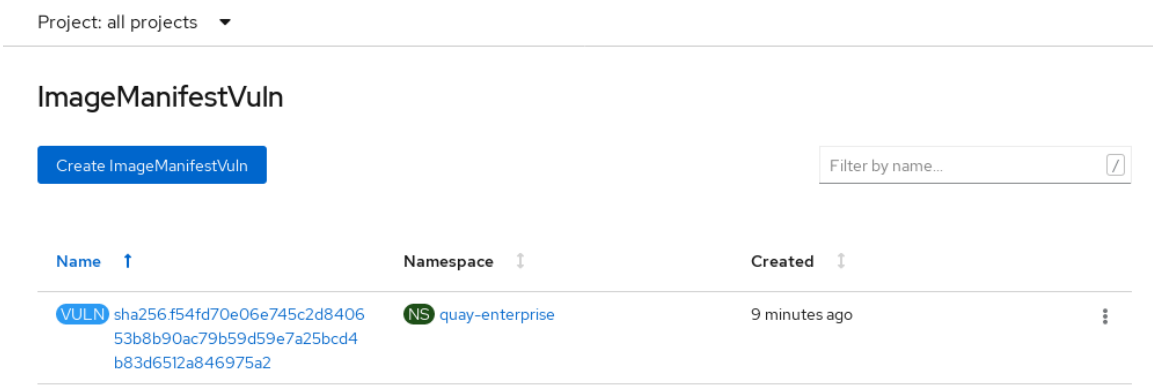
Quay Security Scanner has detected **6** vulnerabilities.
Patches are available for **6** vulnerabilities.
6 High-level vulnerabilities.

Vulnerabilities

Filter Vulnerabilities... Only show fixable

CVE	SEVERITY	PACKAGE	CURRENT VERSION	FIXED IN VERSION
RHSA-2019:4190	High	nss-util	3.44.0-3.el7	0:3.44.0-4.el7_7

- Select the namespaces link to go to the **ImageManifestVuln** screen, where you can see the name of the selected image and all namespaces where that image is running. The following figure indicates that a particular vulnerable image is running in the **quay-enterprise** namespace:



ImageManifestVuln

Name	Namespace	Created
VULN sha256.f54fd70e06e745c2d8406 53b8b90ac79b59d59e7a25bcd4 b83d6512a846975a2	NS quay-enterprise	9 minutes ago

At this point, you know what images are vulnerable, what you need to do to fix those vulnerabilities, and every namespace that the image was run in. So you can:

- Alert anyone running the image that they need to correct the vulnerability
- Stop the images from running by deleting the deployment or other object that started the pod that the image is in

Note that if you do delete the pod, it may take several minutes for the vulnerability to reset on the dashboard.

13.2. QUERYING IMAGE VULNERABILITIES FROM THE CLI

Using the **oc** command, you can display information about vulnerabilities detected by the Container Security Operator.

Prerequisites

- Be running the Container Security Operator on your OpenShift Container Platform instance

Procedure

- To query for detected container image vulnerabilities, type:

  ```
  $ oc get vuln --all-namespaces
  ```

  Example output

  ```
  NAMESPACE     NAME              AGE
  default       sha256.ca90...    6m56s
  skynet        sha256.ca90...    9m37s
  ```

- To display details for a particular vulnerability, provide the vulnerability name and its namespace to the **oc describe** command. This example shows an active container whose image includes an RPM package with a vulnerability:

  ```
  $ oc describe vuln --namespace mynamespace sha256.ac50e3752...
  ```

  Example output

  ```
  Name:         sha256.ac50e3752...
  Namespace:    quay-enterprise
  ...
  Spec:
    Features:
      Name:            nss-util
      Namespace Name:  centos:7
      Version:         3.44.0-3.el7
      Versionformat:   rpm
      Vulnerabilities:
        Description: Network Security Services (NSS) is a set of libraries...
  ```

CHAPTER 14. NETWORK-BOUND DISK ENCRYPTION (NBDE)

14.1. ABOUT DISK ENCRYPTION TECHNOLOGY

Network-Bound Disk Encryption (NBDE) allows you to encrypt root volumes of hard drives on physical and virtual machines without having to manually enter a password when restarting machines.

14.1.1. Disk encryption technology comparison

To understand the merits of Network-Bound Disk Encryption (NBDE) for securing data at rest on edge servers, compare key escrow and TPM disk encryption without Clevis to NBDE on systems running Red Hat Enterprise Linux (RHEL).

The following table presents some tradeoffs to consider around the threat model and the complexity of each encryption solution.

Scenario	Key escrow	TPM disk encryption (without Clevis)	NBDE
Protects against single-disk theft	X	X	X
Protects against entire-server theft	X		X
Systems can reboot independently from the network		X	
No periodic rekeying		X	
Key is never transmitted over a network		X	X
Supported by OpenShift		X	X

14.1.1.1. Key escrow

Key escrow is the traditional system for storing cryptographic keys. The key server on the network stores the encryption key for a node with an encrypted boot disk and returns it when queried. The complexities around key management, transport encryption, and authentication do not make this a reasonable choice for boot disk encryption.

Although available in Red Hat Enterprise Linux (RHEL), key escrow-based disk encryption setup and management is a manual process and not suited to OpenShift Container Platform automation operations, including automated addition of nodes, and currently not supported by OpenShift Container Platform.

14.1.1.2. TPM encryption

Trusted Platform Module (TPM) disk encryption is best suited for data centers or installations in remote protected locations. Full disk encryption utilities such as dm-crypt and BitLocker encrypt disks with a TPM bind key, and then store the TPM bind key in the TPM, which is attached to the motherboard of the node. The main benefit of this method is that there is no external dependency, and the node is able to decrypt its own disks at boot time without any external interaction.

TPM disk encryption protects against decryption of data if the disk is stolen from the node and analyzed externally. However, for insecure locations this may not be sufficient. For example, if an attacker steals the entire node, the attacker can intercept the data when powering on the node, because the node decrypts its own disks. This applies to nodes with physical TPM2 chips as well as virtual machines with Virtual Trusted Platform Module (VTPM) access.

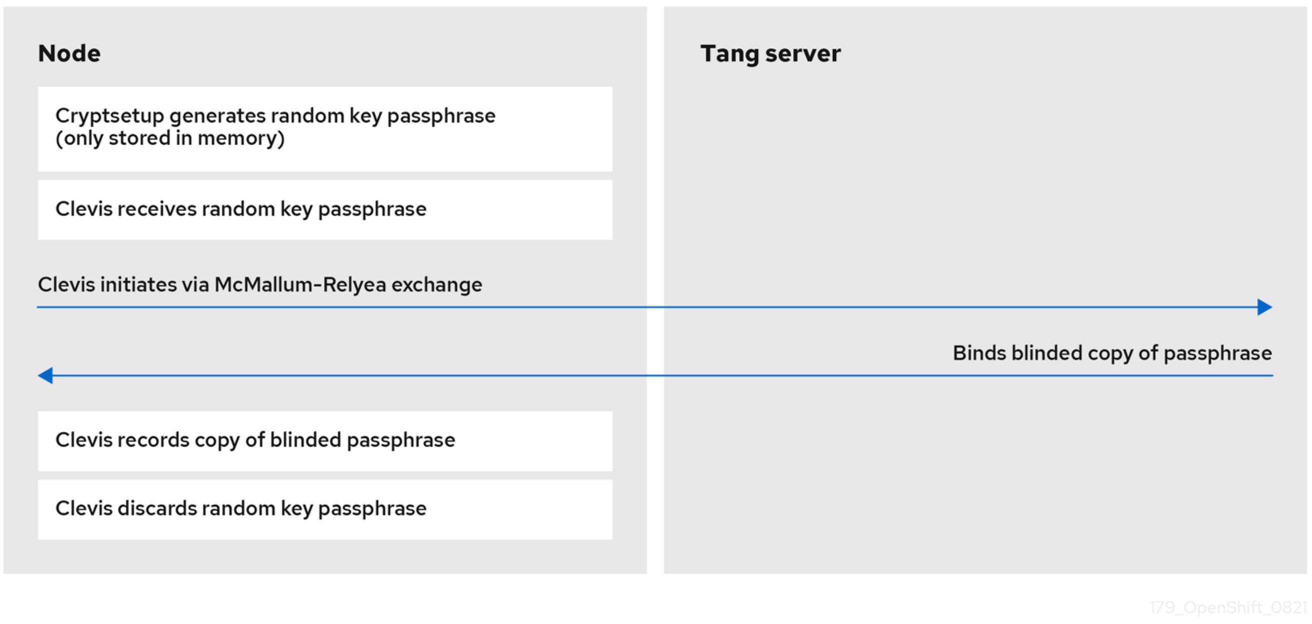
14.1.1.3. Network-Bound Disk Encryption (NBDE)

Network-Bound Disk Encryption (NBDE) effectively ties the encryption key to an external server or set of servers in a secure and anonymous way across the network. This is not a key escrow, in that the nodes do not store the encryption key or transfer it over the network, but otherwise behaves in a similar fashion.

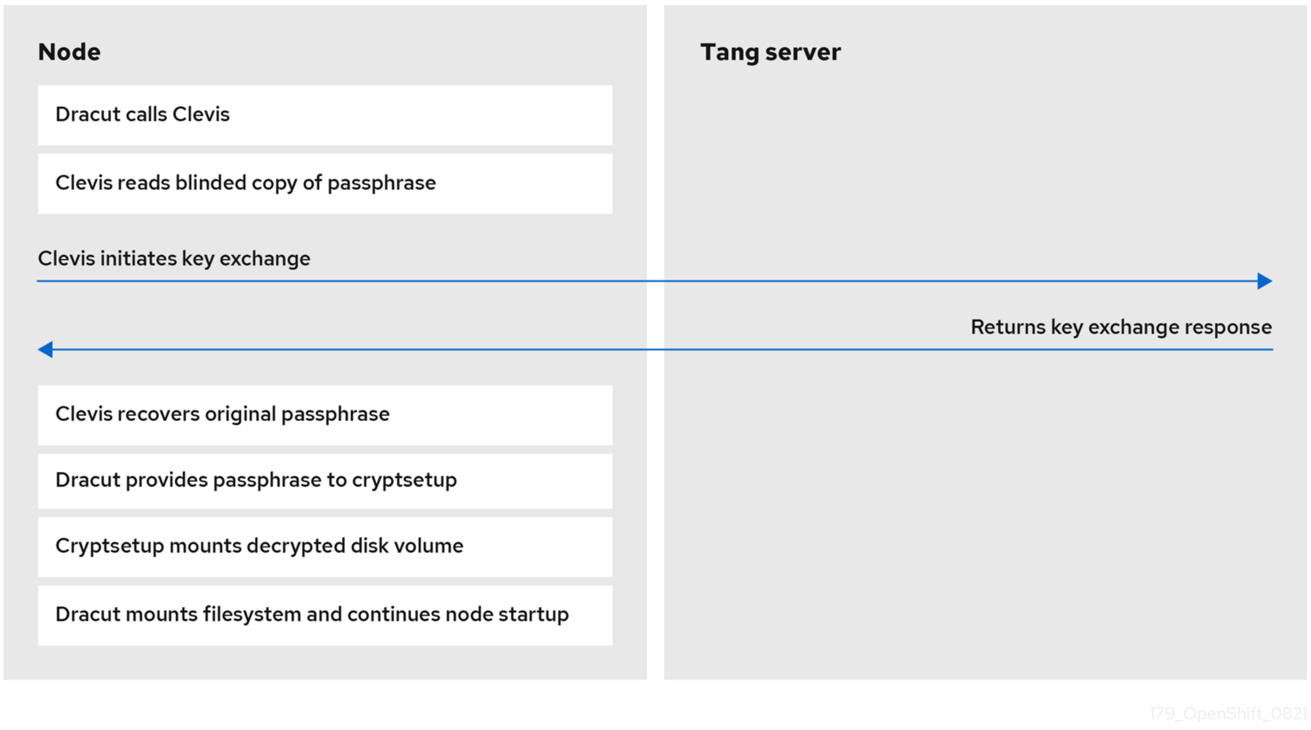
Clevis and Tang are generic client and server components that provide network-bound encryption. Red Hat Enterprise Linux CoreOS (RHCOS) uses these components in conjunction with Linux Unified Key Setup-on-disk-format (LUKS) to encrypt and decrypt root and non-root storage volumes to accomplish Network-Bound Disk Encryption.

When a node starts, it attempts to contact a predefined set of Tang servers by performing a cryptographic handshake. If it can reach the required number of Tang servers, the node can construct its disk decryption key and unlock the disks to continue booting. If the node cannot access a Tang server due to a network outage or server unavailability, the node cannot boot and continues retrying indefinitely until the Tang servers become available again. Because the key is effectively tied to the node’s presence in a network, an attacker attempting to gain access to the data at rest would need to obtain both the disks on the node, and network access to the Tang server as well.

The following figure illustrates the deployment model for NBDE.


Node
Tang server
Cryptsetup generates random key passphrase (only stored in memory)
Clevis receives random key passphrase
Clevis initiates via McMallum-Relyea exchange
Binds blinded copy of passphrase
Clevis records copy of blinded passphrase
Clevis discards random key passphrase
179_OpenShift_0821

The following figure illustrates NBDE behavior during a reboot.


Node
Tang server
Dracut calls Clevis
Clevis reads blinded copy of passphrase
Clevis initiates key exchange
Returns key exchange response
Clevis recovers original passphrase
Dracut provides passphrase to cryptsetup
Cryptsetup mounts decrypted disk volume
Dracut mounts filesystem and continues node startup
179_OpenShift_0821

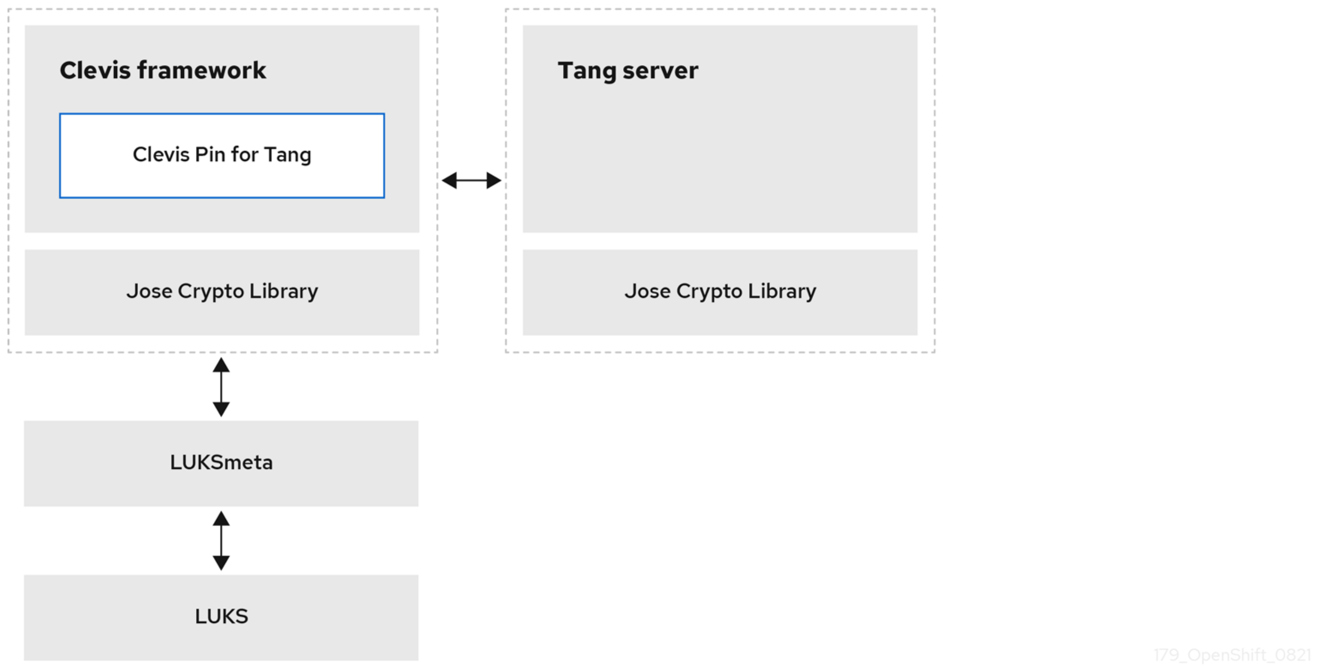
14.1.1.4. Secret sharing encryption

Shamir's secret sharing (sss) is a cryptographic algorithm to securely divide up, distribute, and re-assemble keys. Using this algorithm, OpenShift Container Platform can support more complicated mixtures of key protection.

When you configure a cluster node to use multiple Tang servers, OpenShift Container Platform uses sss to set up a decryption policy that will succeed if at least one of the specified servers is available. You can create layers for additional security. For example, you can define a policy where OpenShift Container Platform requires both the TPM and one of the given list of Tang servers to decrypt the disk.

14.1.2. Tang server disk encryption

The following components and technologies implement Network-Bound Disk Encryption (NBDE).



Tang is a server for binding data to network presence. It makes a node containing the data available when the node is bound to a certain secure network. Tang is stateless and does not require Transport Layer Security (TLS) or authentication. Unlike escrow-based solutions, where the key server stores all encryption keys and has knowledge of every encryption key, Tang never interacts with any node keys, so it never gains any identifying information from the node.

Clevis is a pluggable framework for automated decryption that provides automated unlocking of Linux Unified Key Setup-on-disk-format (LUKS) volumes. The Clevis package runs on the node and provides the client side of the feature.

A *Clevis pin* is a plug-in into the Clevis framework. There are three pin types:

TPM2

Binds the disk encryption to the TPM2.

Tang

Binds the disk encryption to a Tang server to enable NBDE.

Shamir's secret sharing (sss)

Allows more complex combinations of other pins. It allows more nuanced policies such as the following:

- Must be able to reach one of these three Tang servers
- Must be able to reach three of these five Tang servers
- Must be able to reach the TPM2 AND at least one of these three Tang servers

14.1.3. Tang server location planning

When planning your Tang server environment, consider the physical and network locations of the Tang servers.

Physical location

The geographic location of the Tang servers is relatively unimportant, as long as they are suitably secured from unauthorized access or theft and offer the required availability and accessibility to run a critical service.
Nodes with Clevis clients do not require local Tang servers as long as the Tang servers are available at all times. Disaster recovery requires both redundant power and redundant network connectivity to Tang servers regardless of their location.

Network location

Any node with network access to the Tang servers can decrypt their own disk partitions, or any other disks encrypted by the same Tang servers.
Select network locations for the Tang servers that ensure the presence or absence of network connectivity from a given host allows for permission to decrypt. For example, firewall protections might be in place to prohibit access from any type of guest or public network, or any network jack located in an unsecured area of the building.

Additionally, maintain network segregation between production and development networks. This assists in defining appropriate network locations and adds an additional layer of security.

Do not deploy Tang servers on the same resource, for example, the same **rolebindings.rbac.authorization.k8s.io** cluster, that they are responsible for unlocking. However, a cluster of Tang servers and other security resources can be a useful configuration to enable support of multiple additional clusters and cluster resources.

14.1.4. Tang server sizing requirements

The requirements around availability, network, and physical location drive the decision of how many Tang servers to use, rather than any concern over server capacity.

Tang servers do not maintain the state of data encrypted using Tang resources. Tang servers are either fully independent or share only their key material, which enables them to scale well.

There are two ways Tang servers handle key material:

- Multiple Tang servers share key material:
    - You must load balance Tang servers sharing keys behind the same URL. The configuration can be as simple as round-robin DNS, or you can use physical load balancers.
    - You can scale from a single Tang server to multiple Tang servers. Scaling Tang servers does not require rekeying or client reconfiguration on the node when the Tang servers share key material and the same URL.
    - Client node setup and key rotation only requires one Tang server.
- Multiple Tang servers generate their own key material:
    - You can configure multiple Tang servers at installation time.
    - You can scale an individual Tang server behind a load balancer.
    - All Tang servers must be available during client node setup or key rotation.
    - When a client node boots using the default configuration, the Clevis client contacts all Tang servers. Only *n* Tang servers must be online to proceed with decryption. The default value for *n* is 1.

- Red Hat does not support post-installation configuration that changes the behavior of the Tang servers.

14.1.5. Logging considerations

Centralized logging of Tang traffic is advantageous because it might allow you to detect such things as unexpected decryption requests. For example:

- A node requesting decryption of a passphrase that does not correspond to its boot sequence
- A node requesting decryption outside of a known maintenance activity, such as cycling keys

14.2. TANG SERVER INSTALLATION CONSIDERATIONS

14.2.1. Installation scenarios

Consider the following recommendations when planning Tang server installations:

- Small environments can use a single set of key material, even when using multiple Tang servers:
  - Key rotations are easier.
  - Tang servers can scale easily to permit high availability.
- Large environments can benefit from multiple sets of key material:
  - Physically diverse installations do not require the copying and synchronizing of key material between geographic regions.
  - Key rotations are more complex in large environments.
  - Node installation and rekeying require network connectivity to all Tang servers.
  - A small increase in network traffic can occur due to a booting node querying all Tang servers during decryption. Note that while only one Clevis client query must succeed, Clevis queries all Tang servers.
- Further complexity:
  - Additional manual reconfiguration can permit the Shamir's secret sharing (sss) of **any N of M servers online** in order to decrypt the disk partition. Decrypting disks in this scenario requires multiple sets of key material, and manual management of Tang servers and nodes with Clevis clients after the initial installation.
- High level recommendations:
  - For a single RAN deployment, a limited set of Tang servers can run in the corresponding domain controller (DC).
  - For multiple RAN deployments, you must decide whether to run Tang servers in each corresponding DC or whether a global Tang environment better suits the other needs and requirements of the system.

14.2.2. Installing a Tang server

Procedure

- You can install a Tang server on a Red Hat Enterprise Linux (RHEL) machine using either of the following commands:
  - Install the Tang server by using the **yum** command:

    ```
    $ sudo yum install tang
    ```

  - Install the Tang server by using the **dnf** command:

    ```
    $ sudo dnf install tang
    ```

NOTE

Installation can also be containerized and is very lightweight.

14.2.2.1. Compute requirements

The computational requirements for the Tang server are very low. Any typical server grade configuration that you would use to deploy a server into production can provision sufficient compute capacity.

High availability considerations are solely for availability and not additional compute power to satisfy client demands.

14.2.2.2. Automatic start at boot

Due to the sensitive nature of the key material the Tang server uses, you should keep in mind that the overhead of manual intervention during the Tang server's boot sequence can be beneficial.

By default, if a Tang server starts and does not have key material present in the expected local volume, it will create fresh material and serve it. You can avoid this default behavior by either starting with pre-existing key material or aborting the startup and waiting for manual intervention.

14.2.2.3. HTTP versus HTTPS

Traffic to the Tang server can be encrypted (HTTPS) or plaintext (HTTP). There are no significant security advantages of encrypting this traffic, and leaving it decrypted removes any complexity or failure conditions related to Transport Layer Security (TLS) certificate checking in the node running a Clevis client.

While it is possible to perform passive monitoring of unencrypted traffic between the node's Clevis client and the Tang server, the ability to use this traffic to determine the key material is at best a future theoretical concern. Any such traffic analysis would require large quantities of captured data. Key rotation would immediately invalidate it. Finally, any threat actor able to perform passive monitoring has already obtained the necessary network access to perform manual connections to the Tang server and can perform the simpler manual decryption of captured Clevis headers.

However, because other network policies in place at the installation site might require traffic encryption regardless of application, consider leaving this decision to the cluster administrator.

14.2.3. Installation considerations with Network-Bound Disk Encryption

Network-Bound Disk Encryption (NBDE) must be enabled when a cluster node is installed. However, you can change the disk encryption policy at any time after it was initialized at installation.

Additional resources

- Configuring automated unlocking of encrypted volumes using policy-based decryption
- Official Tang server container
- Encrypting and mirroring disks during installation

14.3. TANG SERVER ENCRYPTION KEY MANAGEMENT

The cryptographic mechanism to recreate the encryption key is based on the *blinded key* stored on the node and the private key of the involved Tang servers. To protect against the possibility of an attacker who has obtained both the Tang server private key and the node's encrypted disk, periodic rekeying is advisable.

You must perform the rekeying operation for every node before you can delete the old key from the Tang server. The following sections provide procedures for rekeying and deleting old keys.

14.3.1. Backing up keys for a Tang server

The Tang server, by default, stores its keys in the **/usr/libexec/tangd-keygen** directory. Back up the contents of this directory to enable recovery in the event of the loss of the Tang server. The keys are sensitive and since they are able to perform the boot disk decryption of all hosts that have used them, the keys must be protected accordingly.

Procedure

- Copy the backup key from the **/var/db/tang** directory to the temp directory from which you can restore the key.

14.3.2. Recovering keys for a Tang server

You can recover the keys for a Tang server by accessing the keys from a backup.

Procedure

- Restore the key from your backup folder to the **/var/db/tang/** directory.
  When the Tang server starts up, it advertises and uses these restored keys.

14.3.3. Rekeying Tang servers

This procedure uses a set of three Tang servers, each with unique keys, as an example.

Using redundant Tang servers reduces the chances of nodes failing to boot automatically.

Rekeying a Tang server, and all associated NBDE-encrypted nodes, is a three-step procedure.

Prerequisites

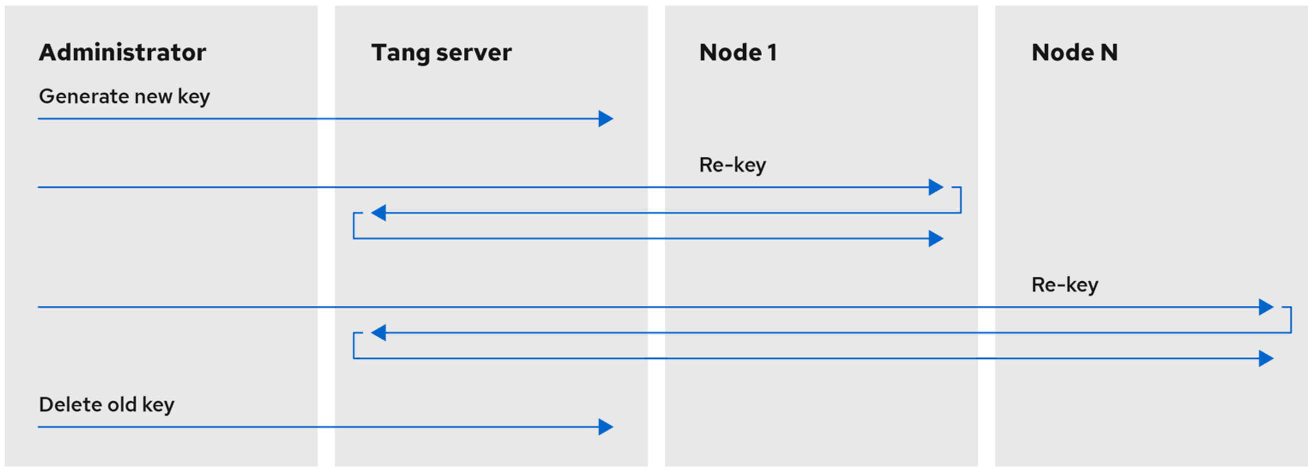
- A working Network-Bound Disk Encryption (NBDE) installation on one or more nodes.

Procedure

1. Generate a new Tang server key.
2. Rekey all NBDE-encrypted nodes so they use the new key.
3. Delete the old Tang server key.

> **NOTE**
>
> Deleting the old key before all NBDE-encrypted nodes have completed their rekeying causes those nodes to become overly dependent on any other configured Tang servers.

Figure 14.1. Example workflow for rekeying a Tang server



14.3.3.1. Generating a new Tang server key

Prerequisites

- A root shell on the Linux machine running the Tang server.
- To facilitate verification of the Tang server key rotation, encrypt a small test file with the old key:

  ```
  # echo plaintext | clevis encrypt tang '{"url":"http://localhost:7500”}' -y >/tmp/encrypted.oldkey
  ```

- Verify that the encryption succeeded and the file can be decrypted to produce the same string **plaintext**:

  ```
  # clevis decrypt </tmp/encrypted.oldkey
  ```

Procedure

1. Locate and access the directory that stores the Tang server key. This is usually the **/var/db/tang** directory. Check the currently advertised key thumbprint:

   ```
   # tang-show-keys 7500
   ```

▪

Example output

```
36AHjNH3NZDSnlONLz1-V4ie6t8
```

2. Enter the Tang server key directory:

```
# cd /var/db/tang/
```

3. List the current Tang server keys:

```
# ls -A1
```

Example output

```
36AHjNH3NZDSnlONLz1-V4ie6t8.jwk
gJZiNPMLRBnyo_ZKfK4_5SrnHYo.jwk
```

During normal Tang server operations, there are two **.jwk** files in this directory: one for signing and verification, and another for key derivation.

4. Disable advertisement of the old keys:

```
# for key in *.jwk; do \
  mv -- "$key" ".$key"; \
done
```

New clients setting up Network-Bound Disk Encryption (NBDE) or requesting keys will no longer see the old keys. Existing clients can still access and use the old keys until they are deleted. The Tang server reads but does not advertise keys stored in UNIX hidden files, which start with the **.** character.

5. Generate a new key:

```
# /usr/libexec/tangd-keygen /var/db/tang
```

6. List the current Tang server keys to verify the old keys are no longer advertised, as they are now hidden files, and new keys are present:

```
# ls -A1
```

Example output

```
.36AHjNH3NZDSnlONLz1-V4ie6t8.jwk
.gJZiNPMLRBnyo_ZKfK4_5SrnHYo.jwk
Bp8XjITceWSN_7XFfW7WfJDTomE.jwk
WOjQYkyK7DxY_T5pMncMO5w0f6E.jwk
```

Tang automatically advertises the new keys.

NOTE

More recent Tang server installations include a helper **/usr/libexec/tangd-rotate-keys** directory that takes care of disabling advertisement and generating the new keys simultaneously.

7. If you are running multiple Tang servers behind a load balancer that share the same key material, ensure the changes made here are properly synchronized across the entire set of servers before proceeding.

Verification

1. Verify that the Tang server is advertising the new key, and not advertising the old key:

```
# tang-show-keys 7500
```

Example output

```
WOjQYkyK7DxY_T5pMncMO5w0f6E
```

2. Verify that the old key, while not advertised, is still available to decryption requests:

```
# clevis decrypt </tmp/encrypted.oldkey
```

14.3.3.2. Rekeying all NBDE nodes

You can rekey all of the nodes on a remote cluster by using a **DaemonSet** object without incurring any downtime to the remote cluster.

NOTE

If a node loses power during the rekeying, it is possible that it might become unbootable, and must be redeployed via Red Hat Advanced Cluster Management (RHACM) or a GitOps pipeline.

Prerequisites

- **cluster-admin** access to all clusters with Network-Bound Disk Encryption (NBDE) nodes.
- All Tang servers, not just the server being rotated, must be accessible to every NBDE node undergoing rekeying.
- Obtain the Tang server URL and key thumbprint for every Tang server.

Procedure

1. Create a **DaemonSet** object based on the following template. This template sets up three redundant Tang servers, but can be easily adapted to other situations. Change the Tang server URLs and thumbprints in the **NEW_TANG_PIN** environment to suit your environment:

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: tang-rekey
  namespace: openshift-machine-config-operator
spec:
  selector:
    matchLabels:
      name: tang-rekey
  template:
    metadata:
      labels:
        name: tang-rekey
    spec:
      containers:
      - name: tang-rekey
        image: registry.access.redhat.com/ubi8/ubi-minimal:8.4
        imagePullPolicy: IfNotPresent
        command:
        - "/sbin/chroot"
        - "/host"
        - "/bin/bash"
        - "-ec"
        args:
        - |
          rm -f /tmp/rekey-complete || true
          echo "Current tang pin:"
          clevis-luks-list -d $ROOT_DEV -s 1
          echo "Applying new tang pin: $NEW_TANG_PIN"
          clevis-luks-edit -f -d $ROOT_DEV -s 1 -c "$NEW_TANG_PIN"
          echo "Pin applied successfully"
          touch /tmp/rekey-complete
          sleep infinity
        readinessProbe:
          exec:
            command:
            - cat
            - /host/tmp/rekey-complete
          initialDelaySeconds: 30
          periodSeconds: 10
        env:
        - name: ROOT_DEV
          value: /dev/disk/by-partlabel/root
        - name: NEW_TANG_PIN
          value: >-
            {"t":1,"pins":{"tang":[
              {"url":"http://tangserver01:7500","thp":"WOjQYkyK7DxY_T5pMncMO5w0f6E"},
              {"url":"http://tangserver02:7500","thp":"I5Ynh2JefoAO3tNH9TgI4obIaXI"},
              {"url":"http://tangserver03:7500","thp":"38qWZVeDKzCPG9pHLqKzs6k1ons"}
            ]}}
        volumeMounts:
        - name: hostroot
          mountPath: /host
        securityContext:
          privileged: true
      volumes:
      - name: hostroot
        hostPath:
          path: /
      nodeSelector:
        kubernetes.io/os: linux
      priorityClassName: system-node-critical
      restartPolicy: Always
      serviceAccount: machine-config-daemon
      serviceAccountName: machine-config-daemon
```

In this case, even though you are rekeying **tangserver01**, you must specify not only the new thumbprint for **tangserver01**, but also the current thumbprints for all other Tang servers. Failure to specify all thumbprints for a rekeying operation opens up the opportunity for a man-in-the-middle attack.

2. To distribute the daemon set to every cluster that must be rekeyed, run the following command:

```
$ oc apply -f tang-rekey.yaml
```

However, to run at scale, wrap the daemon set in an ACM policy. This ACM configuration must contain one policy to deploy the daemon set, a second policy to check that all the daemon set pods are READY, and a placement rule to apply it to the appropriate set of clusters.

NOTE

After validating that the daemon set has successfully rekeyed all servers, delete the daemon set. If you do not delete the daemon set, it must be deleted before the next rekeying operation.

Verification

After you distribute the daemon set, monitor the daemon sets to ensure that the rekeying has completed successfully. The script in the example daemon set terminates with an error if the rekeying failed, and remains in the **CURRENT** state if successful. There is also a readiness probe that marks the pod as **READY** when the rekeying has completed successfully.

- This is an example of the output listing for the daemon set before the rekeying has completed:

```
$ oc get -n openshift-machine-config-operator ds tang-rekey
```

Example output

```
NAME        DESIRED   CURRENT   READY   UP-TO-DATE   AVAILABLE   NODE
SELECTOR         AGE
tang-rekey   1         1         0       1            0          kubernetes.io/os=linux   11s
```

- This is an example of the output listing for the daemon set after the rekeying has completed successfully:

```
$ oc get -n openshift-machine-config-operator ds tang-rekey
```

Example output

```
NAME        DESIRED   CURRENT   READY   UP-TO-DATE   AVAILABLE   NODE
SELECTOR         AGE
tang-rekey   1         1         1       1            1          kubernetes.io/os=linux   13h
```

Rekeying usually takes a few minutes to complete.

NOTE

If you use ACM policies to distribute the daemon sets to multiple clusters, you must include a compliance policy that checks every daemon set's READY count is equal to the DESIRED count. In this way, compliance to such a policy demonstrates that all daemon set pods are READY and the rekeying has completed successfully. You could also use an ACM search to query all of the daemon sets' states.

14.3.3.3. Troubleshooting temporary rekeying errors for Tang servers

To determine if the error condition from rekeying the Tang servers is temporary, perform the following procedure. Temporary error conditions might include:

- Temporary network outages
- Tang server maintenance

Generally, when these types of temporary error conditions occur, you can wait until the daemon set succeeds in resolving the error or you can delete the daemon set and not try again until the temporary error condition has been resolved.

Procedure

1. Restart the pod that performs the rekeying operation using the normal Kubernetes pod restart policy.
2. If any of the associated Tang servers are unavailable, try rekeying until all the servers are back online.

14.3.3.4. Troubleshooting permanent rekeying errors for Tang servers

If, after rekeying the Tang servers, the **READY** count does not equal the **DESIRED** count after an extended period of time, it might indicate a permanent failure condition. In this case, the following conditions might apply:

- A typographical error in the Tang server URL or thumbprint in the **NEW_TANG_PIN** definition.
- The Tang server is decommissioned or the keys are permanently lost.

Prerequisites

- The commands shown in this procedure can be run on the Tang server or on any Linux system that has network access to the Tang server.

Procedure

1. Validate the Tang server configuration by performing a simple encrypt and decrypt operation on each Tang server's configuration as defined in the daemon set.
   This is an example of an encryption and decryption attempt with a bad thumbprint:

```
$ echo "okay" | clevis encrypt tang \
  '{"url":"http://tangserver02:7500","thp":"badthumbprint"}' | \
  clevis decrypt
```

Example output

```
Unable to fetch advertisement: 'http://tangserver02:7500/adv/badthumbprint'!
```

This is an example of an encryption and decryption attempt with a good thumbprint:

```
$ echo "okay" | clevis encrypt tang \
  '{"url":"http://tangserver03:7500","thp":"goodthumbprint"}' | \
  clevis decrypt
```

Example output

```
okay
```

2. After you identify the root cause, remedy the underlying situation:
   a. Delete the non-working daemon set.
   b. Edit the daemon set definition to fix the underlying issue. This might include any of the following actions:
      - Edit a Tang server entry to correct the URL and thumbprint.
      - Remove a Tang server that is no longer in service.
      - Add a new Tang server that is a replacement for a decommissioned server.
3. Distribute the updated daemon set again.

NOTE

When replacing, removing, or adding a Tang server from a configuration, the rekeying operation will succeed as long as at least one original server is still functional, including the server currently being rekeyed. If none of the original Tang servers are functional or can be recovered, recovery of the system is impossible and you must redeploy the affected nodes.

Verification

- Check the logs from each pod in the daemon set to determine whether the rekeying completed successfully. If the rekeying is not successful, the logs might indicate the failure condition. The following log is from a completed successful rekeying operation:

```
$ oc logs rekey-tang-kp4q2
```

Example output

```
Current tang pin:
1: sss '{"t":1,"pins":{"tang":[{"url":"http://10.46.55.192:7500"},{"url":"http://10.46.55.192:7501"},
{"url":"http://10.46.55.192:7502"}]}}'
Applying new tang pin: {"t":1,"pins":{"tang":[
  {"url":"http://tangserver01:7500","thp":"WOjQYkyK7DxY_T5pMncMO5w0f6E"},
  {"url":"http://tangserver02:7500","thp":"I5Ynh2JefoAO3tNH9TgI4obIaXI"},
  {"url":"http://tangserver03:7500","thp":"38qWZVeDKzCPG9pHLqKzs6k1ons"}
]}}
Updating binding...
Binding edited successfully
Pin applied successfully
```

14.3.4. Deleting old Tang server keys

Prerequisites

- A root shell on the Linux machine running the Tang server.

Procedure

1. Locate and access the directory where the Tang server key is stored. This is usually the **/var/db/tang** directory:

```
# cd /var/db/tang/
```

2. List the current Tang server keys, showing the advertised and unadvertised keys:

```
# ls -A1
```

Example output

```
.36AHjNH3NZDSnlONLz1-V4ie6t8.jwk
.gJZiNPMLRBnyo_ZKfK4_5SrnHYo.jwk
Bp8XjITceWSN_7XFfW7WfJDTomE.jwk
WOjQYkyK7DxY_T5pMncMO5w0f6E.jwk
```

3. Delete the old keys:

```
# rm .*.jwk
```

4. List the current Tang server keys to verify the unadvertised keys are no longer present:

```
# ls -A1
```

Example output

```
Bp8XjITceWSN_7XFfW7WfJDTomE.jwk
WOjQYkyK7DxY_T5pMncMO5w0f6E.jwk
```

Verification

At this point, the server still advertises the new keys, but an attempt to decrypt based on the old key will fail.

1. Query the Tang server for the current advertised key thumbprints:

   ```
   # tang-show-keys 7500
   ```

   Example output

   ```
   WOjQYkyK7DxY_T5pMncMO5w0f6E
   ```

2. Decrypt the test file created earlier to verify decryption against the old keys fails:

   ```
   # clevis decrypt </tmp/encryptValidation
   ```

   Example output

   ```
   Error communicating with the server!
   ```

If you are running multiple Tang servers behind a load balancer that share the same key material, ensure the changes made are properly synchronized across the entire set of servers before proceeding.

14.4. DISASTER RECOVERY CONSIDERATIONS

This section describes several potential disaster situations and the procedures to respond to each of them. Additional situations will be added here as they are discovered or presumed likely to be possible.

14.4.1. Loss of a client machine

The loss of a cluster node that uses the Tang server to decrypt its disk partition is *not* a disaster. Whether the machine was stolen, suffered hardware failure, or another loss scenario is not important: the disks are encrypted and considered unrecoverable.

However, in the event of theft, a precautionary rotation of the Tang server's keys and rekeying of all remaining nodes would be prudent to ensure the disks remain unrecoverable even in the event the thieves subsequently gain access to the Tang servers.

To recover from this situation, either reinstall or replace the node.

14.4.2. Planning for a loss of client network connectivity

The loss of network connectivity to an individual node will cause it to become unable to boot in an unattended fashion.

If you are planning work that might cause a loss of network connectivity, you can reveal the passphrase for an onsite technician to use manually, and then rotate the keys afterwards to invalidate it:

Procedure

1. Before the network becomes unavailable, show the password used in the first slot **-s 1** of device **/dev/vda2** with this command:

   ```
   $ sudo clevis luks pass -d /dev/vda2 -s 1
   ```

2. Invalidate that value and regenerate a new random boot-time passphrase with this command:

```
$ sudo clevis luks regen -d /dev/vda2 -s 1
```

14.4.3. Unexpected loss of network connectivity

If the network disruption is unexpected and a node reboots, consider the following scenarios:

- If any nodes are still online, ensure that they do not reboot until network connectivity is restored. This is not applicable for single-node clusters.
- The node will remain offline until such time that either network connectivity is restored, or a pre-established passphrase is entered manually at the console. In exceptional circumstances, network administrators might be able to reconfigure network segments to reestablish access, but this is counter to the intent of NBDE, which is that lack of network access means lack of ability to boot.
- The lack of network access at the node can reasonably be expected to impact that node's ability to function as well as its ability to boot. Even if the node were to boot via manual intervention, the lack of network access would make it effectively useless.

14.4.4. Recovering network connectivity manually

A somewhat complex and manually intensive process is also available to the onsite technician for network recovery.

Procedure

1. The onsite technician extracts the Clevis header from the hard disks. Depending on BIOS lockdown, this might involve removing the disks and installing them in a lab machine.
2. The onsite technician transmits the Clevis headers to a colleague with legitimate access to the Tang network who then performs the decryption.
3. Due to the necessity of limited access to the Tang network, the technician should not be able to access that network via VPN or other remote connectivity. Similarly, the technician cannot patch the remote server through to this network in order to decrypt the disks automatically.
4. The technician reinstalls the disk and manually enters the plain text passphrase provided by their colleague.
5. The machine successfully starts even without direct access to the Tang servers. Note that the transmission of the key material from the install site to another site with network access must be done carefully.
6. When network connectivity is restored, the technician rotates the encryption keys.

14.4.5. Emergency recovery of network connectivity

If you are unable to recover network connectivity manually, consider the following steps. Be aware that these steps are discouraged if other methods to recover network connectivity are available.

- This method must only be performed by a highly trusted technician.
- Taking the Tang server's key material to the remote site is considered to be a breach of the key material and all servers must be rekeyed and re-encrypted.

- This method must be used in extreme cases only, or as a proof of concept recovery method to demonstrate its viability.
- Equally extreme, but theoretically possible, is to power the server in question with an Uninterruptible Power Supply (UPS), transport the server to a location with network connectivity to boot and decrypt the disks, and then restore the server at the original location on battery power to continue operation.
- If you want to use a backup manual passphrase, you must create it before the failure situation occurs.
- Just as attack scenarios become more complex with TPM and Tang compared to a stand-alone Tang installation, so emergency disaster recovery processes are also made more complex if leveraging the same method.

14.4.6. Loss of a network segment

The loss of a network segment, making a Tang server temporarily unavailable, has the following consequences:

- OpenShift Container Platform nodes continue to boot as normal, provided other servers are available.
- New nodes cannot establish their encryption keys until the network segment is restored. In this case, ensure connectivity to remote geographic locations for the purposes of high availability and redundancy. This is because when you are installing a new node or rekeying an existing node, all of the Tang servers you are referencing in that operation must be available.

A hybrid model for a vastly diverse network, such as five geographic regions in which each client is connected to the closest three clients is worth investigating.

In this scenario, new clients are able to establish their encryption keys with the subset of servers that are reachable. For example, in the set of **tang1**, **tang2** and **tang3** servers, if **tang2** becomes unreachable clients can still establish their encryption keys with **tang1** and **tang3**, and at a later time re-establish with the full set. This can involve either a manual intervention or a more complex automation to be available.

14.4.7. Loss of a Tang server

The loss of an individual Tang server within a load balanced set of servers with identical key material is completely transparent to the clients.

The temporary failure of all Tang servers associated with the same URL, that is, the entire load balanced set, can be considered the same as the loss of a network segment. Existing clients have the ability to decrypt their disk partitions so long as another preconfigured Tang server is available. New clients cannot enroll until at least one of these servers comes back online.

You can mitigate the physical loss of a Tang server by either reinstalling the server or restoring the server from backups. Ensure that the backup and restore processes of the key material is adequately protected from unauthorized access.

14.4.8. Rekeying compromised key material

If key material is potentially exposed to unauthorized third parties, such as through the physical theft of a Tang server or associated data, immediately rotate the keys.

Procedure

1. Rekey any Tang server holding the affected material.
2. Rekey all clients using the Tang server.
3. Destroy the original key material.
4. Scrutinize any incidents that result in unintended exposure of the master encryption key. If possible, take compromised nodes offline and re-encrypt their disks.

TIP

Reformatting and reinstalling on the same physical hardware, although slow, is easy to automate and test.